MINERAL RESOURCE ASSESSMENT OF MACKAY-PROSERPINE CENTRAL COAST QUEENSLAND

A report prepared by the Queensland Department of Natural Resources and Mines

MINERAL RESOURCE ASSESSMENT OF THE MACKAY-PROSERPINE REGION, CENTRAL COAST QUEENSLAND

This report compiles information on the mineral resources within the Mackay-Proserpine Region, central coast Queensland, including: currently operating mines, known resources, abandoned mines, mineral occurrences, and undiscovered mineral resources.

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Geological Survey of Queensland
9/12/2002

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Prepared by
Department of Natural Resources and Mines
December 2002

Printed February 2003

NR&M #18122

QNRM03034

EXECUTIVE SUMMARY

The Queensland Government recently commissioned a study to determine the economic and social benefits from Queensland's mining industries (including exploration, and production of mineral and energy resources)[1]. The report indicates that exploration is the key to sustaining a competitive mining industry and a competitive mining industry is a prerequisite for the growth of high-value mineral processing and technological service industries.

The Government Submission to the *House of Representatives Standing Committee on Industry and Resources Inquiry into Resources Exploration Impediments* documents that Queensland exploration is currently at its lowest in real terms for the last 25 years and that at the present low rate of exploration, resources and reserves are not being identified to support future sustainable development. It states that unless viable base and precious metal discoveries are made, only one metalliferous mine will be operating in Queensland in 2020. The need for future exploration is even more pronounced in Queensland's petroleum industry, where at current rates of production, Queensland's identified oil and gas reserves will run dry within 8 years.

The submission emphasises that exploration is the lifeblood for the resources sector: 'for Queensland and ultimately the Australian community to accrue significant economic benefits from mining industries, there needs to be a robust exploration industry searching for and discovering commercially exploitable mineral and petroleum resources'. Impacting on this in recent years has been the changing structure of the global mining industry, with consolidation resulting in the top five metal and mining companies accounting for 50 percent of the total equity value of the industry. As rationalisation continues both in Australia and overseas, the result is a reduction of combined exploration budgets when compared to the pre-amalgamation budgets of the individual companies. The effect of native title and land access issues is recognised to have exacerbated this downward trend.

There is an important role for government to play in relation to the reinvigoration of resources exploration investment in Queensland. Official statistics show that exploration expenditure has fallen by over 60 percent over a four-year period, from $295 million in 1996-97 to $117 million in 1999-2000. Whilst several factors have contributed to this steep decline, native title processes and the issue of land access have had a major impact.

The significance of the exploration industry needs to be considered in terms of its economic impact and the linkages with mining through to mineral processing and beyond. The recently commissioned study – *'Queensland's Mining Industries: Creating Wealth for the Community, the State, and the Nation'* found that the industry and minerals processing sectors currently contribute around 10.2 percent of Gross State Product or around $9.4 billion per year in Queensland.

Queensland's mining industries directly and indirectly generate 86,000 full-time equivalent jobs in Queensland and another 7,000 throughout Australia. This represents about 7.2 percent of total employment in the state. The mining industry also accounts for about 17 percent of all capital expenditure in Queensland. The industry also supports the generation of wealth and jobs in other sectors of the economy, such as manufacturing, machinery and equipment (annual value added of $580 million and a total effect of 5700 jobs), construction (annual value added of $150 million and a total effect of 1400 jobs),

[1] The findings of the study are contained in 'Queensland's Mining Industries: Creating Wealth for the Community, the State, and the Nation' an attachment in Queensland Government Submission to the House of Representatives Standing Committee on Industry and Resources Inquiry into Resources Exploration Impediments, 2002.

transport and communication (annual value added of $880 million and a total effect of 8400 jobs), and service ($620 million and around 6000 jobs).

More than one-third of the State's research and development expenditure relates to mining and processing (approximately $70million in 1999/2000). The mining industry produces an array of products, which has led to the development of value-adding industries such as mineral processing, and high technology service industries. Australian mining companies are leaders in the area of technology development – both of advanced mining equipment and systems, and in the areas of mining software and management systems. Exports of Australian mining-related intellectual property totalled over $1 billion in 1999/2000. Consistent with the 'Smart State' vision, research and development by many Queensland-based companies and institutions servicing the mining and energy industries have established them as world leaders in their field.

Underpinning this economic contribution is a strong export performance - over the 12 month period ending 31March 2002 Queensland recorded $12.5 billion in mining related exports. This represents 54 percent of Queensland's total exports for that period. The report also notes that the most notable growth area in recent years has been the mineral-processing sector. In the 5-year period ending June 2001, the State's processed minerals exports increased 157 percent to $3.1 billion and with Comalco's $1.5 billion alumina refinery at Gladstone and AMC's $1.3 billion magnesium plant at Stanwell to come on-line, this performance will strengthen. The mining industry is also recognised as a key driver in making the state the most decentralised economy in the country.

The mineral resources sector provides benefits to the community including:

- Lower prices for goods and services – abundant and high-quality black coal resources contribute to electricity prices that are among the lowest in the world.
- Jobs in service and support industries – mining companies spend about $2.2 billion each year in Queensland and in doing so support almost 60000 full-time and part-time jobs for Queenslanders.
- Taxes – royalties and company income taxes are returned to the community in the form of public services such as hospitals, schools, police etc. Last year the Queensland mining sector paid $463 million in royalties alone.
- Return of profits to shareholders – the profitability of mining is translated into benefits to most Queenslanders through their superannuation funds.

Critical to sustainable mine development in Queensland is the generation of new mineral resource projects and this requires access to prospective ground for exploration. It also needs to be recognised that successful exploration typically involves an iterative process of investigation that occurs over many years.

Prospective ground has been identified in this report for undiscovered mineral resources that are likely to occur within the Mackay-Proserpine Region and these areas are ranked using the terms 'High', 'High-medium', 'Medium' and 'Low'. The definition of these terms varies between commodity groups and in some cases by deposit type. A generalisation of these criteria follows:

High: refers to areas that are considered to have the greatest exploration potential and highest potential for future developments or expansions (ie having identified resources or covered by granted mining tenures or applications).

High-Medium: refers to areas outside known deposits or currently held mining titles that contain prospective rock units. In the case of petroleum and coal, they may have potential for development in the short to medium term (<15 years). For

metallic minerals, these areas include currently held exploration permits (EPs) and contain or are near mineral occurrences that indicate the presence of a mineralising system.

Medium: refers to areas that are outside known deposits or EPs, but are closely associated with mineral occurrences. For petroleum and coal, these areas have potential for development in the long term (>15 years). Other areas designated as of medium potential are based on magnetic interpretation of potential host units under cover. This group is considered to be 'under-explored' and therefore to have greater potential to host deposits than similar units exposed at the surface.

Low: refers to areas that contain prospective rock units but have no other indicators of mineralisation, or in the case of petroleum and coal, either have a low potential to contain prospective units or have their prospectivity diminished by factors such as quality, proximity to established infrastructure, or geological constraints.

Potential Untested: refers specifically to areas that are currently held under tenure and have potential for shale gas.

Table A identifies State Forest and Timber/Forest Reserves that contain either operating mines or proposed developments held under mining leases (MLs) and mine development leases (MDLs).

TABLE A - Mines/proposed development within forested areas.

Forest name (estate_id)	Commodity	MDL/ML
Junee State Forest (5919, 5950)	OIL SHALE	MDL192, 297
Homevale Resources Reserve (5450, 5485-87, 5493, 5496, 5500-01, 5505, 5508-10)	ALLUVIAL GOLD	ML4782, 4785,70039, 70089-90, 7418-26
Credition State Forest (5348), Homevale Resources Reserve (5450, 5451, 5485-87, 5493, 5496, 5495, 5505, 5507-10), Mount Archer State Forest (144, 151)	EPITHERMAL GOLD	ML4756, 4782, 4785, 6516, 6520, 6948, 5878, 80031
MiaMia State Forest (5482), Homevale Resources Reserve (5485, 5495, 5504, 5507), Lake Learmouth State Forest (77)	MESOTHERMAL GOLD	MDL 272, ML4726, 4756, 4764, 80097, 80099
MiaMia State Forest (5482-83, 5482), Credition State Forest (5436), Ben Mohr State Forest (5447), Bouldercombe Gorge Resources Reserve(202)	HYDROTHERMAL	ML4726, 6520, 4775, 5887, 80001, 80006-7, MDL272
Proserpine State Forest (5091, 5105, 5111, 5114, 5116) Credition State Forest (5436), Homevale Resources Reserve (5450)	PORPHYRY	ML1017-19, 1072-73, 1080, 1020-23, 6516
Flat Top Range Resources Reserve (169, 192)	VOLCANOGENIC MASSIVE SULPHIDES	ML5861, 5889

Table B identifies State Forest and Timber/Forest Reserves that contain ground prospective for one or more deposit models.

TABLE B - Areas deemed to be high or high-medium potential, and mining tenure intersecting forested areas.

Forest name (estate_id)	Commodity	EPs	Intersection Area (km^2)
Byfield State Forest (5, 8, 15,16,18-26, 28-34)	COAL	EPC774, 653, 801, 716, 733, 689	130
Drylanders State Forest (4998), Conway State Forest (5024), Proserpine State Forest (5033, 5043, 5047, 5052)	COAL SEAM GAS/SHALE GAS	EPP712, 678, 688, 700, 716	113
Junee State Forest (5919)	OIL SHALE	EPM10622	N/A
Proserpine State Forest (5073, 5091, 5105, 5113-17, 5124-25, 5127, 5132-33, 5139), Sonoma State Forest (5078-84, 5086-87, 5107, 5111-12), Cathu State Forest (5191), Macartney State Forest (5204, 5207, 5212), Lacy Timber Reserve (5209, 5214, 5233, 5243), Saint Helens State Forest (5235), Mia Mia State Forest (5421, 5425, 5439-40, 5442, 5444, 5468, 5482-84), Ben Mohr Timber Reserve (5443, 5446-48, 5455-56, 5464, 5466-67, 5472), Eton State Forest (5452, 5454), Mount Bridgeman State Forest (5457), Spencer Gap State Forest (5469-71, 5479), Epson State Forest 1 (5537), Epson State Forest 2 (5489, 5493-94, 5496), Epson State Forest 3 (5543, 5545, 5575), Kelvin State Forest (5564, 5568, 5571-73, 5584, 5586-88, 5591, 5593-96, 5599, 5605-06, 5608, 5610, 5613-14, 5624-25, 5627, 5634-35, 5638-39), Koumala State Forest (5612), Carminya State Forest (5631), Rosedale State Forest (5632, 5654, 5656), West Hill State Forest (5636, 5642, 5646-47, 5649-52, 5655), Tierawoomba State Forest (5665-66, 5668), Collaroy State Forest 1 (5669), Porphyry Hill State Forest (5684, 5687-88, 5690), Glencoe State Forest (5757, 5760-61, 5764), Mount Buffalo State Forest (5791), Develin State Forest (6142), Gamma State Forest (5272, 5277), Bluff Hill State Forest (5280, 5315), Pelion State Forest (5282,5209, 5314, 5325), Credition State Forest (5322, 5329-30, 5340-41, 5348, 5387-96, 5401, 5403-18, 5436), Homevale Resources Reserve (5450, 5451, 5485-87, 5493-5511, 5519, 5522), Mount Archer State Forest (131-32, 139-40, 143-155), Gogango Range State Forest (235-36).	Epithermal - GOLD	EPM 13761, 13007, 13061, 11745, 11744, 12277, 13127, 12579, 13591, 13593-95, 13734, 11738, 13482, 11483, 9937, 11134, 13481, 10132	2049
Carminya State Forest (5631), Bouldercombe Gorge Reserve (200-203, 207, 210), Gelobera State Forest (221-224), Ulam Range State Forest (230-232), Aricia State Forest (101), Mornish State Forest (130, 138), Bouldercombe State Forest (198)	Skarn – BASE METALS AND GOLD	EPM 11901, 13491, 12218, 10677	58

Forest name (estate_id)	Commodity	EPs	Intersection Area (km^2)
Proserpine State Forest (5073, 5091, 5105, 5111-14, 5116-117, 5124-25, 5127, 5132-33, 5139), Homevale Resources Reserve (5450, 5485-87, 5493-96, 5498-5510), Bouldercombe Gorge Resources Reserve (200-203, 207, 210), Bouldercombe State Forest (198), Credition State Forest (5322, 5436, 5329-30, 5340-41, 5387-96, 5401, 5403-18), Mia Mia State Forest (5421, 5439-40, 5442, 5444-45, 5450, 5468, 5482-83), Ben Mohr Timber Reserve (5443, 5446, 5448), Ben Mohr State Forest (5447, 5455-56, 5464, 5466-67, 5472), Eton State Forest (5452, 5454), Mount Bridgeman State Forest (5457), Spencer Gap State Forest (5470-71, 5479), Epson State Forest 1 (5537), Epson State Forest 3 (5543, 5575), Kelvin State Forest (5564, 5568, 5571-73, 5584, 5587-88, 5591, 5593-95, 5599, 5605-06, 5608, 5610, 5613-14, 5624-25, 5627, 5634-35, 5638-39), Connors State Forest (5596), Carminya State Forest (5631), Rosedale State Forest (5632, 5654, 5656), West Hill State Forest (5636, 5642, 5646-47, 5649-52, 5655), Tierawoomba State Forest (5657, 5665-66, 5668), Collaroy State Forest (5669), Porphyry Hill State Forest (5684, 5687-88, 5690),Glencoe State Forest (5761, 5764), Mount Buffalo State Forest (5791), Sonomia State Forest (5078-84, 5086-87, 5107, 5111-12), Cathu State Forest (5191), Macartney State Forest (5204, 5207, 5212), Lacy Timber Reserve (5209, 5214, 5233, 5243), St Helens State Forest (5235), Gamma State Forest (5272, 5277), Bluff Hill State Forest (5280, 5315-17), Pelion State Forest (5282, 5309-11, 5325), Gelobera State Forest (221-224, 228-29), Ulam Range State Forest (230-234), Don River State Forest (238).	Porphyry-GOLD AND BASE METALS	EPM 11779, 11759, 13761, 13007, 11535, 11744-45, 12277, 13127, 12579, 13593-95, 11901, 13591, 13734, 11738, 13482, 13799, 11483, 9937, 11134, 13481, 10132, 12947, 13491, 12218	2029
Proserpine State Forest (5073, 5091, 5105, 5111-13, 5115-17, 5127, 5132-33), Sonoma State Forest (5086), Homevale Resources Reserve (5450, 5485-87, 5493-94, 5495-96, 5498-5510), Bouldercombe Resources Reserve (210), Gelobera State Forest (229), Ulam Range State Forest (232). MiaMia State Forest (5482-83, 5482), Credition State Forest (5436), Ben Mohr State Forest (5447), Bouldercombe Gorge Resources Reserve(202).	Hydrothermal vein style – GOLD AND BASE METALS	EPM 13761, 12579, 11779, 13421, 13007, 11507, 9728, 7725, 11842, 11837	1059
MiaMia State Forest (5482), Homevale Resources Reserve (5485, 5495, 5504, 5507), Lake Learmouth State Forest (77), Sonoma State Forest (5078, 5083, 5086, 5107, 5124-25, 5127), Mount Archer State Forest (131-32, 134, 13940, 142-155), Flat Top Range Resources Reserve (169).	Mesothermal gold	EPM 12339	33
Homevale Resources Reserve (5450, 5485-87, 5493, 5496, 5500-01, 5505, 5508-10), Lake Learmouth State Forest (77,89,90), Mornish State Forest (130), Bouldercombe State Forest (198), Bouldercombe Gorge Resources Reserve (200-203, 207, 210).	Alluvial gold		14
Sonoma State Forest (5078-79, 5081, 5083, 5086, 5107, 5124-25, 5127), Marlborough State Forest (5908-09), Alligator Creek State Forest (27, 35-36), Eugene State Forest (6014), Canal Creek State Forest (73), Lake Learmouth State Forest (77-80, 82-90, 94-98), Aricia State Forest (101), Mount Archer State Forest (131,132, 134, 139-140, 143-155), Flat Top Range Resources Reserve (169-70, 192), Bouldercombe Resources Reserve (200-03, 207, 210), Gelobera State Forest (221-24, 228-29), Ulam State Forest (230-34), Don River State Forest (238).	Volcanogenic Massive Sulphides - BASE METALS		335
Flat Top Range Resources Reserve (4083, 4124), Aricia State Forest (3948), Lake Learmouth State Forest (3917-21), Eugene State Forest (3869), Marlborough State Forest (3781-82), Alligator Creek State Forest (3848)	Lateritic Nickel-Chromite	-	92

Forest name (estate_id)	Commodity	EPs	Intersection Area (km^2)
Bouldercombe Gorge Reserves Reserve (210), Gelobera State Forest (222)	Volcanogenic Cu-Ni-Zn-Pb - BASE METALS	EPM7940	10
Abbott Bay Resources Reserve (4946)	MINERAL SANDS	EPM1850, 9541	N/A

It should be noted that whilst precedents have been set in Queensland in terms of exploration for conventional petroleum sources, with drilling having been carried out in several National Parks (eg Lakefield National Park), coal seam gas is considered separately in this report because there are important differences with conventional hydrocarbon fields. The drillhole spacing for coal seam gas is less and water management is a significant issue, factors that may restrict resource development within Category A and B Conservation Areas depending on the environmental management process currently being finalised by the Environmental Protection Agency (EPA).

The category 'potential untested', because of its absence of geoscientific and technical information, has been equated to medium-high potential areas because of the combination of: the rapid rate of technological development; the increasingly diverse energy mix contributing to the State's energy needs; and the low risk nature of shale gas plays.

Recommendations:

- **No change should be made to the classification of crown owned forested land where MLs or MDLs exist.**
- **Crown owned forested areas that are identified as high or high-medium potential should have no change to their classification.**
- **Because of the economic significance of coal and the potential contribution of coal seam gas and shale gas to the future energy/greenhouse requirements of the State, forested areas identified as having high, high-medium (potential untested) and medium potential for these resources should have no change to their classification.**

INTRODUCTION

This report provides an assessment of the mineral resources of the Mackay-Proserpine Region to help consider alternative uses of the land. In this instance crown land currently classified as State Forest or Timber Reserve is being considered for transfer to Conservation Park status. The implication of this in terms of exploration and mining is that, whilst activities involving machinery can be undertaken in State Forests, Timber Reserves and Forest Reserves following consultation with the relevant administering authority and undertaking conditions deemed necessary, in Conservation Parks and similar environmentally sensitive areas (categories A and B) mining/exploration activities would be totally excluded (refer Schedule 1A of the Environmental Protection Regulation 1998).

A decision process that has the potential to exclude exploration/mining development projects needs to recognise that the continued generation of new mineral resource projects is of vital importance to Queensland, and that the discovery of future mineral deposits requires access to prospective land and prolonged periods of intensive investigation by exploration companies. ***The issue of sustainable mineral wealth generation provides the focus for the following report.*** Other areas of government policy that would be adversely affected by the exclusion of exploration and mining include the creation of jobs and support for regional communities. Mining is recognised as important to many regional centres, providing much needed boosts to local economies, further opportunities for employment and, in the case of the gemfields, tourism.

The following facts are significant in the discussion.

1) It will not be possible to maintain present levels of production from Queensland's major base and precious metal mines in the medium to long term, with current base metal operations expected to close or near the end of their economic life before 2015.

2) In 2001, the State's two main gold producers, Kidston and Mount Leyshon closed, significantly reducing future gold production despite expansion and development of existing operations elsewhere and potential projects such as Cracow.

3) Small to medium scale base metal and gold projects currently under appraisal will contribute to the State's wealth in the medium term.

4) Queensland's known oil and gas reserves at current rates of production will run dry within 8 years.

5) The mining industry and minerals processing sector contributes 10.2% GSP ($9.4 billion).

6) 86000 full-time equivalent jobs are generated directly and indirectly through the mining industry.

7) The industry also supports the generation of wealth and jobs in other sectors of the economy, such as manufacturing, machinery and equipment (annual value added of $580 million and a total effect of 5700 jobs), construction (annual value added of $150 million and a total effect of 1400 jobs), transport and communication (annual value added of $880 million and a total effect of 8400 jobs), and service ($620 million and around 6000 jobs).

8) More than one-third of the State's research and development expenditure relates to mining and processing (approximately $70million in 1999-2000).

Critical to sustainable mine development in Queensland is the generation of new mineral resource projects and this requires access to prospective ground. This report identifies regions that are prospective for a range of deposit types that are known to occur in the area and for some that have potential to occur in the geological environment of the Mackay-Proserpine Region but are yet to be discovered. Specific locations of undiscovered/potential resources are not identified, but general regions where deposits could occur are defined and described using the terms 'High', 'Medium', 'Low' potential or

gradations such as 'Medium-High'. Because of the probability that the majority of mineral deposits exposed at the surface have already been discovered in Queensland, a concern of this study has been the possible occurrence of mineralised systems under cover and at depth.

In order to construct the boundaries of these areas, a number of data types were integrated: geological maps, geophysical data, and mineral occurrence data.

Geological maps are the foundation of the analysis, simply because they represent geology that is exposed and therefore best known. These maps are used to delineate areas that may contain particular deposit models as inferred by analogy with deposits in the same or similar geological settings elsewhere. An issue that arose in the assessment has been the need to use data sets that varied in age and scale. In some instances broad groupings of rock units have had to be used to ensure the inclusion of all prospective units, and remotely sensed data has been used to interpret the geology hidden under cover. Inconsistencies across map junctions have affected the effectiveness of the analysis. Problems of using geological data of variable quality are apparent in the figures produced for this report where, for example, map boundaries are clearly indicated by abrupt and artificial terminations of some rock units. Geophysical magnetic data are used in the analysis to identify the distribution of near surface magnetic sources in order to delineate shallowly buried magnetic rocks – typically volcanic rocks and unexposed intrusive bodies. This additional information is particularly important for the mineral resource analysis in that numerous types of mineral deposits could be associated with possible volcanic and intrusive rocks hidden under cover. Knowledge of where these rocks occur is therefore critical in identifying where particular styles of mineralisation could exist. Geophysical data are also used to interpret structural features that can localise mineralisation. Mineral occurrence data on the types of mineral deposits and occurrences within the Mackay-Proserpine Region confirms that the region is prospective for the same deposit types, and also suggest the possibility of genetically related deposit types. Again the issue of missing data, in this instance for the northern portion of the study area (Bowen, Proserpine and Ayr 1:250 000 sheet areas), necessitated interpretation from hardcopy reports that discussed the economic geology of these areas.

All geological data used in the analysis are listed in Appendix 1. A GIS project has been compiled for the assessment process and is provided with the report (including primary datasets: exploration and mining lease tenure, geology, mineral occurrences, geophysics, forested crown land and infrastructure; and derivative analyses).

The link between these diverse information sets is the mineral deposit model. Deposit models form the link because: (1) they describe the different environments (rock types etc) in which specific types of mineralisation can be expected, and (2) they form the basis of exploration rationale.

To identify what deposit models are relevant to the Mackay-Proserpine Region two approaches were used. Firstly a listing of exploration models used by companies and their target rock units was constructed from exploration permit applications. The geological settings in the Mackay-Proserpine Region were then assessed to determine if there were any other deposit types that could occur in the area but were not being considered by industry (reference – Cox and Singer, 1986: USGS Bulletin 1693). Figures 3-22 in the text highlight regions where rock types are compatible with specific deposit models.

This report is organised on a commodity basis – coal & petroleum (liquid/gas), industrial minerals, metallic minerals – gold and base, and 'others' which refers in this instance to brine and phosphate. For each commodity, an overview provides a general discussion of the significance of the commodity to Queensland, including current uses and markets as well as recent developments that are significant to production, for example the introduction of new technology. Following this is a

discussion of the Mackay-Proserpine Region identifying: (1) operating mines and new projects being developed; (2) past mining activity and mineral occurrences; (3) areas currently deemed to be prospective based on company activity; and (4) in the case of metalliferous commodities, the exploration models currently being applied. These data form the basic input to the assessment of prospectivity. Criteria used to define and rank areas as 'High', 'Medium', or 'Low' prospectivity are defined in the text. The results of this analysis are then considered in terms of the specific areas of interest within the Mackay-Proserpine Region - forested crown land (Figure 1) - and recommendations have been made.

A qualitative approach to the assessment of mineral resources in the Mackay-Proserpine Region has been taken because of the constraints of a short time frame and limited resources. It is recognised that such an approach is far from comprehensive and fails to fully convey geoscientific knowledge of the region.

To provide some economic framework for areas identified as likely to have undiscovered metallic mineral resources, frequency distributions of tonnages and average grades of well-explored deposits of each type from around the world are provided in Appendix 3. Grade and tonnage models have been included only for deposit types that are assessed as having the potential to occur within forested areas. These models give an indication of the possible grades and tonnages that could occur should a discovery be made and thus provide the connection between deposit models and economics. It needs to be recognised that these grade and tonnage models have not been adjusted to better suit local characteristics and that they serve merely as a preliminary guide.

This report is a purpose specific document designed to support the Statewide Forest Process. The short-time frame set for the assessment has necessitated the use of readily accessible data and required interpretations to be made in some cases where data are missing. Consequently, some uncertainty should be attached to final interpretations of prospectivity.

ACKNOWLEDGEMENTS

A number of officers in the Department of Natural Resources and Mines contributed to this report: J. Draper – petroleum; J. Smart – metallic and industrial mines/projects; D. Coffey – coal; P. Donchak, L. Hutton, I. Withnall, C. Murray, P. Blake – geology/mineral occurrence; GIS support – J.Tuttle; C. Carniel, E. Abbott – statistics of mine production; R. Huber – geophysics; Dr C. Murray, Sharon Beeston – editorial.

Figure 1 Locality Plan

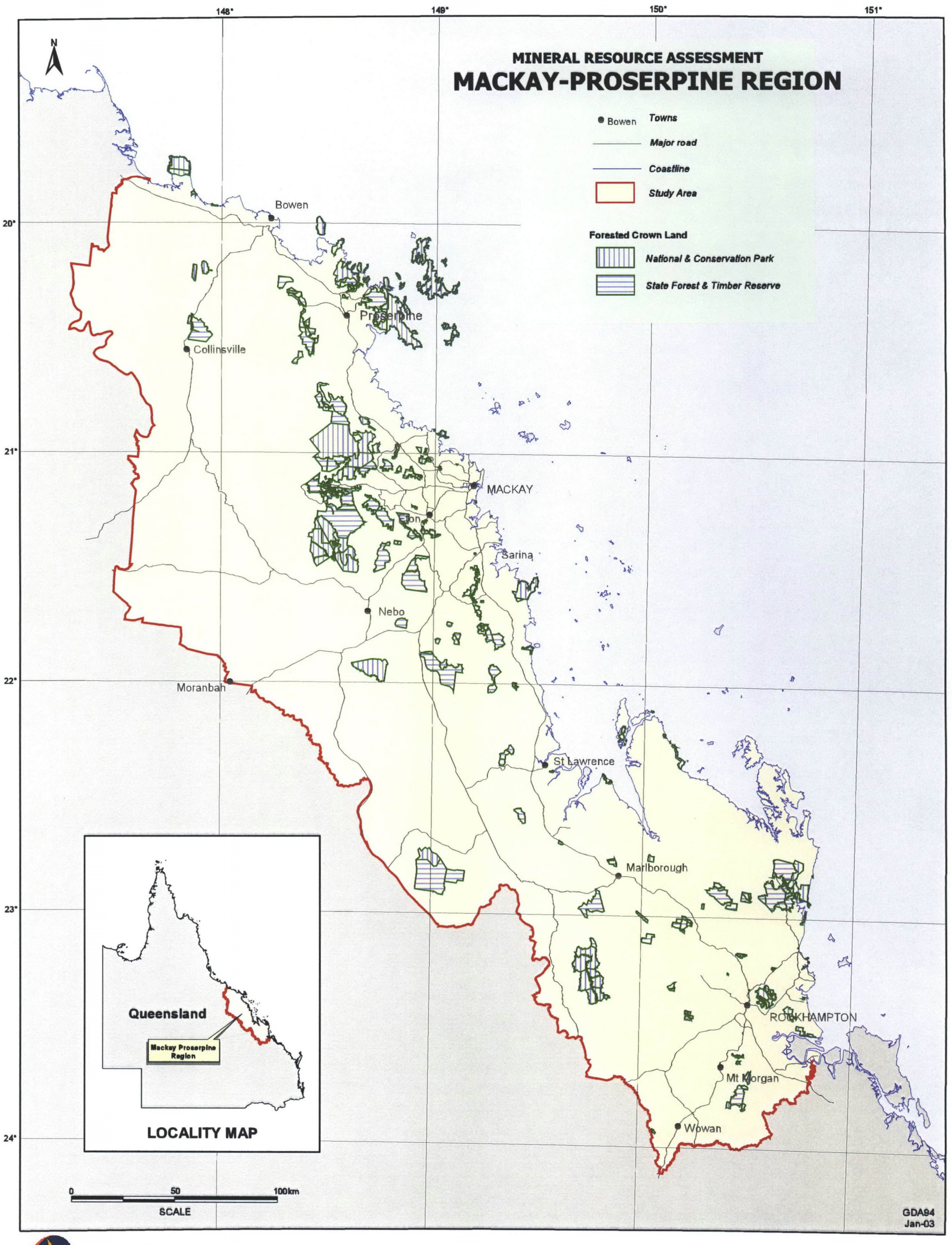

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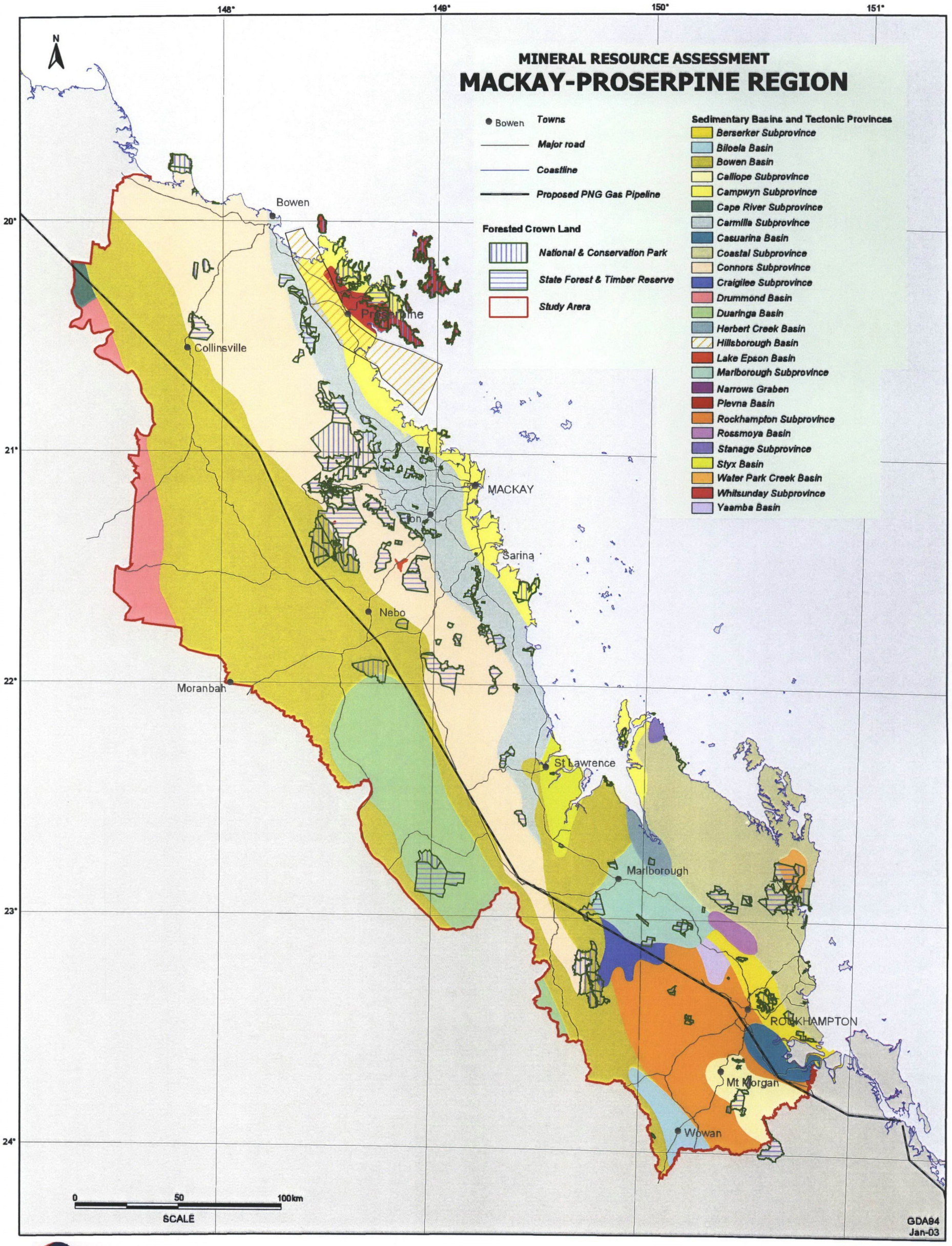
Figure 2: Sedimentary Basins and Tectonic Provinces



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COAL AND PETROLEUM (liquid and gas)

Overview

In Australia black coal and petroleum mining contribute each year:

- **Over $8100 million in output/turnover (some $7650 million of which is generated in Queensland)**
- **Over $1800 million in income to workers and shareholders ($1650 million in Queensland)**
- **Over $3200 million in net additions to GSP, which is equal to 3.5% of total GSP ($3000 million in Queensland)**
- **Support, directly and indirectly, for almost 36000 full-time equivalent jobs (32500 in Queensland)**

Coal is Queensland's highest export earner, and in 2001/02 the industry achieved overseas sales revenue of $8.7 billion. In addition, domestic sales of lower grade thermal coals were worth more than $0.5 billion (ex-mine).

Total production of saleable coal in Queensland was in excess of 148 Mt in 2001/02. During 2001/02 domestic coal sales within the State amounted to 23.7 Mt and a further 84,000 tonnes were shipped interstate. In 2001/02 the Queensland coal industry directly employed in excess of 9,600 people in 42 mines throughout the State (35 located in the Bowen Basin).

During the past 40 years, Queensland producers have developed a diverse range of domestic and export markets providing a range of metallurgical and thermal coal products with 119.2 Mt shipped to 35 countries throughout the world in calendar 2001. Japan is the largest importer of Queensland coals, buying 48.5 Mt representing some 40.7% of the State's coal exports for the year with European countries also major importers, collectively taking 26.9 Mt (22.9% of the State's coal exports for the year). Forecasts are for Australian production levels to reach 275 Mt per annum by 2020 (EIA, 2002), with the Queensland industry having the potential to capture a significant share of this market growth.

In excess of 85% of the Queensland's annual coal production is now obtained from the Bowen Basin of central Queensland by a variety of both open-cut and underground mining techniques. As yet, a relatively small additional tonnage of Walloon coal is also produced for domestic consumption and export (around 4.6 Mt or 3% in calendar 2001) by open-cut mines in the Moreton Basin and Surat Basin in south-east Queensland. Open-cut mines in the Callide and Tarong basins make up most of the remainder of the State's annual coal production (amounting to around 14.6 Mt or just over 10% in calendar 2001) producing coal for domestic power generation.

In fiscal 2001/2002, private expenditure on coal exploration in Queensland increased substantially to $34.1 million, an increase of over 45% on expenditure during the previous fiscal year. On-going coal exploration must be maintained to ensure the long-term viability of the coal industry by enabling it to accommodate future market demands, optimise future development opportunities and maintain cost competitiveness. Access to suitably prospective areas of the State is a key factor in helping to achieve this goal.

Coal mine development is largely driven by market demand, project economics and land availability with elapsed times between discovery and development tending to be long – (typically 5 to 30^{+} years). To this must also be added sufficient time for staged and structured exploration that may eventually lead to a discovery. While the current outlook for the coal industry appears promising, access to suitably prospective land, as well as the timely development of future projects and related infrastructure, will continue to remain key factors to ensure the competitiveness of the industry in Queensland.

Coal exploration activities were sustained at reasonable levels during fiscal 2000/2001, with the majority of work being undertaken in the Bowen Basin. While some regional exploration for shallow coal was undertaken within the central portion of the Basin, the larger mining companies tended to focus activities on and adjacent to their operating mines. In general terms, these activities were aimed at confirming geological interpretations and 'fine-tuning' geological models, increasing confidence in reserve estimates associated with existing operations, as well as delineating additional coal resources for potential longer term development.

During fiscal 2001/2002, companies have continued with regional coal exploration in the central and northern parts of the Bowen Basin, continued with and/or commenced exploration in the Denison Trough adjacent to the Rolleston deposit in the southern Bowen Basin, and made numerous applications for coal exploration permits over much of the Surat and Moreton basins in the south-east of the State.

At present, the majority of the potentially productive coal bearing strata within the Bowen, Callide, Moreton, Mulgildie Styx and Surat basins (east of Injune) are covered by exploration permits for coal as well as other retention and coal mining tenures.

Table 1 **Queensland Coal Inventory 2001 - Summary**

(million tonnes; raw coal *in-situ*)

PERIOD/ Basin	Coking Coal						Thermal Coal						Total
	Opencut			Underground			Opencut			Underground			
	M	I	M+I	M	I	M+I	M	I	M+I	M	I	M+I	
PERMIAN													
Bowen*	3240	400	3640	4340	6970	11310	2300	840	3140	2210	5380	7590	**25680**
Galilee*	-	-	-	-	-	-	1270	950	2220	530	-	530	**2750**
Sub-Total	**3240**	**400**	**3640**	**4340**	**6970**	**11310**	**3570**	**1790**	**5360**	**2740**	**5380**	**8120**	**28430**
MESOZOIC													
Callide*	-	-	-	-	-	-	370	190	560	245	20	265	**825**
Ipswich	-	-	-	-	-	-				480	80	560	**560**
Laura	-	-	-	-	50	50	-	-	-	-	-	-	**50**
Moreton*	-	-	-	-	-	-	1370	1030	2400	15		15	**2415**
Mulgildie*	-	-	-	-	-	-	50	60	110	-	-	-	**110**
Styx	-	-	-	-	-	-	-	-	-	5	-	5	**5**
Surat*	-	-	-	-	-	-	1670	2610	4280	-	-	-	**4280**
Tarong	-	-	-	-	-	-	825	280	1105	-	-	-	**1105**
Sub-Total	-	-	-	-	**50**	**50**	**4285**	**4170**	**8455**	**745**	**100**	**845**	**9350**
	3240	**400**	**3640**	**4340**	**7020**	**11360**	**7855**	**5960**	**13820**	**3485**	**5480**	**8965**	**37780**

M = Measured, I = Indicated *Partly or wholly within Mackay-Proserpine Region

The ***petroleum*** exploration industry in Queensland is seen as having a positive future due to developing gas markets, relatively favourable oil prices, and an expanding pipeline network throughout the State. For 2000/01, gas production was approximately 130 petajoules (PJ) of which 80 PJ were consumed within the State. The remaining 50 PJ were transported interstate to meet the ever-increasing gas demand in south-eastern Australia. The market for gas in eastern Australia is predicted to increase significantly in the next few years as a result of deregulation to enable growth in the interstate trade. Potential shortfalls in supply have been identified, indicating a need to develop additional gas resources. In May 2000, the Government released its 'Queensland Energy policy – A Cleaner Strategy'. This strategy will see the increasing use of gas as an energy source with the Government committed to requiring, by January 2005, that 15 percent of electricity sold in Queensland is derived from gas or renewable energy.

Since the release of the energy policy, agreements have been signed between gas producers and electricity generators for the supply of gas (Scotia to Swanbank; Surat to Swanbank). The construction of the Papua New Guinea to Gladstone pipeline is seen as a means of introducing competitively priced gas into Queensland. The Townsville-Gladstone section of the pipeline will enable development of gas-fired base-load power stations and the establishment of gas related industries (eg Townsville power station, Gladstone alumina refinery). Whilst the pipelines will introduce gas from other sources, it is expected that Queensland's gas resources will also be needed to meet growing demand. Delays to the construction of the pipelines (Timor Sea and Papua New Guinea) are providing an opportunity for gas explorers in Queensland to make and market further discoveries.

Coal seam gas exploration and production is now an established part of the oil and gas industry in Queensland with the first commercial production occurring in 1996. Coal seam gas exploration has increased significantly in the last few years with 30 exploration wells being drilled in 2000/01 compared with one in the previous year. Twenty-four development wells and 19 appraisal wells were also drilled in 2000. The increase in activity results from a combination of new exploration companies with new ideas (eg medium radius drilling), and the availability of markets for coal seam gas.

The establishment of a significant coal seam gas industry will be greatly enhanced if the development of pipelines connecting the Bowen Basin coal fields to existing pipelines is realised. Production is also likely to be increased as aggregation of production and sales is realised through agreements between gas suppliers and energy providers and as new government regulations are put in place.

Shale gases are accumulations that have potential to provide long term reservoirs and importantly have attractive discovery costs. The major exploration risk in most shale gas plays is generally not the drilling of a dry hole, but rather in not obtaining economically viable gas production rates. Shale gas production is not new with commercial gas wells drilled in the United States in the late 1820s, and where today over 28000 gas shale wells produce from 5 basins. Modern gas shale production was spurred in the United States by the Section 29 non-conventional fuels production tax credit, but the tax credit expired in 1992, and operations have continued to expand gas shale productions. However, it is over the next decade that the gas industry is expected to expand the shale gas plays. The combination of increased demand and diminishing supplies of known gas resources in eastern Australia is expected to lead to increased interest in the potential of local basins to host economic shale gas.

The majority of identified ***oil shale*** resources in Australia are located in Queensland with more than 36.7 billion barrels of *in-situ* shale oil identified, equivalent to more than 22 times the remaining identified conventional oil and condensate resources in Australia. Oil is produced from oil shale through the physical or chemical treatment of the rock to break down organic solids into a form that can be extracted as oil. Although oil shale extraction technology has yet to be proven, most of the holders of oil shale deposits in Queensland have applied for mineral development licences so they can retain titles until the technology to economically extract it is developed and the deposits become viable. Whilst there is currently no commercial production of petroleum products from oil shale, the $300 million Stuart Oil Shale Project is located 12km north-west of Gladstone. Stage one of the Stuart project has produced over 500,000 barrels of high quality oil products. Queensland oil shale seams are thick, have a high average yield (91 LTOM), are at shallow depths and close to infrastructure.

Australia produces about 230 million barrels of oil and consumes about 280 million barrels per year, which is unsustainable. Whilst development of an oil shale industry has potential to boost Queensland's oil production by more than 25 percent, it is dependent on the ability of stage one of the Stuart oil shale project to demonstrate its economic and environmental viability.

Mackay-Proserpine Region

The principal ***coal*** bearing basins relevant to the Mackay-Proserpine region are the Bowen (northern, central and eastern portions) and Styx basins. In addition, coal and lignite occurrences within a Tertiary basin in the Waterpark Creek area, north of Yeppoon, and a small basin of Late Permian age containing the Calen Coal Measures north-west of Mackay have also been considered (*Figure 2*).

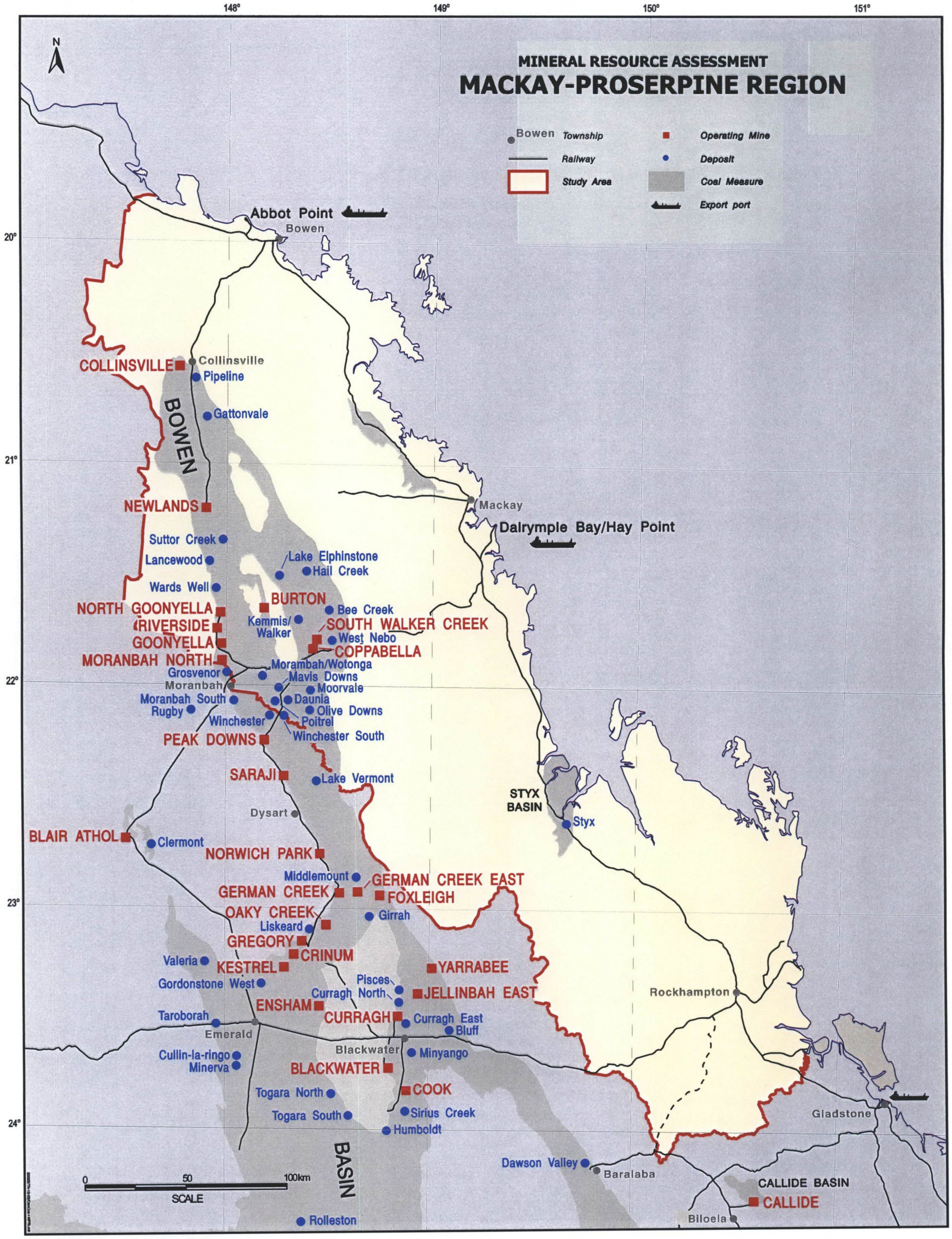
Coal bearing strata occur at numerous stratigraphic levels throughout the *Bowen Basin*. However deposits of economic importance are restricted to four age groups - refer to Appendix 2. Coal seams in the Bowen Basin exhibit variations in rank and quality. A broad pattern of increasing rank of coal within individual formations from west to east is apparent and tends to reflect the effects of depth of burial, although igneous intrusions can locally influence rank. In the eastern part of the basin, the coal rank ranges from low volatile bituminous to anthracitic and deposits are structurally more complex. Coals in the central and north-western part of the basin are medium to high volatile bituminous, and include the best quality coking coals. Structural deformation in these deposits is often relatively mild.
To the central-west and south-west, coal rank falls below the coking range and the most significant deposits are of low ash non-coking coal. These deposits are generally unaffected by major structural complications.

There are now 31 coal mines operating in the Bowen Basin, 9 of which are located within the Mackay - Proserpine area. These are listed in Appendix 2 and shown on *Figure 3*. Most of these operations are expected to have 'life-spans' in excess of 10 to 15 years with some likely to be greater than 20 years.

The *Styx Basin* located on the Queensland coast about 130 km north of Rockhampton, is an elongate geological structure about 40km long by 8km wide which contains the Cretaceous Styx Coal Measures. Exploration undertaken in the basin has established that although there are numerous seams in the sequence, these are generally quite variable in terms of thickness and areal extent. The high volatile bituminous coal has a low sulphur content, a relatively low raw coal ash content and weak coking properties. It is generally considered of an acceptable quality for use as a thermal coal and is strategically located with respect to transport infrastructure and the major coastal towns of Mackay and Rockhampton.

The *Calen Coal Measures* are present within a predominately fault-bounded basin, north-west of Mackay. Prior to 1939, several attempts were made to mine seams from the coal measures, which crop out in two areas totalling approximately 240km^2, although these were relatively short-lived. The low-volatile bituminous coal is contained in relatively thin, banded seams that are locally affected by intrusions and faulting. Inferior coal quality, prevailing geological conditions and limited areal extent of the coal measures, make the probability of discovering a potentially significant deposit within the area extremely unlikely.

Figure 3 Operating Coal Mines



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The *Waterpark Creek* Tertiary lignite deposits occur in a north-west trending sedimentary basin of relatively limited areal extent (approximately 65 km^2) located about 40 km north of Yeppoon on the central Queensland coast. The fault-controlled basin contains several lenticular seams of soft, dark brown lignite interbedded with oil shale with recorded thicknesses of up to 6.4m. In the late 1940s, open-cut mining was attempted from a coal outcrop in Valentine Creek but was discontinued due to the inferior quality of the coal.

Figure 4 defines potential coal resources within the Mackay-Proserpine Region as 'High', 'High-Medium', 'Medium' or 'Low'. Ranking of regions has been determined using the following criteria:

High: In general terms this category refers to those areas of the known coal bearing measures located within the Mackay - Proserpine area that are considered to have the highest potential for future coal mine developments or expansions and greatest exploration potential. The areas selected in this category are those:

- containing identified coal resources (the term *'identified coal resources'* refers to coal resource estimates which have been reported to either 'Measured' or 'Indicated' Status in accordance with Galligan and Mengel, 1986); or
- currently covered by granted mining tenures or applications (*'mining tenures'* refers to both mining leases and mineral development licences).

Medium-High: This category applies to the Bowen Basin only and is assigned to areas that are outside known coal deposits or areas currently held under mining titles and Exploration Permits for Coal (including applications). These areas contain coal-bearing measures that are considered to be the most prospective for seams that may have development potential in the short to medium term (<15 years).

Medium: Areas assigned to this category are within the known extent of prospective coal bearing measures but occur outside identified coal deposits or granted mining titles. They are also considered to be prospective for seams having potential for development in the longer term (>15 years). Most of the areas assigned this status within the Bowen and Styx basins are presently covered by either a granted Exploration Permit for Coal or an EPC application.

Low: This category has been assigned to areas considered to have either a low exploration potential for prospective coal measures **or** those areas containing coal bearing measures which, due to geological constraints or other modifying factors, are not considered be prospective for coal seams having development potential in the foreseeable future.

Based on the above criteria, the following priorities have been assigned to the Bowen Basin (northern, central and eastern margins), Styx Basin, Calen Coal Measures and Waterpark Creek area within the Mackay - Proserpine region.

The currently identified underground and open-cut coal deposits within the Bowen Basin where development within the short to medium (<15 year) and longer term (15 to 25^+ years) is considered a reasonable possibility are presented in the tables below. These areas are assigned as having **high potential**:

Table 2: Possible underground mine developments – short to medium term

Mine	Tenure	Owner	Comment
*Newlands North	ML4754, 4774	MIM	Feasibility study completed. Initial development work to commence in 2003.
*Goonyella	ML 1763 MDL 307	BHP Billiton, Mitsubishi	Experimental drifts have been developed to lease boundary. Project remains under review.
Grosvenor	MDLs 273, 274	Anglo	Adjoins company's Moranbah North mine. Deposit extent lies partly within the Mackay-Proserpine Area
Grasstree	ML 1831	Anglo	Under development as replacement for dwindling reserves at Southern Colliery
Ensham	MDLs 217, 218	Idemitsu	Still considerable open-cut available
Togara North	MLA 70149, 70162	Togara North Joint Venture	Thermal coal

* Within Mackay - Proserpine Area

Table 3: Possible underground mine developments – long term (>15 year timeframe)

Mine	Tenure	Owner	Comment
*Burton/Kerlong	MDL 315 & ML 70109	RAG	Underground extraction unlikely until open-cut reserves are depleted
*Wards Well	ML 1790	BHP/Mitsui	Coking coal
Moranbah South	MDL 277		Coking coal
Togara South	MDL (Appl'n) 340	BHP Billiton, Mitsubishi	Thermal coal
Humboldt	MDLs 155, 189	BHP Billiton, Mitsubishi	Thermal coal
Moura	MLs	Anglo/Mitsui	Coking coal
Dawson	MDL 216	Anglo	Thermal coal

* Within Mackay - Proserpine Area

Table 4: Possible open-cut mine developments - short to medium term

Deposit	Tenure	Owner	Comment
North Bowen Basin			
*Hail Creek	ML 4738	Rio Tinto	Under construction – Production planned for late 2003.
*Moorvale	EPC, MLA	Macarthur Coal	Lease applications lodged - Development by 2003 anticipated
Clermont	MLs 1884,1904	Rio Tinto	Replacement for Blair Athol (from 2006).
*Suttor Creek	ML 4761	MIM	Replacement capacity for Newlands open-cut coal
*Burton	MLs, MDLs	RAG	Satellite shallow deposits to be developed adjacent to current mining operation.
*Daunia	MLs1781, 70115	BHP Billiton, Mitsubishi	
*Poitrel	ML4749	BHP Mitsui	
Unnamed	EPCs	MacArthur Coal	Exploration of other deposits (eg Olive Downs) south and east of the Coppabella Mine in progress with a view to sequential development as markets and economics allow.
Various unnamed	EPCs	Various	Possibility also exists for some small scale open-cut operations being developed by other small mine developers (eg unnamed areas held by Millennium Coal and Mount Robert Coal).
Central and Southern Bowen Basin			
Rolleston	MDL 227, EPCs		Feasibility study in progress – bulk sampling commenced with development of a large scale open-cut planned from 2003
Girrah	MDL	Wesfarmers	Augment coal supply to the Curragh operation
Pisces	MDL 162	Stanwell Corporation	For long term supply of Stanwell Power Station
Theodore/Dawson	ML 5657, MDL 216	Anglo/Mitsui	JV keen to progress as part of combined Moura - Theodore operation

* Within Mackay - Proserpine Area

A large portion of the Styx Basin has recently been covered by an application for a coal exploration permit (EPC No 822). While the currently estimated tonnages of coal within the Styx Basin are small, there is considered to be some potential for the discovery of additional resources. A medium priority for protection has consequently been assigned to the basin. Areas

of the Bowen Basin within the Mackay-Proserpine region classified as medium priority mostly comprise untenured ground within the known extent of the prospective coal measures. These include areas in the north of the basin, where the prospective Permian coal measures are concealed at depth below younger (mostly Triassic) sediments such as in the vicinity of Mount Coxendean south-east of the Poitrel deposit and the Kerlong and Carborough Ranges east of the Burton mine.

The following portions of the Bowen Basin within the study area have been assigned as low potential:

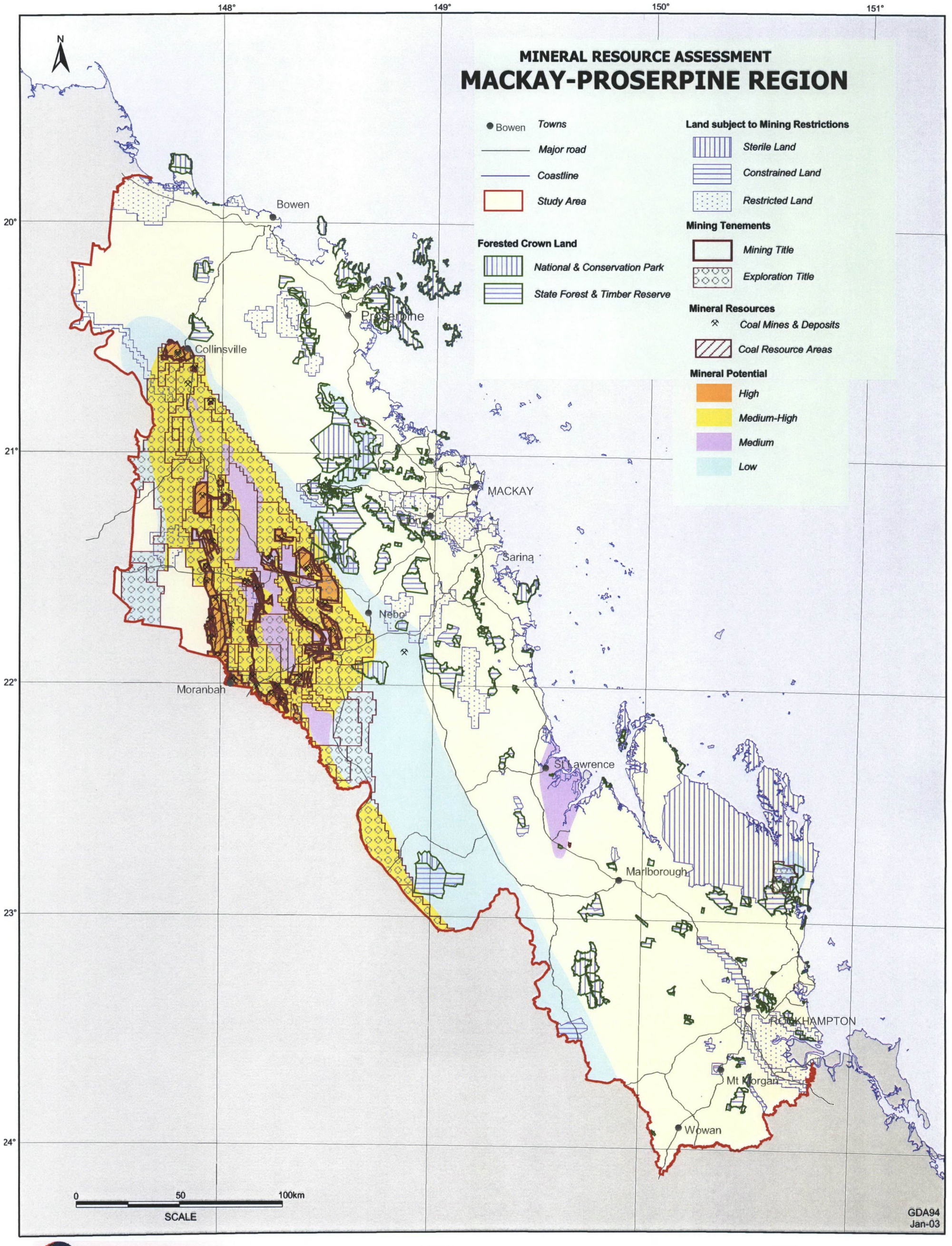
- the area covered by EPC 660 and EPC applications 659 and 770 straddling/adjacent to the western margin of the northern Bowen Basin. Due to the lack of adequate geological information in this part of the basin, ***a low*** level of prospectivity rather than a 'not prospective' or 'non-permissive' status, has also been assigned to the area of the EPC applications which occurs beyond the depicted extent of the basin, until the results of exploration suggest otherwise.
- The area situated between the eastern extent of the Basin's current EPC coverage and the Connors Arch – although little is presently known about the coal geology in this part of the basin, there is still considered to be some prospectivity for future coal discoveries.
- The area where the basin is concealed by and extends at depth beneath the Tertiary Duaringa Basin - (note that the Duaringa Basin has been assigned a medium priority due to its oil shale potential).

In the far north of the Basin, coal bearing strata of Early Permian age (informally referred to as the 'Crush Creek Coal Measures') are also known to occur beyond the mapped extent of the Collinsville Coal Measures. Only limited exploration of these strata (which occur within the Lizzie Creek Volcanics) has been undertaken and the coal occurrences located in this area to date have been found to be relatively thin and of poor quality. While future exploration in this area cannot be ruled out, the probability of locating significant deposits is considered to be very low to negligible.

To the north-west of Mackay, EPC 733 presently covers an area of 4 sub-blocks (approximately 12 km^2) over a portion of the Calen Coal Measures. The Calen Coal Measures, however, are considered to lack significant exploration potential owing to their limited occurrence and unfavourable geology (ie relatively thin seams, faulting, and intrusions), and consequently are assigned a low priority for protection.

The Waterpark Creek area, now partly covered by an EPC application (No716) has also been assigned a low preservation priority owing the area's relatively high conservation value that is considered to outweigh the rather limited potential for development of the lignite occurrences in the area.

Figure 4 Potential Coal Areas



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There is no significant potential for conventional ***petroleum*** production within the Mackay-Proserpine Region. However, in today's energy mix market, alternative sources of petroleum gas are increasingly being sought. Prior to late 2000, the Permian Bowen Basin was the major target for ***coal seam methane*** explorers and producers. However the combination of new markets and advances in technology has resulted in significant expansion in exploration, and exploration licences now also cover the Hillsborough Basin in the Mackay-Proserpine Region.

CH4 Pty Ltd has been exploring in the Bowen Basin within the Mackay-Proserpine region, and in November 2002 announced that it had tripled its reserves within its PL191 petroleum lease (212 PJ of 2P reserves). CH4 has contracted to supply gas to the Townsville Power Station from July 2004.

The majority (95%) of coal seam gas exploration and development currently occurs under the *Petroleum Act 1923*, but the utilisation of coal seam gas produced in association with coal mining is also being actively considered. Presently the only coal mine producing gas is Moura. The other underground mines, all in the western Bowen Basin, are remote from pipelines and their gas production is either vented or flared. However, over the past few years greenhouse gas concerns have become a powerful driver for the capture and utilisation of methane associated with coal mining. There is now a strong focus on pre-draining of gas from the surface in advance of mining to produce a pipeline quality gas.

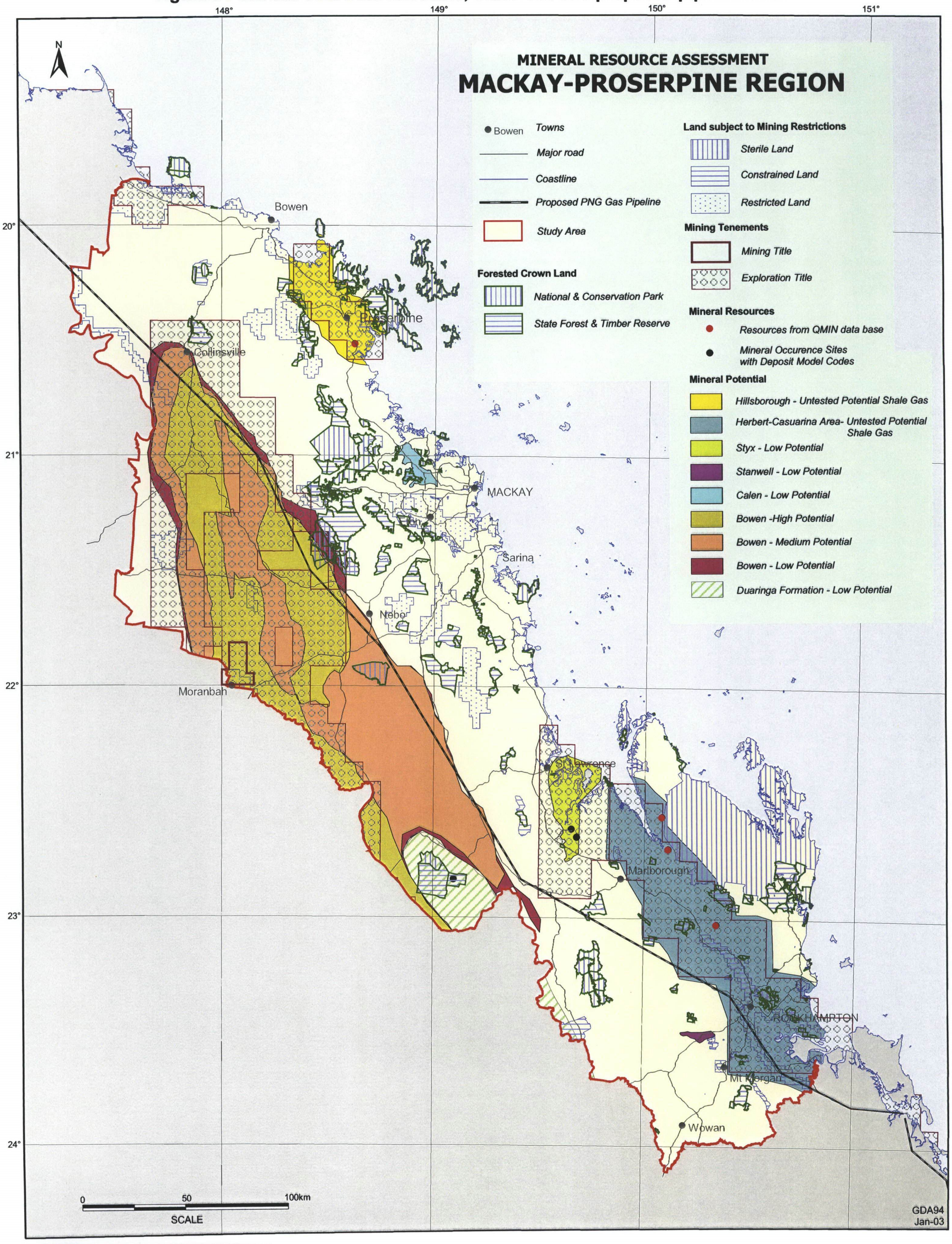
The criteria used to classify areas in terms of coal seam gas potential are: Low - coal present <100m or >1000m; Medium: - coal present >400m <1000m; High - coal present >100m <400m.. Prospective rock units in the Bowen Basin are identified as Blackwater Group - Moranbah and Rangal Coal Measures, German Creek Formation, Bandanna Formation and Reids Dome beds. In the Hillsborough Basin the prospective rock units are referred to by the informal name of the Hillsborough beds.

Shale gas is recognised to occur in the assessment area but the extent of its potential remains untested.
Refer *Figure 5* – Areas of coal seam methane gas and shale gas potential and proposed pipeline access routes within Mackay-Proserpine Region.

There is also very significant ***oil shale*** potential in six Tertiary basins adjacent the coast in the Mackay-Proserpine Region: the Hillsborough, Herbert Creek, Water Park, Rossmoya, Yaamba and Casuarina Basins. Exploration has also been conducted in Tertiary basins further inland at Plevna and the northern half of Duaringa. Oil shale is also known to occur within the study area in the coal measures in the Bowen Basin. The principal Permian resource is the Alpha deposit, which despite having the highest average oil yield in the State, is considered to have low potential for economic development because of its small size (90 million barrels) and inland location.

The Tertiary oil shales were deposited in shallow freshwater lacustrine environments and are comparatively soft, with moisture contents of around 20 to 30 percent. Compared to United States oil shale resources (over 2 trillion barrels – Smith 1980), Queensland oil shales are soft, easy to mine and have few impurities. They also consist of thick seams, are at shallow depths and are close to infrastructure. By virtue of their grade, size and location, the Tertiary deposits within the Mackay-Proserpine region have considerable potential for early development – dependent on the development of economically viable extraction technologies.

Figure 5 Potential Coal Seam Methane, Shale Gas and proposed pipeline route



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The Condor deposit (EPM 3520, MDL(A) 202) is located south of Proserpine and whilst not as high yielding as Stuart it is the largest proven deposit of oil shale in Queensland (9.7 billion barrels at an average yield of 66 LTOM). The deposit lies within the Hillsborough Basin, which extends offshore under Repulse Bay. Intensive exploration studies were undertaken in the early 1980s including the major Condor Oil Shale Feasibility Study by Japan Australia Oil Shale Corporation. Work over the last few years has involved characterisation and comparative mineralogy processing studies.

Herbert Creek Basin contains over 600m of Tertiary sediments. The Boundary Lagoons-Fernlea (MDL 196, EPM 3469) resource area lies in the north-eastern part of the basin and has an inferred resource of 860 million barrels. The Block Creek resource area (MDL 197) is located in the southern part of the eastern limb of the Herbert Creek Syncline and has an inferred resource of 670 million barrels of shale oil to a depth of 270m (Matheson, 1992).

The majority of the oil shale resource in the Yaamba deposit (MDL 197, EPM 3470) is contained within the lower part of the Yemeappo Formation, the Pink Lagoon Formation and the upper part of the Calioran Formation. A total resource of 4.14 billion barrels has been estimated.

Duaringa oil shale resource (tenured under MDL 297, EPMs 3459, 10622 in the Mackay-Proserpine region) has an inferred resource of 4.1 billion barrels. A small resource, the Plevna deposit, has been identified north-west of Nebo. The exact extent of the deposit is unknown due to coverage by overlying volcanic rocks, however the shales have been described as of a low-grade type (Reid, 1942). It is not currently tenured.

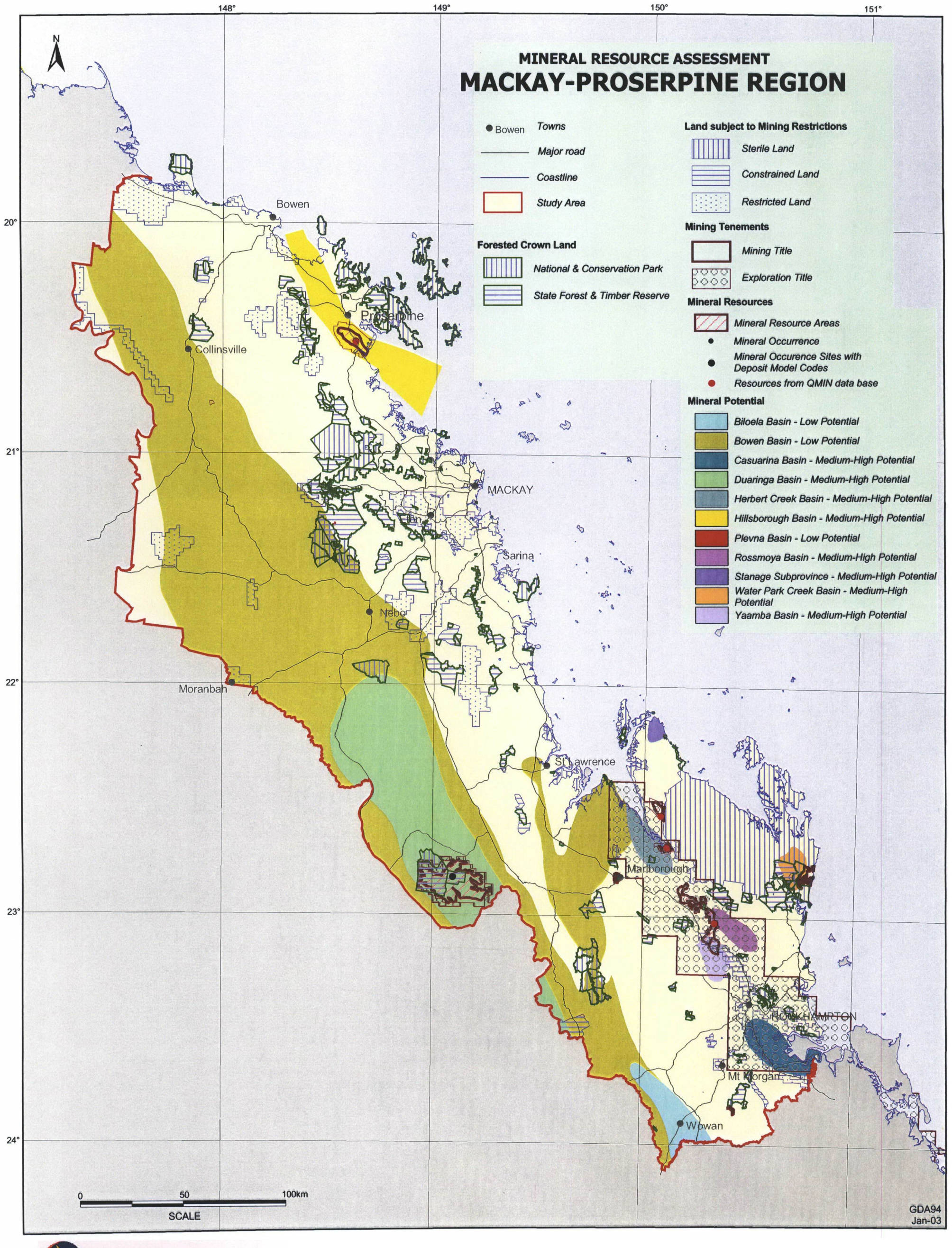
The criteria used in this assessment to define potential are based on distance from infrastructure, size and quality of deposit. Tertiary basins close to the coast contain the oil shale deposits most likely to be exploited in the next decade. However, ultimately the potential for future development of oil shale in Queensland is very dependent on the success or otherwise of the Stuart Oil Shale Project.

The assessment defines oil shale resources within the Mackay-Proserpine Region as of 'High-Medium', 'Medium' or 'Low' potential.

1. High-Medium: Condor, Duaringa, Herbert Creek, Yaamba, Hillsborough, Water Park Creek, Rossmoya and Casuarina Basins – currently held as MDL192, 196, 197, 202, 279, 297; EPM 3459, 3469, 3470, 3520, 13228. These basins contain significant resources that may have potential for eventual development in the short to medium term (<15 years).
2. Low: Both the Biloela and Bowen Basins as well as the Plevna resource are considered to have low potential for oil shale resources. All are located in inland basins and some distance from infrastructure. In the case of the Biloela Basin the area has been extensively explored for oil shale and although present, seams were too deep and too thin to be considered to have economic potential. In the case of Plevna, exploration investigations considered the basin too small to have economic significance. Whilst no specific oil shale resource has been defined in the Bowen Basin, with the exception of Alpha, there remains some limited potential for oil shale amongst known coal resources.

Figure 6 defines the main areas of potential for oil shale in the Mackay-Proserpine Region.

Figure 6 Oil Shale Potential



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Conclusions:

- Areas identified as having medium-high potential are only present within the Bowen Basin and correspond to areas currently held either as EPCs or as an EPC application. The Byfield State Forest (5, 8, 15,16,18-26, 28-34) is intersected. The Styx Basin is identified as having medium potential. Two Conservation Parks occur in the basin: Tooloombah Creek Conservation Park (5817) and Newport Conservation Park (5766).

- Large areas of the Mackay-Proserpine Region are also identified as having high or medium potential for ***coal seam gas*** or ***shale gas*** production (tenure for shale gas is held over the Styx Basin and extending south-east). An important difference from petroleum is that coal seam gas can currently be explored for and developed under both the *Mineral Resources Act 1989* and the *Petroleum Act 1923*. It is anticipated that an outcome of the current review of the Petroleum Act is that coal seam gas will be covered legislatively and administratively solely by this Act. Relevant to the Mackay-Proserpine assessment is that, compared with conventional hydrocarbon fields, drillhole spacing for coal seam gas is less and water management is a significant issue that may restrict development within Category A and B Conservation Areas depending on the environmental management process currently being finalised by the Environmental Protection Agency (EPA). The following forested areas are intersected: Cape Upstart National Park (4945), Drylander National Park (4981, 4999, 5041), Drylanders State Forest (4998), Conway State Forest (5024), Conway National Park (5054), Proserpine State Forest (5033, 5043, 5047, 5052).

- The North Duaringa ***oil shale*** deposit, Hillsborough, Herbert Creek, Yaamba, Water Park, Rossmoya and Casuarina Basins are rated as high-medium potential. Junee National Park (5866) and Junee State Forest (5919, 5950) are intersected.

INDUSTRIAL MINERALS

Overview

This section covers a diverse group of minerals: limestone, magnesite, mineral sands, salt and clays.

Industrial minerals and gems contribute each year:

- **approximately $240 million in value of output/turnover ($225 million of which is in Queensland),**
- **over $50 million in additional factor incomes (mostly in Queensland),**
- **approximately $100 million in net additions to GSP, and**
- **over 2000 full-time jobs supported (mostly in Queensland).**

Limestone is the second largest non-metallic mineral produced in Queensland with production of 2.6Mt valued at $26.4 million in 2000/01. Limestone is used in cement production, as a flux in zinc, copper and lead smelting and as raw material in glass manufacturing. The Sun Metals zinc refinery in Townsville uses about 1000t of lime (calcined limestone) at its facility. Other uses of limestone are as an aggregate, in agriculture, as a filler, in asphalt, paper, paint, rubber and plastics extrusion, and as dust stone in underground coal mines. Lime is used in the aluminium, sugar and building industries, in water treatment, for road stabilisation, and gold and base metal processing. New uses for limestone are emerging in mineral processing, waste-water treatment and environmental rehabilitation.

The demand for limestone is related to economic activity, particularly when it is associated with growth in the construction and industrial sectors. Demand is forecast in the short-term to parallel industrial growth but in the medium and long-term several major projects in the State and the Pacific region could increase demand significantly.

Magnesite metal is a lighter-weight, higher-strength alternative to aluminium, consequently it is gaining interest world-wide with a large number of new magnesium metal projects under consideration in Australia. Although no commercial metal is currently produced here, Queensland is leading the field with the Australian Magnesium Corporation Limited (AMC) successfully producing magnesium metal from its Gladstone demonstration plant. AMC has commenced construction of the $1.3 billion Stanwell magnesium project (February 2002) with first metal scheduled for the December quarter of 2004. The Stanwell magnesium project will employ 1300 engineers and construction workers and 350 staff when operational. Stage 1 of the project is anticipated to produce 97,000t of magnesium and magnesium alloys for use predominately in the automotive industry. The Stanwell plant will be both the largest magnesium producer in the world and among the lowest cash cost producers.

Project stakeholders include CSIRO with a royalty interest and the Ford Motor Company with a 10 year 45,000tpa sales agreement. In addition to its sales agreement with Ford, AMC has a research alliance with VAW Aluminium AG of Germany. VAW is the world's largest supplier of aluminium engine blocks to the automotive industry. A report by Deloitte Touche Tohmatsu early in 2000 indicated the potential for $4.6 billion in project investments over the next decade in the Stanwell-Rockhampton-Gladstone area, providing 2500 direct jobs and contributing an additional $2 billion a year to Gross State Product. The proposed Stanwell Industrial-Energy Park will be significant to the central Queensland light metals hub, encompassing a range of magnesium, aluminium and manufacturing industries between Rockhampton and Gladstone.

The world magnesia market is about 8Mtpa with more than 75 percent being used in refractory applications, principally by the steel industry. World demand for magnesium is expected to more than double by 2010, with major applications being die-casting, aluminium alloying and desulphurisation. The outlook for Queensland and its high quality magnesite is positive, with the potential to capture increased market share by displacing lower quality macrocrystalline magnesite-based products and higher-cost synthetic magnesia in the international market. Continued market development is anticipated for downstream processed magnesite product – magnesia, magnesium hydroxide and magnesium metal. Calcined magnesia sales to buyers within Australia, New Zealand and South-East Asia rose 31.8 percent to a record level of 55,583t. Another development in downstream processing of magnesite is the Flamemag flame retardant project (50 percent owned by AMC and 50 percent by the French group, Mines de la Lucette). Flamemag aims to produce flame retardant products for the plastics industry. Demand for this product is being driven by environmental concerns over the current use of halogens, which evolve corrosive and toxic fumes during combustion.

Queensland's ***mineral sands*** production will continue to be underpinned by CRL's North Stradbroke Island operation for the foreseeable future with probable reserves as at December 2000 of 1.994Mt of rutile, 1.642Mt of zircon and 6.452Mt of ilmenite. Production in Queensland of titanium minerals (ilmenite, rutile) is valued at about $58 million. A new project under development, the Goondicum Crater, has identified potential offshore markets for its ilmenite product and globally it will partly fill the gap caused by the closure of BHP's Beenup operation in Western Australia.

Queenslands salt production for 2000/01 was 245,400t, valued at $22.5M. Cheetham Salt Ltd produces salt by seawater and groundwater brine evaporation at Bajool, Port Alma and Bowen.

Mackay-Proserpine Region

Limestone is produced in the Mackay-Proserpine Region at Ben Lomond Hill (ML10228) and from adjacent unnamed mining leases (ML10160, 10161) in the Edgecoumbe Beds, and from Mount Etna, with a resource of 70Mt (ML 340). The Caves area, including the Mount Etna limestone, is the closest high quality resource to Rockhampton and is of economic significance in the short to medium term. There was considerable opposition to the mine in the early days of development, particularly concerning the possible effects quarrying would have on the Bent Wing Bat population. The matter was resolved with quarrying ceasing on the eastern face in favour of a new quarry on the western side and the central zone being gazetted as a National Park. A large portion of the original resource became unavailable but access remained to sufficient resources to supply the company's plant at Parkhurst. However, the depletion of workable resources may result in consideration of resources in the area in Unallocated State Land that currently is situated to the immediate east, north and west of the National Park, which the company currently holds under mining lease.
The prospectivity of the Ben Lomond area is highlighted by the number of MLs held (1012-14, 10121, 10187, 1038, 1062-63, 10228, 10235).

The demand for limestone products is likely to increase in the medium to long term with major proposals of mineral value adding projects in Queensland and in the Pacific region. In the short-term there will be continued demand for milled products for the underground coal mines of the Bowen Basin as well as ground limestone for stock feed and agriculture. EPM 13804/ML80103 and EPM12796 (delineating prospective resources at Home Hill and Glenroy) are held by Marlborough Nickel Pty Ltd with the intended use stated as a reagent for nickel-cobalt extraction. A number of MDLs, MLs and EPs are

located on the eastern boundary of the Back Creek Group (MDL318, 319/EPM 13490 and ML 6532 near the Sundown mine) and in the Mount Alma Formation of the Yarrol Province (MLs 5763,-68, 5804 over the Marmor deposit).

Earthy lime has been produced from Emu Creek (ML4776, 4783) and Plain Creek (ML 4777) from Early Permian Mount Benmore Volcanics and is the result of dissolution, precipitation, and concentration of calcium and magnesium carbonate from the weathering and decomposition of basic lavas. The earthy lime has been used as an agricultural additive.

The Mackay-Proserpine Region has the world's largest known deposit of high purity, nodular cryptocrystalline ***magnesite***. AMC's Kunawarara deposit (EPM 9728, MDL 256, MLs 80067, 5868-70) 65km north-west of Rockhampton in central Queensland contains an inferred resource of around 400 million tonnes of magnesite in shallow, flat-lying sediments. A proved and probable resource of 118.6Mt of ore containing 33.7Mt of magnesite. This resource will feed the Stanwell magnesium processing plant, a significant part of the central Queensland light metals industry. The adjoining Yaamba tenements are beneficially owned by Acacia Resources Ltd, and which contain a further 100Mt of magnesite. The deposits are derived from ultramafic rocks. The combination of Kunwarara-Yaamba's size and purity makes it unique. Cryptocrystalline deposits elsewhere in the world are commonly small, while the larger deposits are usually of the macrocrystalline variety and are generally of lower quality.

Other deposits of cryptocrystalline magnesite occur in the Kunwarara district and include: Herbert Creek (MDL 194); Marlborough (MDL 120, 6) - with an inferred resource of 77Mt; Lowville – Princhester (EPM 13475, 13459 and ML 6605, 5831-32, 55775-79, 5845, 80069); unnamed MDLs (MDL 195, 198, 256, 302); and unnamed MLs (ML 5779, 5831-32, 5844-45, 5868-71, 6605, 7132). Mt Grace Resources NL recently announced that it has negotiated an option agreement to purchase the MLs covering the Princhester magnesite deposit, located 95km north of Rockhampton (5.4Mt of high grade magnesite). Mt Grace views the deposit as an alternative to its Bachelor deposit in the Northern Territory, and is in response to delays in development of the Timor Sea gas fields and the construction of a pipeline. Mt Grace has recently extended its option with up to four 3 month extensions until September 2003. Magnesite sales in 2000-01 totalled 41,300t, which included a bulk export shipment as part of a 10-year contract with a North American customer, and sales to the Gladstone magnesium demonstration plant and to other customers for agricultural applications.

Heavy ***mineral sand*** resources are known within the Mackay-Proserpine region in strandline beach ridges and dunes held under MLs 7624-7628 by Pivot Mining. Byfield is a proposed dredging operation of 18.6Mt of ilmenite, 1.3Mt rutile and 3.5Mt zircon held under ML 80005 by RZM Pty Ltd. Byfield has conceptual estimates of capital investment of about $1 billion dollars, employing over 750 people and having an anticipated operating life over 25years. East and north of Byfield there are a number of mineral sand MLs including ML 55806, held by BHP Titanium Minerals Pty Ltd and ML 7624-28 held by Pivot Mining NL. Exploration tenure (EPM 11850) covers the abandoned Abbot Bay operation, which targets magnetite in heavy mineral sands within Quaternary coastal sediments for use in coal washing. This area is described in the Geology of the Ayr 1:250 000 Sheet Area (Paine *et al*, 1970) as ' a thin blanket of dark blue-black ilmenite-magnetite sand that has concentrated from gabbro which crops out nearby.....The old beach dune inland from the present beach contains a considerable portion of dark minerals; the grade is much lower than in the sands on the beach, but the deposit is much larger'.

Monto Minerals NL has mineral sand (ilmenite and titano-magnetite) resources near Mt Goondicum, 30km east of Monto. The $65 million Goondicum project conducted a successful pilot plant trial to establish techniques to treat tailings and provide concentrates for synthetic rutile pilot plant test work. Whilst this project is outside of the assessment region, Monto Minerals

has also reported a measured and indicated resource of 4.05Mt of mineral sand-bearing alluvium in the upper Burnett River (MLA80040), and at Eulogie Park (EPM 9541) that are considered to be very similar to that at Goodicum, both of which occur in the Mackay-Proserpine Region

Salt is produced at the Bowen Salt works via evaporation of seawater and at Port Alma from evaporation from both seawater and underground brine water. Both operations are considered long-term. Cheetham Salt Limited holds tenure in the area (MLs 5783-85, 5787, 5790, 5796-99, 5822). Exploration for additional sources of salt brines is occurring within the Port Alma district under EPMs 12447, 12448, and 13228.

The Mackay-Proserpine Region has both operating mines and identified future resources of ***dimension stone***. Ulam Marble is a quarrying operation in the Erebus Beds (MLs:3662-3663, 3666, 3638, 5810-5812, 5814, 5825, 5827, 5884-85, 80028) and the Stanwell Quarry (ML 7341 also referred to as the Scotsman's Folly deposit) and nearby ML 80102 are located in Precipice Sandstone. MLs for dimension stone are also held in the area over parts of the Gracemere Gabbro (MLs 5800, 80043), Quarry Gabbro (ML 7529, 80055, 80056, 80076), Kabra Quartz Monzodiorite (ML 7390), unnamed Permian microgranite on the Bowen 1:100 000 Sheet (ML 10058), and the Mount Salmon Volcanics (ML 5818, 5819, 5828).

The Queensland Resources Industries Review Series – Building Stones (Tresize, 1990) listed the following quarries as abandoned or as having sporadic production and rock units as having future potential: Allan's Quarry, Lucas Street Quarry and Table Mountain located in intrusive rock units of the Bouldercombe Complex; Marble Mountain and Cedric Mountain in the Capella Creek Group with potential for building stone slabs and terrazzo chips; Mount Larcom Quarry producing limestone that is in part recrystallised to marble from Erebus Beds; Mount McDonald Slate located in Back Creek Group.

Tenure for clay production is held by Clifton Brick Pty Ltd (ML4728, 4735, 4763, 4772, 4778), Central Queensland Cement (ML 5786), Monier PGH Holdings Limited (ML 5793, 5842) and Bouldercombe Brickworks (ML5836, 5840, 5855).

Figures 7A-8A show the spatial relationship between prospective rock units, current EPMs (including applications), known mineral occurrences, and State Forest, Timber Reserve and Forest Reserve. Figures 7B-8B identify regions in terms of their prospectivity.

Prospective regions are described as either:

1. High: areas of known resources that are considered to have the greatest exploration potential and highest potential for future developments or expansions (ie having identified resources or covered by granted mining tenures or applications).
2. High-Medium: areas outside known deposits or mines currently held as EPs (including applications). These areas either contain or are near known mineral occurrences.
3. Medium: areas that contain prospective rock units, but are not closely associated with known mines or mineral occurrences; or where isolated EPMs occur at considerable distance from what are identified as prospective rock units in this report.
4. Low: areas that contain prospective rock units but due to a combination of factors (such as quality, proximity to established infrastructure or other modifying factors), are not considered to be prospective in the short to medium term.

Conclusions:

- Areas of high-medium potential areas (including EPM 1850, 9541) intersect Abbott Bay Resources Reserve (4946). Areas of high-medium potential also extend into Mount Hopeful Conservation Park (226), Byfield National Park (6,17,22), Five Rocks Conservation Park (14) and Cape Upstart National Park (4884, 4945).

- Areas of high potential for the occurrence of future limestone resources (including ML5765-68) are identified adjacent the Mount Etna Caves National Park. Resources are available in Unallocated State Land that currently is situated to the immediate east, north and west of the National Park, which the company currently holds under mining lease. Areas of high and medium-high potential also extend into North Pointer Conservation Park (74).

Figure 7A Geological Units with Potential for Mineral Sands, Clays and Dimension Stone

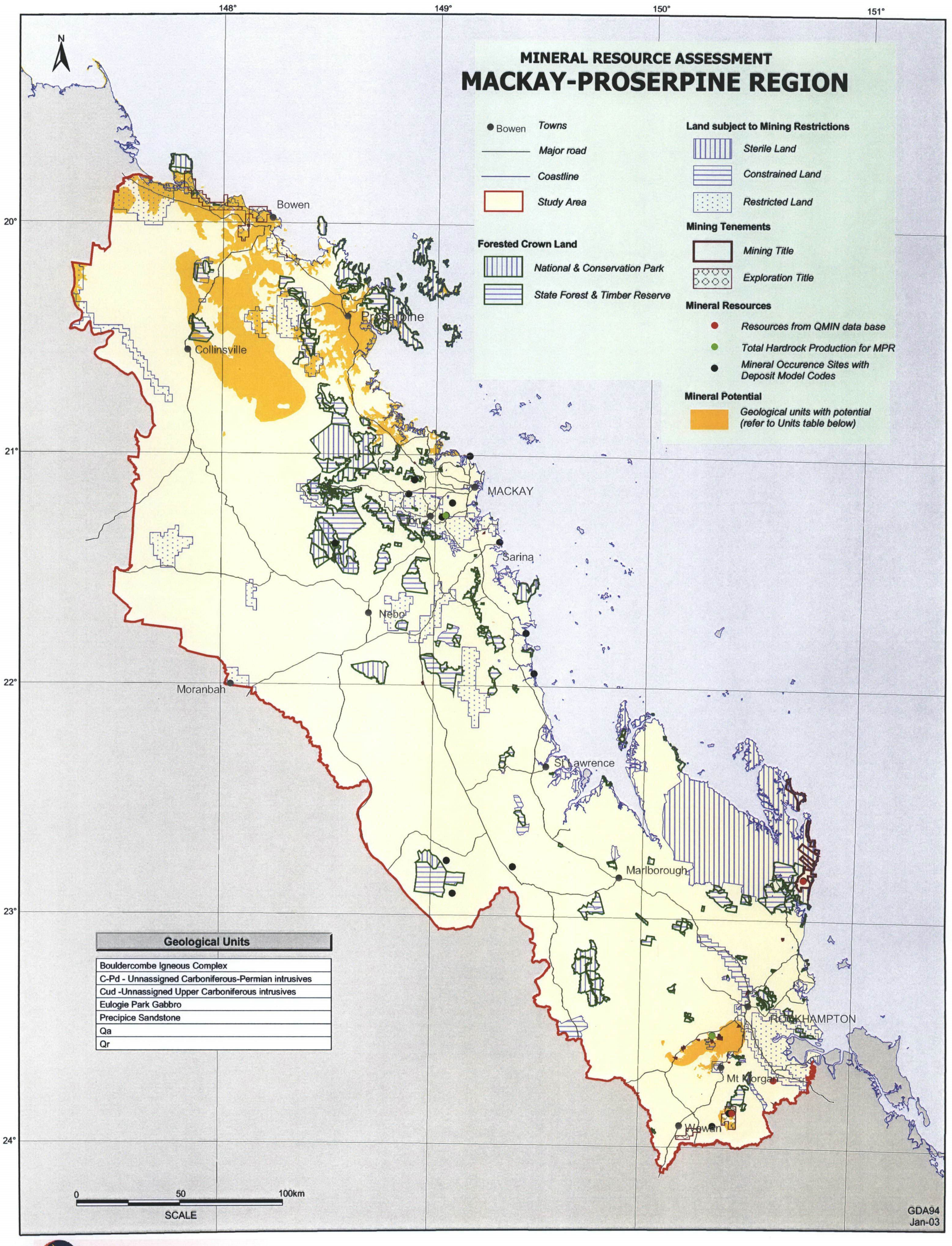

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Figure 7B Potential for Mineral Sands, Clays and Dimension Stone

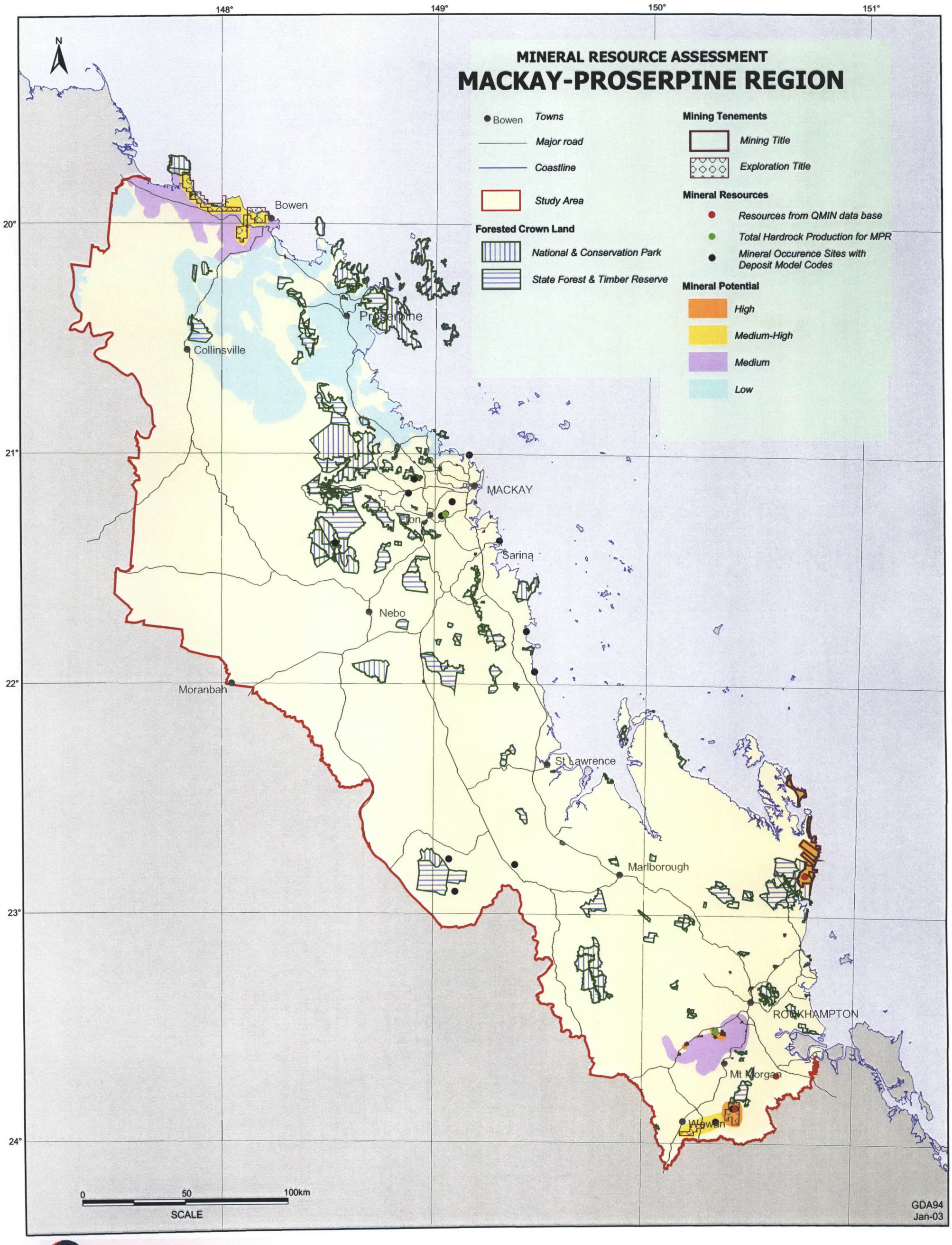

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Figure 8A Geological Units with Potential for Limestone, Earthy Lime and Magnesite Deposits

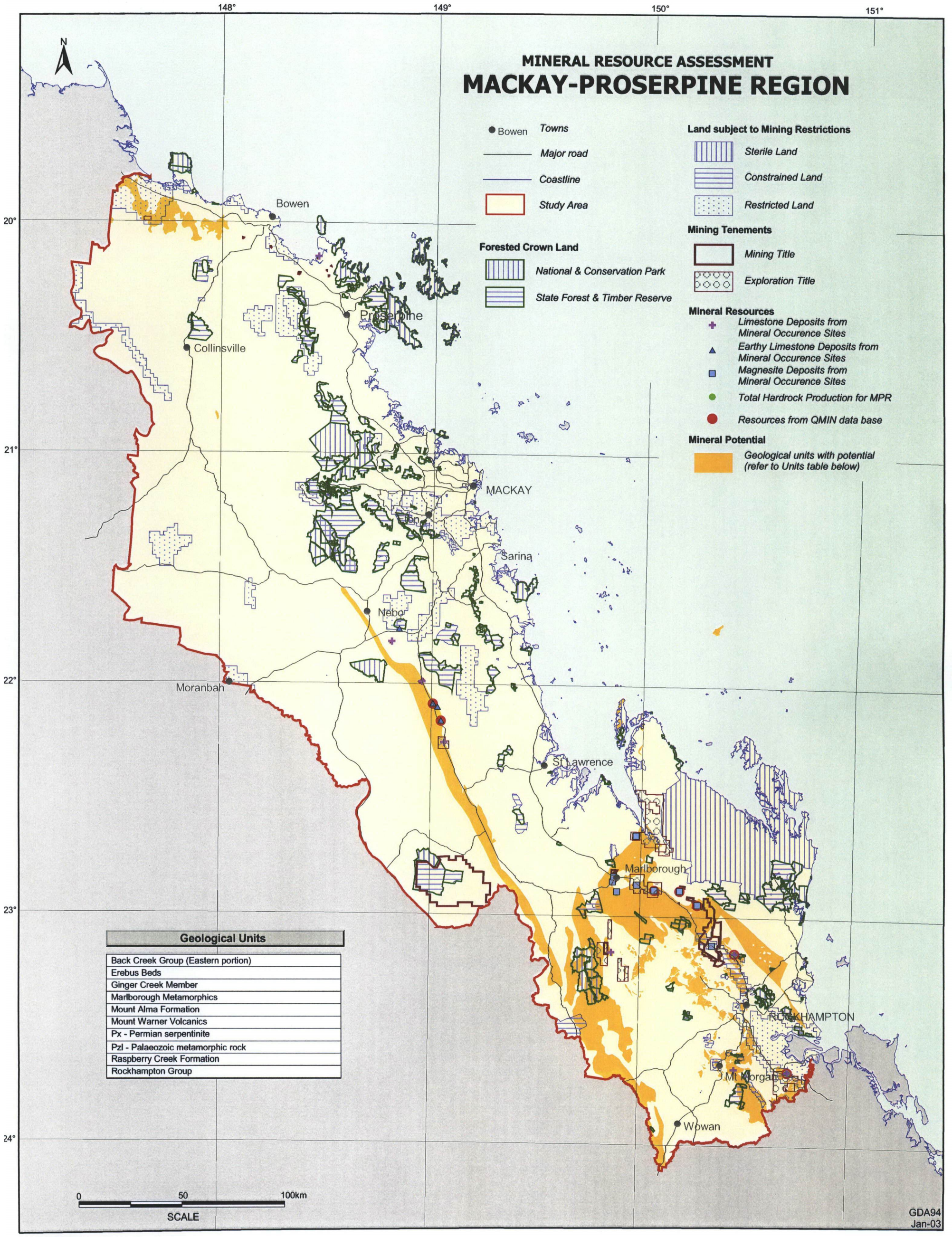

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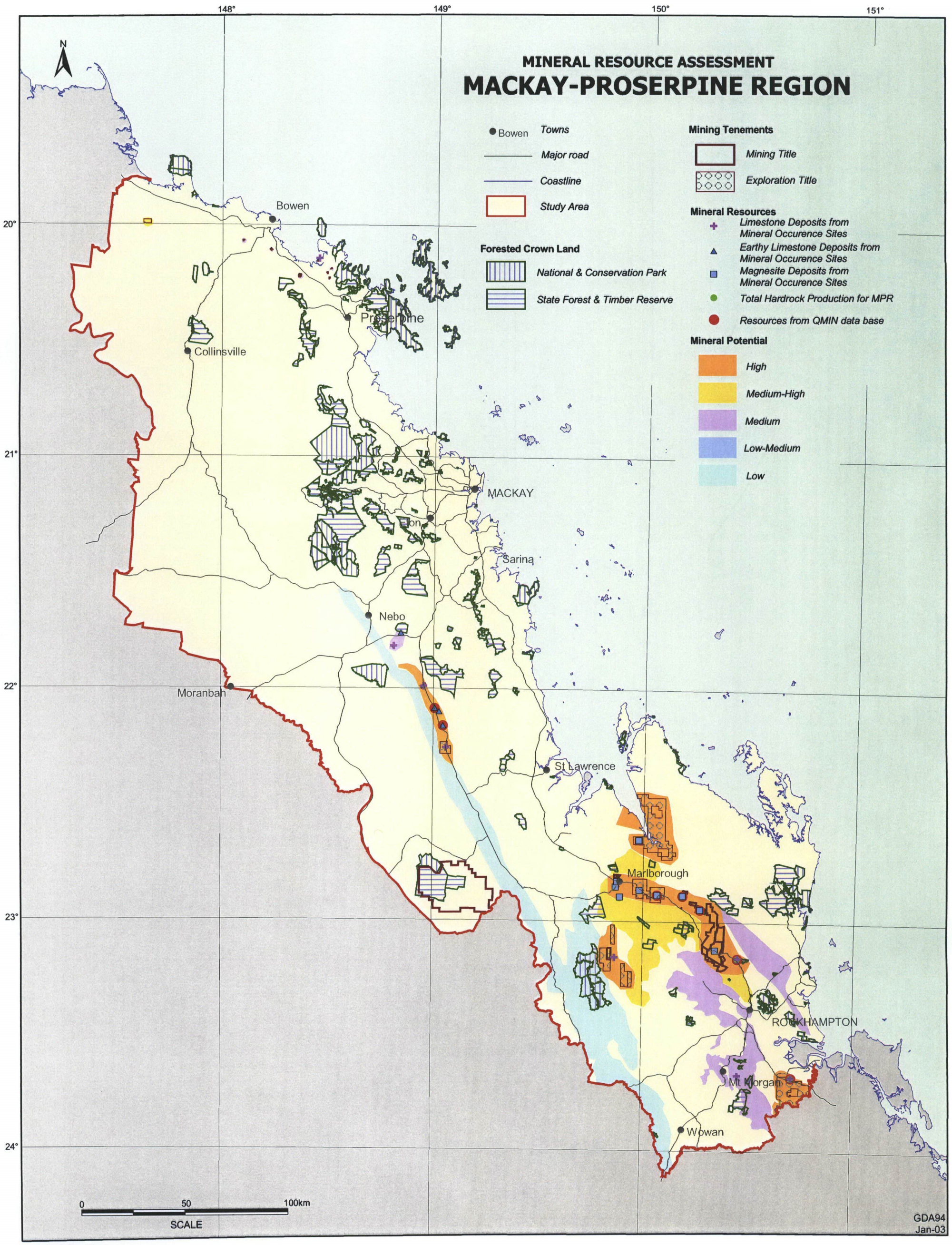
Figure 8B Potential for Limestone, Earthy Lime and Magnesite Deposits



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METALLIC MINERALS

Overview

The following section discusses gold, base metals (copper, lead, zinc, silver), nickel-cobalt and platinum group metals (PGE).

The second major component of the mining industry in Queensland is the metals sector. Each year this sector contributes:

- **over $4600 million in output/turnover ($4400 million in Queensland),**
- **$1200 million in income to workers and shareholders ($1150 million in Queensland),**
- **$2300 million in net additions to GSP ($2150 million in Queensland), and**
- **20300 full-time jobs, directly and indirectly (19100 in Queensland).**

Queensland is Australia's second-largest ***gold*** producer with a value of approximately $395 million for 2000/01. Total annual demand for gold has increased with the effects of 11 September 2001. This trend in overall demand is due to investment buying, resulting from gold's status as a safe-haven commodity in times of world political instability. The price of gold during 2001/02 remained low, averaging $551.62. However, many major gold producers have developed strategies involving new business units related to gold that are intended to stimulate demand through direct access to a number of gold-product markets.

During 2000/01 Mount Leyshon and Kidston, Queensland's former premier gold producers, ceased mining operations after depleting all known resources. These closures will result in the loss of about 500 000oz of gold production per year, which will be only partly offset by new production from Mount Rawdon. Whilst additional resources of gold were identified at Mount Rawdon, Gympie and Cracow/Klondyke, the medium future of gold production will depend on the discovery of new ore bodies. This is of concern in view of the last 6 consecutive years of falling exploration expenditures for gold, suggesting that Queensland's future rate of discoveries of deposits for development is likely to remain low.

Queensland's export earnings in 2000/01 for ***base metals*** (silver, lead and zinc) mining were $820 million, with the majority of production coming from the north-west region. Whilst Queensland should remain Australia's leading producer of copper, silver, lead and zinc over the medium-term, the State's base metal operations are expected to close or be near the end of their economic life in the next two decades unless new ore reserves are found. New discoveries are essential to sustain the viability of these Queensland industries over the long-term. As the large deposits of the north-west have now been developed it is likely that new base metal projects will be medium-sized mines. New discoveries are expected to be more evenly distributed across the state and will come on stream more slowly because of low metal prices and delays caused by native title claims.

The short-term outlook for ***nickel-cobalt*** mine production in Queensland is not certain. Weakening world economics and falling demand for stainless steel have seen nickel prices drop to less than 50% of their cyclic highs in the past 18 months. Cobalt prices have also been driven down by falling demand and recent supply growth. QNI remained the State's sole producer of nickel and cobalt and production was from imported ores processed at its Yabulu refinery near Townsville. A feasibility study of the Yabulu expansion project continues. However, progress on Queensland's nickel-cobalt projects is slow. Preston Resources Ltd's $688 million Marlborough Nickel lateritic nickel-cobalt project is on hold awaiting project

finance. Development of cost-effective, front-end processing technology for treatment of lateritic ores, possibly using atmospheric acid leach technology, and the availability of spare refining capacity at Yabulu may be needed before remaining resources in the State are economically developed.

Platinum group elements (PGE) are not commercially produced in Queensland.

Mackay-Proserpine Region

Relevant to the assessment of the Mackay-Proserpine Region is that by 2015 much of the State's known base metal and gold resources will be exhausted. It is anticipated that small to medium scale base metal and gold mines under appraisal and discoveries yet to be made, will contribute to the State's wealth in the medium and long-term. The rocks of the Mackay-Proserpine Region are highly prospective for base metals and gold. Deposits found in this region to-date have generally been in the small to medium size range, with the exception of the world class Mount Morgan gold-copper deposit (102 Mt ore). This abandoned mine was a major producer of gold and copper and is generally considered to be a volcanogenic massive sulphide deposit hosted by the middle unit of the Capella Creek Group. The upper parts of the Craigilee Beds, which occur within the assessment area, can be correlated by age and rock types with the Capella Creek Group, and therefore are considered to have potential to contain equivalents of the host rocks of the Mount Morgan gold-copper deposit.

In the assessment area there are three known epithermal-style gold deposits: Crush Creek (resources < 100,000 oz gold), hosted by Lizzie Creek Volcanics and equivalent units, is currently held under EPM 9937; Mount Mackenzie (indicated resource of 2.9 Mt of ore), located in Mount Benmore Volcanics, is held under EPM 10006; and the Zelda Gold Prospect (inferred resource of 85000t ore), located in the Campwyn Volcanics, is held under MDL 11. A number of significant epithermal gold deposits are also known to occur outside of the assessment region and importantly are hosted in rock units or equivalents that extend into the region. These include the State's main ***gold*** producers: Pajingo (hosted in undifferentiated Devonian-Carboniferous volcanics, probable equivalents to the Silver Hills Volcanics) and Cracow/Klondyke (hosted in Camboon Volcanics). The sub-economic Moonmera porphyry deposit also occurs in the assessment region and is held under MDL86, ML5594 and EPMs 13491. This deposit is located in the Permo-Triassic Moonmera Porphyritic Granodiorite, part of the Bouldercombe Igneous Complex.

The most extensive identified resources of nickel and cobalt in Queensland fall within the Mackay-Proserpine Region in the Marlborough district, north-west of Rockhampton, where serpentinised peridotites have undergone lateritic enrichment. The only mining in the area has been at Brolga, the largest and richest of the eastern group of deposits, from which QNI Pty Lt treated 620,000t of screened ore from 1993-95, averaging 1.59 percent nickel and 0.14 percent cobalt. QNI produces a range of high-purity nickel and cobalt products at its Yabulu refinery. The plant has a production capacity of 30,000tpa of nickel and 2,000tpa of cobalt, which is currently imported from New Caledonia, Indonesia and the Philippines.

The combination of known world-class deposits, favourable tectonic settings and rock units known to host a number of economically significant deposit styles (eg epithermal, volcanogenic massive sulphide) highlights the exploration potential of much of the Mackay-Proserpine Region. There are numerous EPs granted within the assessment region (refer *Figures 9A-15A*). *Table 5* summarises deposit models, associated rock units and source of the model.

Table 5 DEPOSIT MODELS AND PROSPECTIVE ROCK UNITS FOR GOLD MINERALISATION IN MACKAY-PROSERPINE

Deposit Model	***Rock Unit/type***	***Model Source***
Epithermal	*Undivided Late Devonian - early Carboniferous volcanics (equivalent to Silver Hills Volcanics), Silver Hills Volcanics, Camboon Volcanics*	*eg Crush Creek, Mount Mackenzie – active prospect, mine*
Potential Epithermal	*Silver Hills Volcanics, Bulgonnuna Volcanics, Camboon Volcanics, Torsdale beds, Mount Wyatt Formation, Three Moon Conglomerate, Torsdale Volcanics, Chalmers Formation, Mt Salmon Volcanics, Winterbourne Volcanics, Owl Gully Volcanics, undifferentiated Lower Permian volcanics*	*eg Waitara South, Kuala Lumpur – mineral occurrences*
Potential Gold-Silver-Telluride Veins	*As above*	*USGS Bulletin 1693*
Hydrothermal veins	*Intrusives and surrounds eg undifferentiated Permo-Triassic intrusives*	*eg Pinevale, Anglo Saxon – abandoned mine*
Alluvial/Placer and Deep Lead Placer	*Alluvium*	*eg, Mount Victoria Group – abandoned operation*
Potential/Alluvial Placer and Deep Lead Placer	*Alluvium*	*eg Drainage from Mount Hector Goldfield*
Porphyry type (Copper-Molybdenum-Gold; Copper-Gold)	*Surrounds and within intrusive bodies eg Unnamed Granodiorites/Diorite,*	*eg Moonmera – subeconomic deposit*
Potential Porphyry type	*Surrounds and within intrusive bodies eg. unnamed Permo-Triassic Intrusives, Cretaceous intrusives;*	*Company Exploration models*
Gold Skarn	*Intrusives and limestone/calcareous contact rocks (eg Rockhampton Group)*	*Ridgelands, Hector, Mystery – abandoned mine, Company exploration model*
Potential Sediment-hosted (gold)/Homestake	*Silver Hills Volcanics, Bulgonnuna Volcanics*	*Company Exploration model WHR*

Potential Low Sulphide Gold Quartz Veins/Turbidite hosted Gold/Listwanite	*Wandilla Formation, Doonside Formation, Calliope beds, Erebus beds, Marble Waterhole beds, Mt Dick beds, Mt Warner Volcanics, Raspberry Creek Formation, Shoalwater Formation; Anakie Metamorphic Group, Serpentinised ultramafics, Mount Alma Formation, Craiglee beds*	*eg Mount Cassidy – abandoned mine*
Low Angle Fault Hosted	*Erebus beds, Mount Alma Formation, Calliope beds, Doonside Formation*	*eg.Duke of York, Mount Holly, Mount Raglan, Mount Hiron – abandoned mine*

A number of alluvial gold operations occur in the southern portion of the Mackay-Proserpine Region suggesting potential for similar deposits in nearby drainage channels. The Geology of the Proserpine 1:250 000 Sheet Area (Clarke and Paine, 1971) suggests potential for alluvial gold deposits in Quaternary sediments derived from the Proserpine and Andromache Rivers which drain the Mount Hector Goldfield and the eastern half of the Normanby Goldfield and the abandoned but rich Dittmer mine.

Figures 9A-15A show the spatial relationship between prospective rock units, current EPMs (including applications), known mineral occurrences, and State Forest, Timber Reserves and Forest Reserves. Figures 9B-15B identify regions in terms of their prospectivity. Deposit models that are genetically associated with intrusive rock units, but may occur some distance from the intrusive body (eg porphyry, skarn, hydrothermal veins, polymetallic veins), have prospective rock units defined on the basis of a 'buffer' around the intrusive. A 1 km buffer has been used for porphyry and skarn deposit models and for the more distal hydrothermal deposit types a 3 km buffer was used.

In delineating prospective rock units an inclusive approach has been taken. For example, it is recognised that some preferred relationships exist between pluton age and certain deposit types (eg copper-molybdenum porphyries tend to occur in Permo-Triasssic granitoid intrusives). However, these relationships have important exceptions, and serve only as a general guide. To apply these generalisations would exclude areas that may in fact be prospective (eg south of the assessment area the Burns Spur porphyry prospect is located in the Cretaceous Burns Spur Nepheline Monzosyenite). Consequently, in this assessment, all intrusive bodies within the Mackay-Proserpine Region are considered to have potential to source hydrothermal and skarn deposits, and all granitoid intrusives are considered potential sources for porphyry deposits.

Prospective regions are described as either:

1. High: areas of known resources that are considered to have the greatest exploration potential and highest potential for future developments or expansions (ie having identified resources or covered by granted mining tenures or applications) or where there is numerous indicators suggesting high potential for undiscovered resources (ie co-incidental mineral occurrences, EPs and prospective host rocks).
2. High-Medium: areas outside known deposits or mines but containing currently held EPs (including applications). These areas either contain or are near known mineral occurrences.

3. Medium: areas that are outside known deposits or EPs but contain prospective rock units, and are closely associated with known mines or mineral occurrences; where isolated EPMs occur at considerable distance from what are identified as prospective rock units in this report; or where magnetic interpretation suggest prospective rock units under cover that considered to be under-explored.

4. Low: areas that contain prospective rock units but have no other indicators of mineralisation.

Figure 9A Geological units with Potential for Sediment-hosted Gold and Homestake-type Deposits

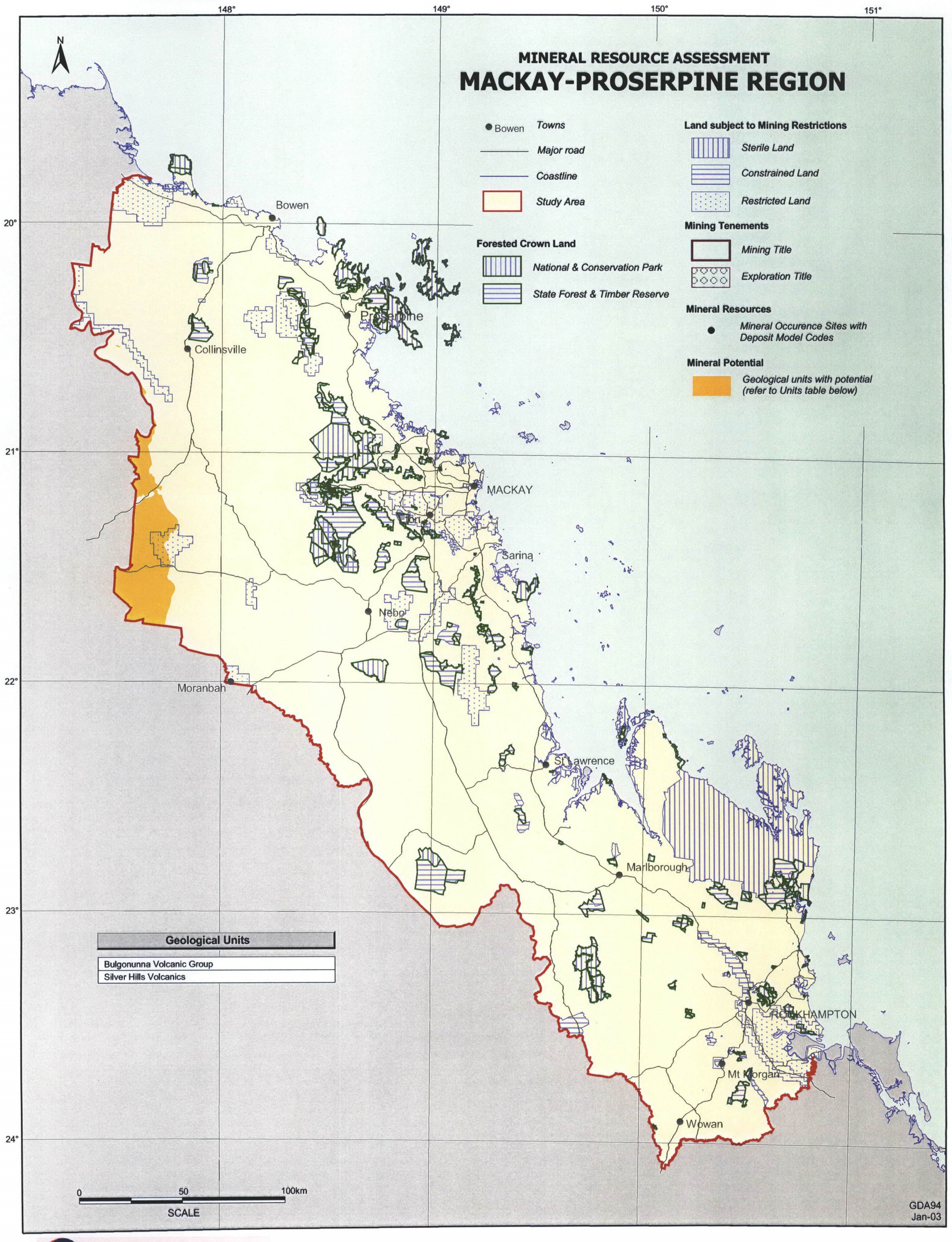

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Figure 9B Potential for Sediment-hosted Gold and Homestake-type Deposits

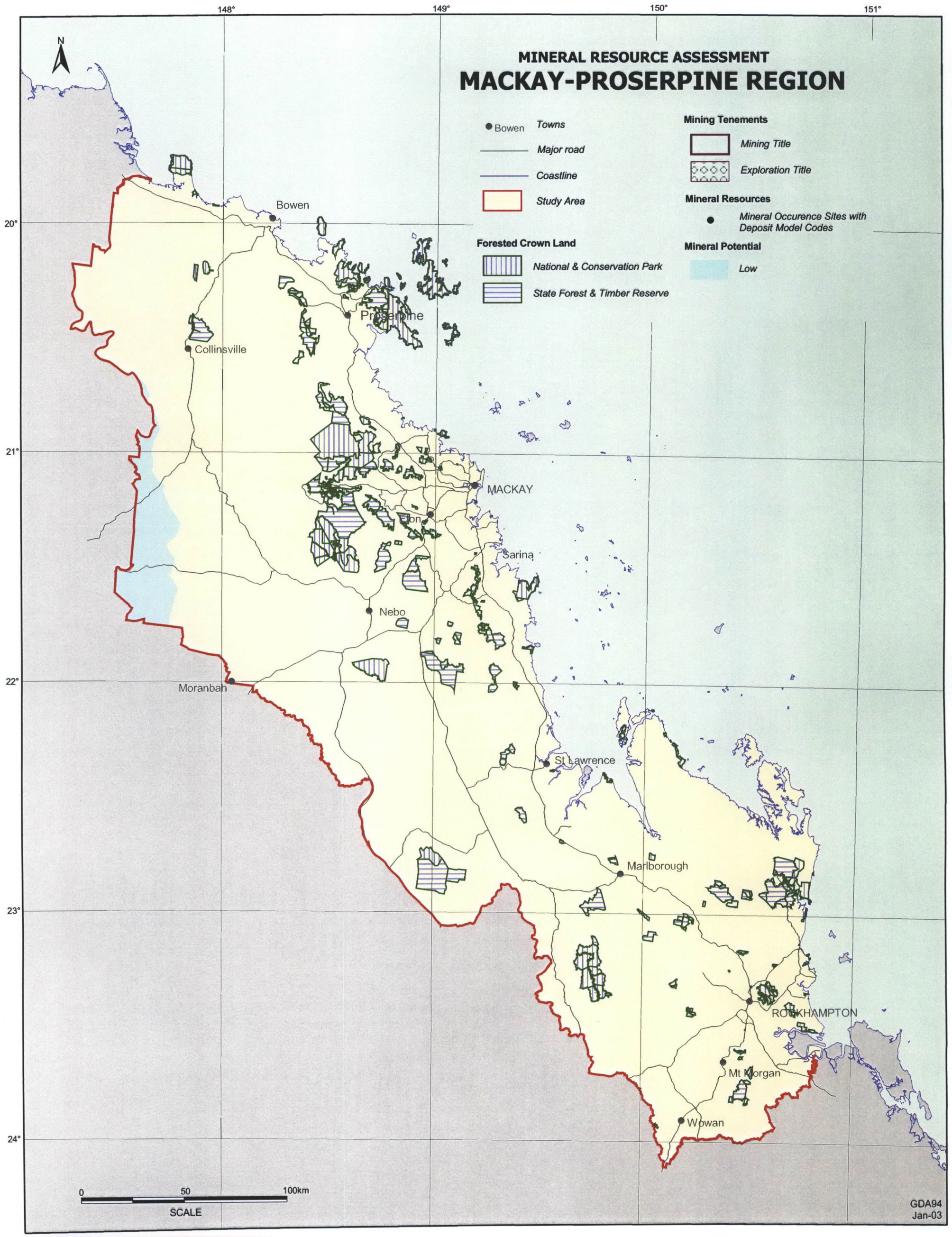

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Figure 10A Geological Units with Potential for Replacement-type Gold Deposits - Skarn

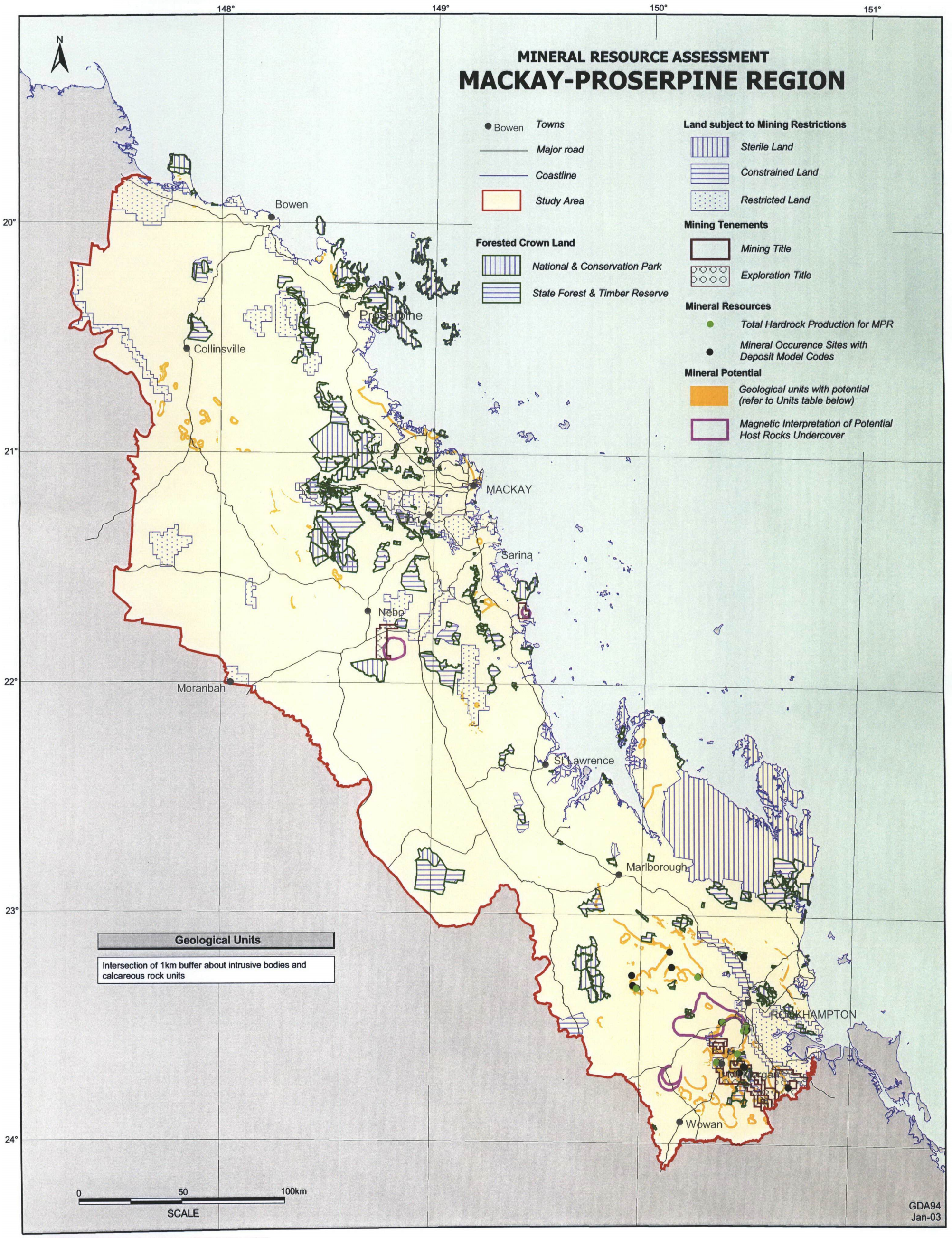

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Figure 10B Potential for Replacement-type Gold Deposits - Skarn

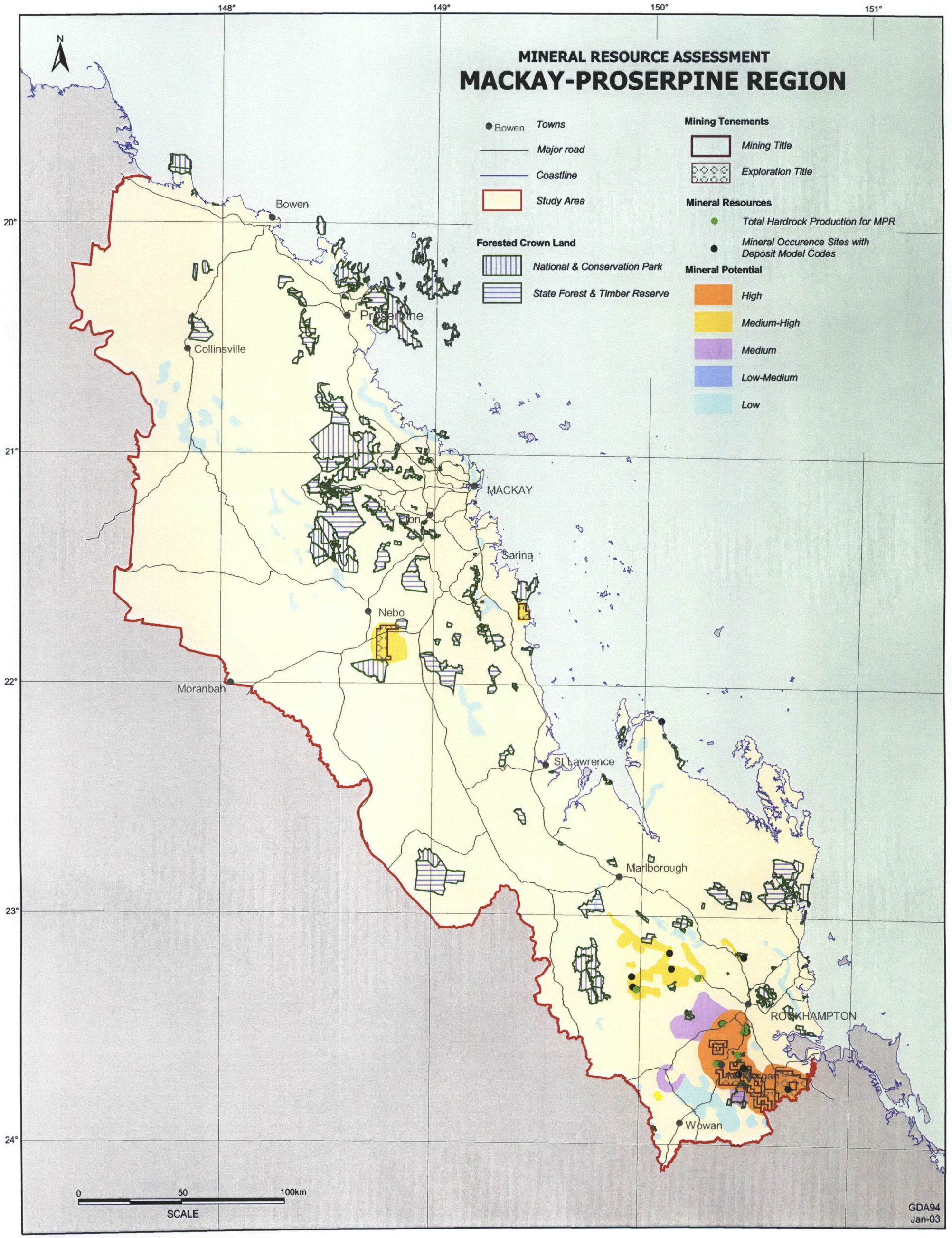

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Figure 11A Geological Units with Potential for Epithermal Deposits

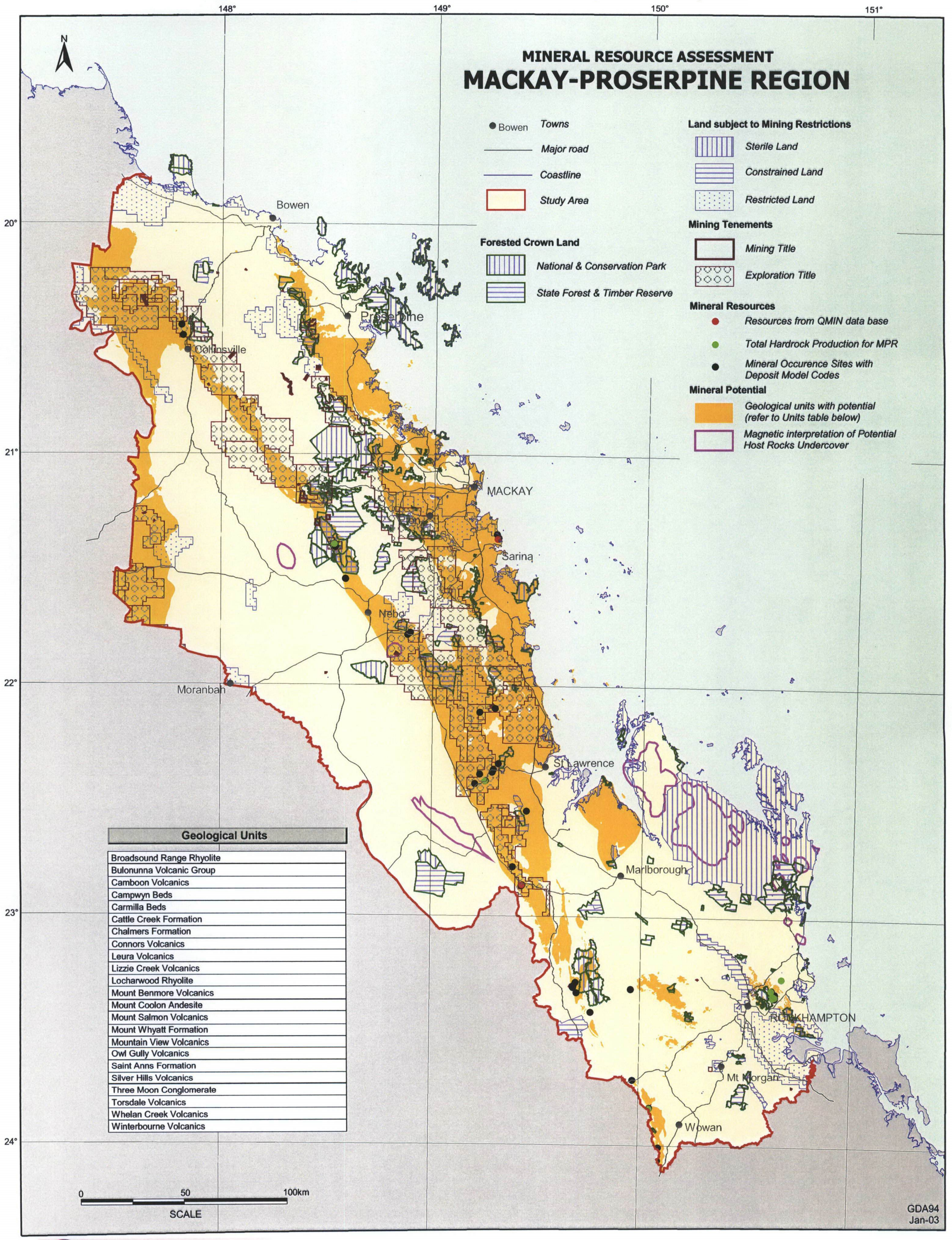

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Figure 11B Potential for Epithermal Deposits

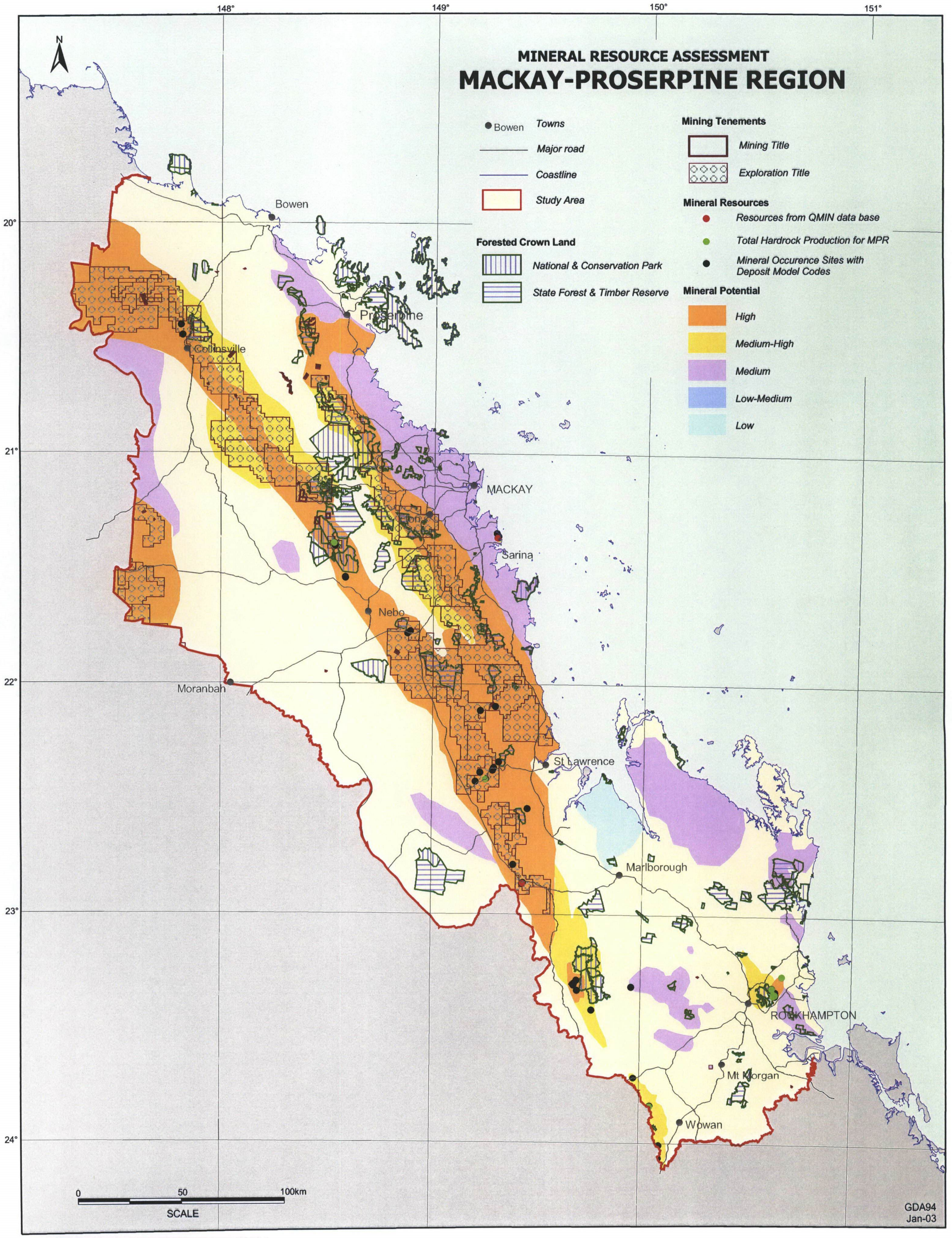

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Figure 12A Geological Units with Potential for Hydrothermal Deposits

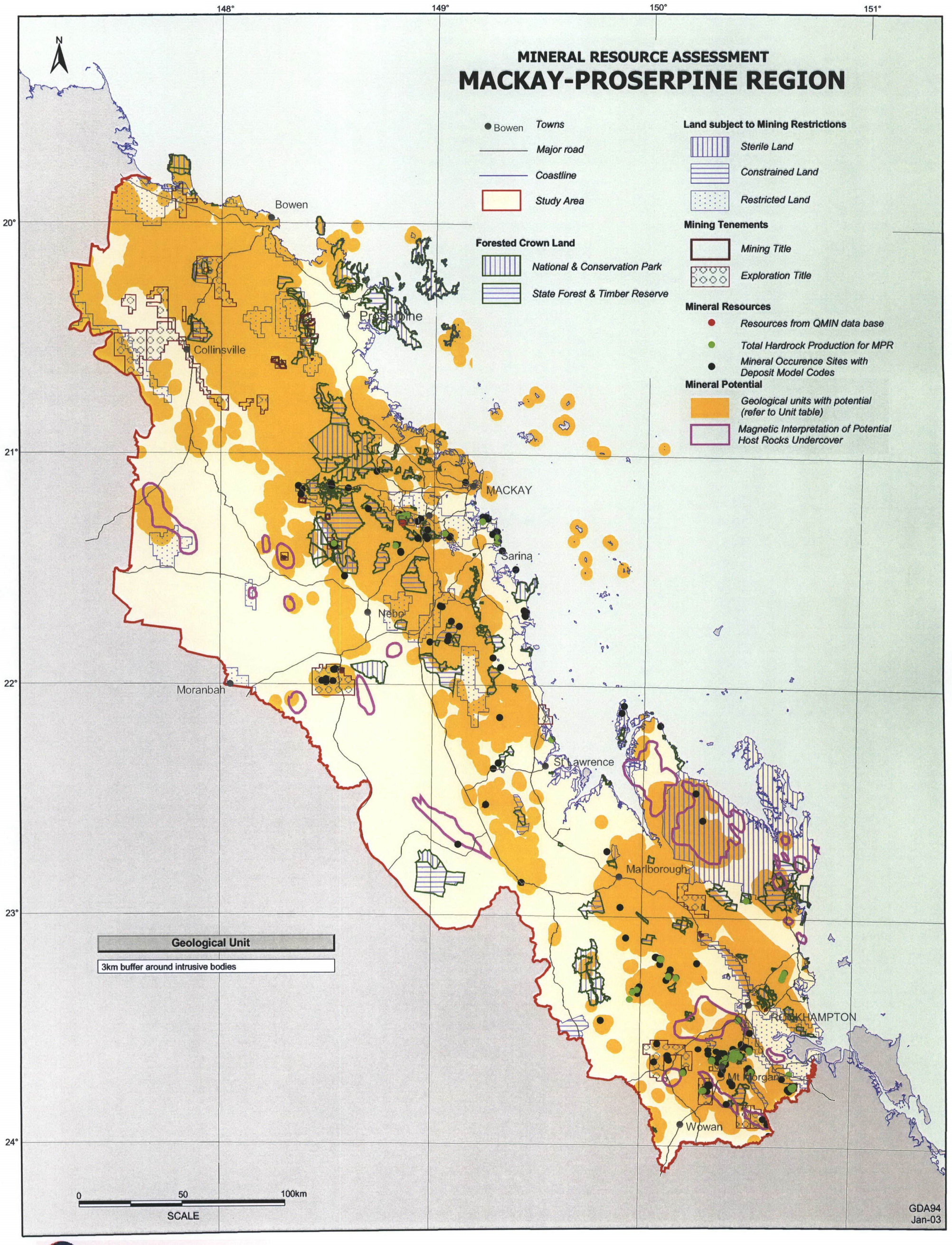

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Figure 12B Potential for Hydrothermal Deposits

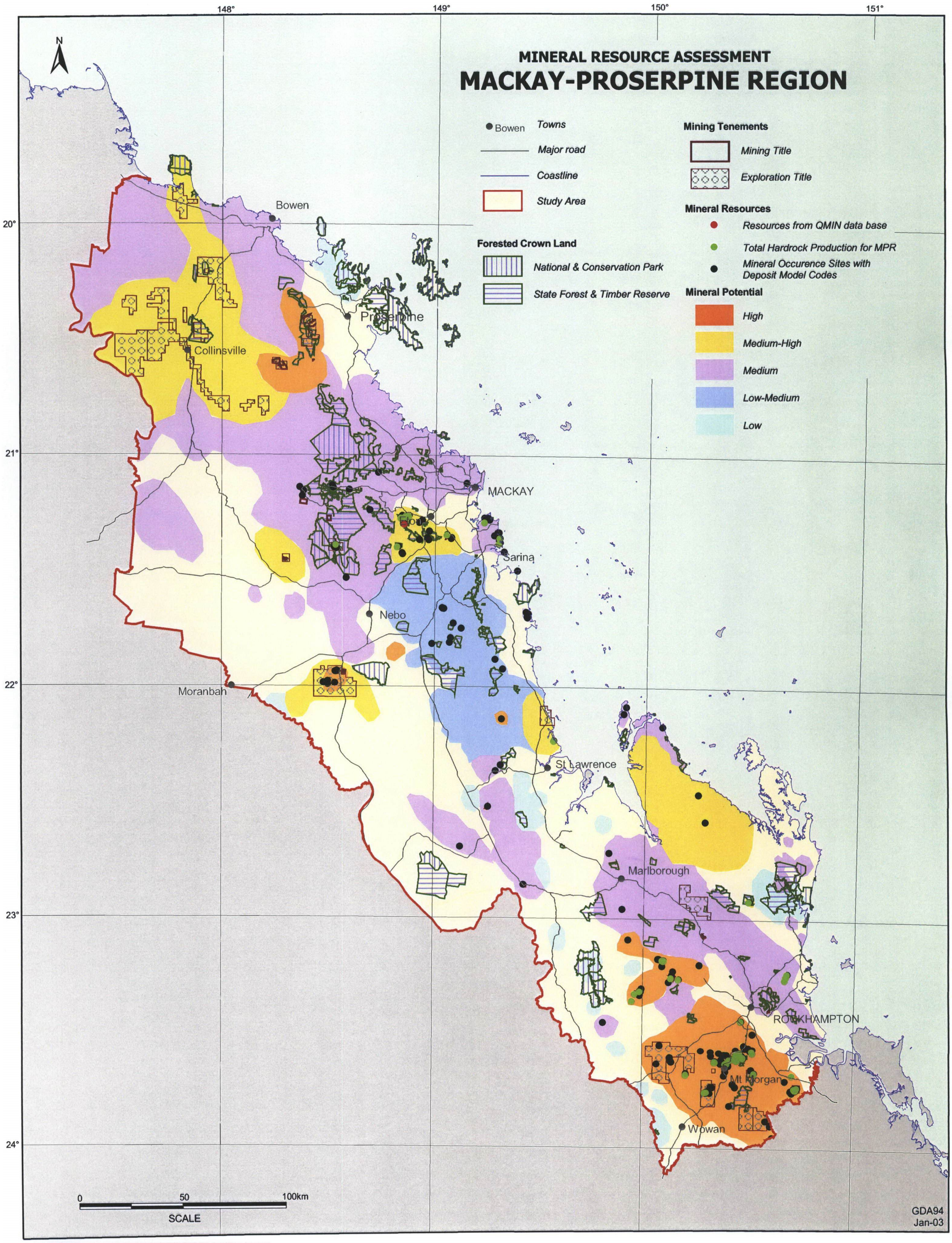

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Figure 13A Geological Units with Potential for Porphyry-type Copper-Molybdenum-Gold Deposits

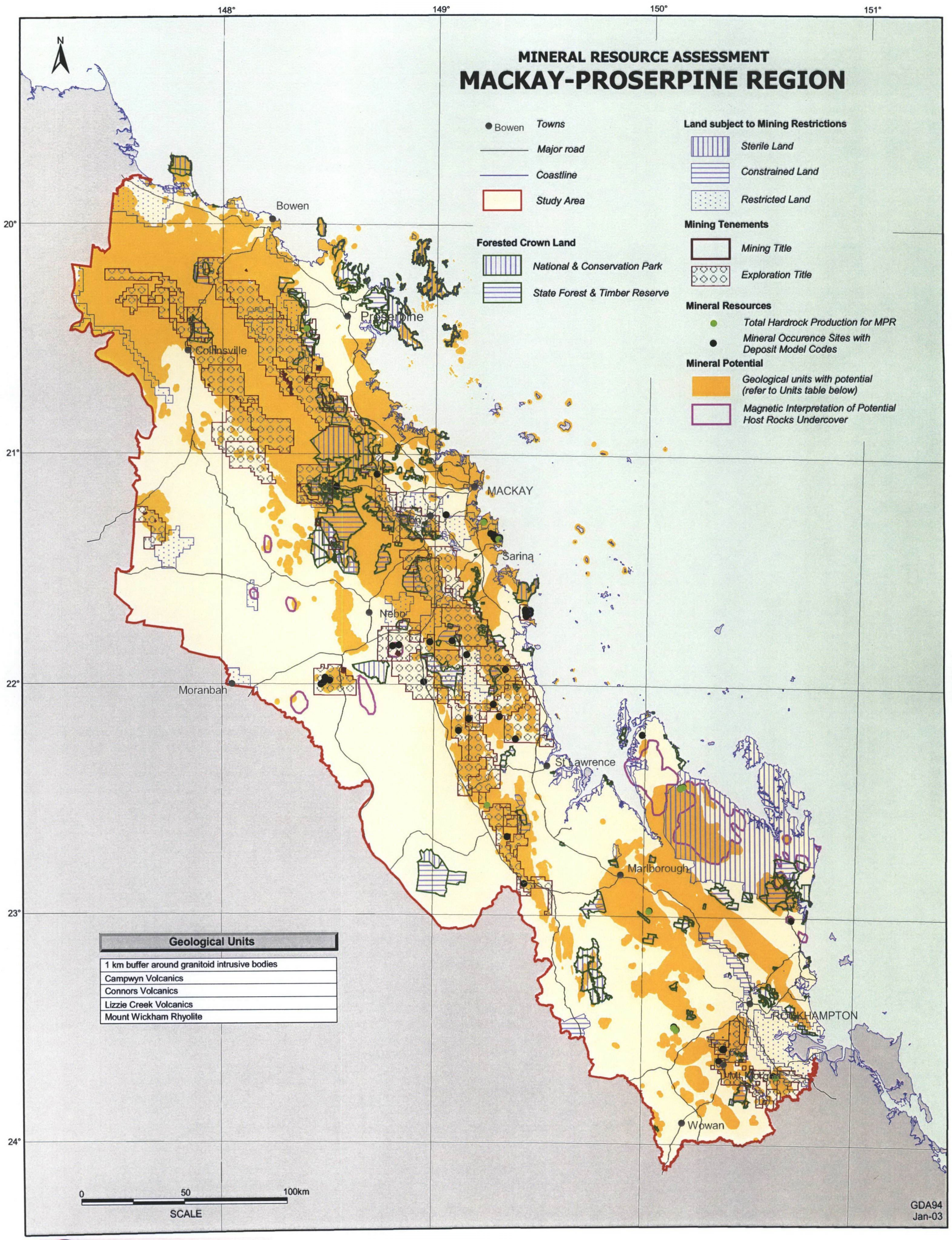

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Figure 13B Potential for Porphyry-type Copper-Molybdenum-Gold Deposits

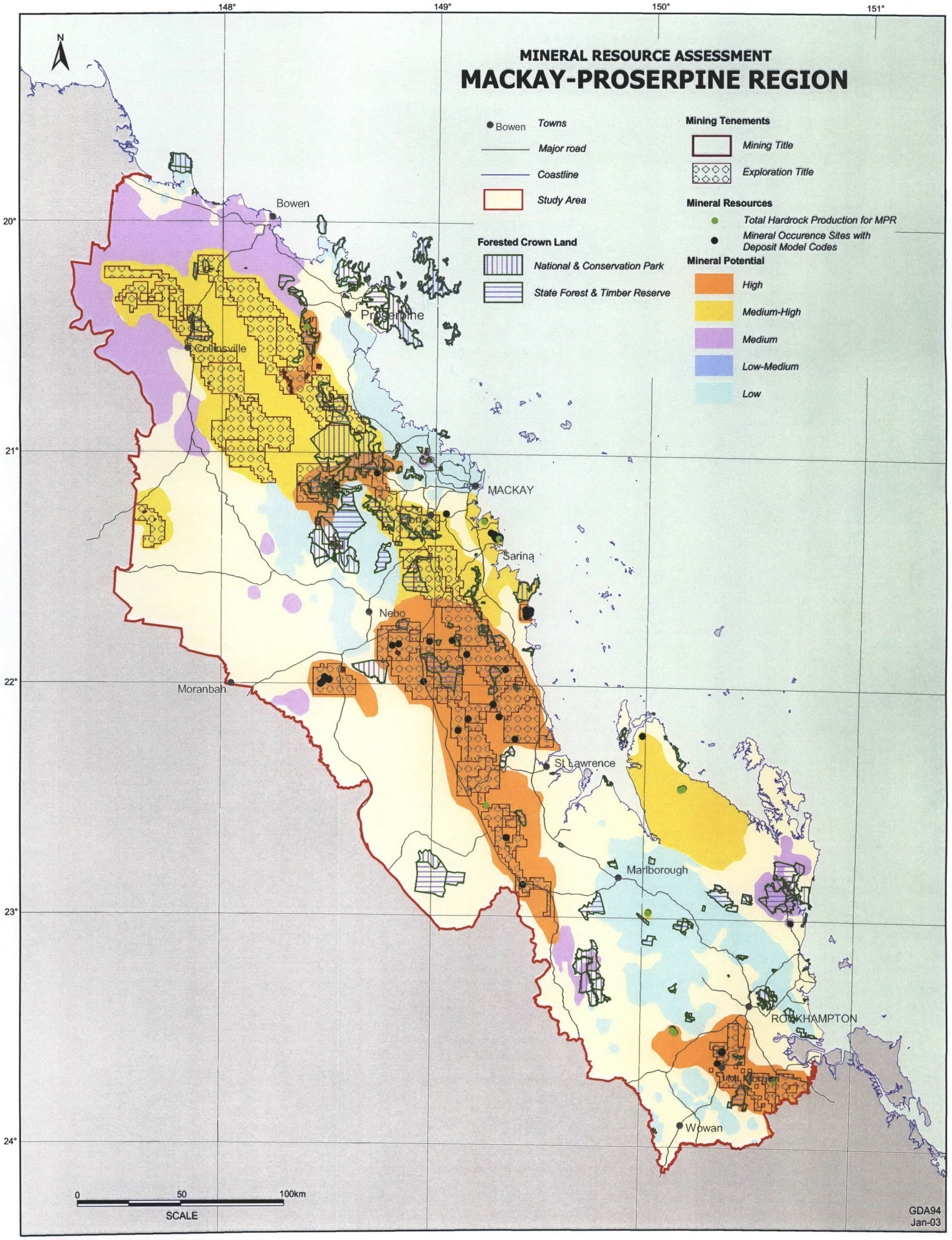

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Figure 14A Geological Units with Potential for Low Sulphide Gold Quartz Veins; Turbidite-hosted Gold; Low-angle Fault-hosted Gold Deposits

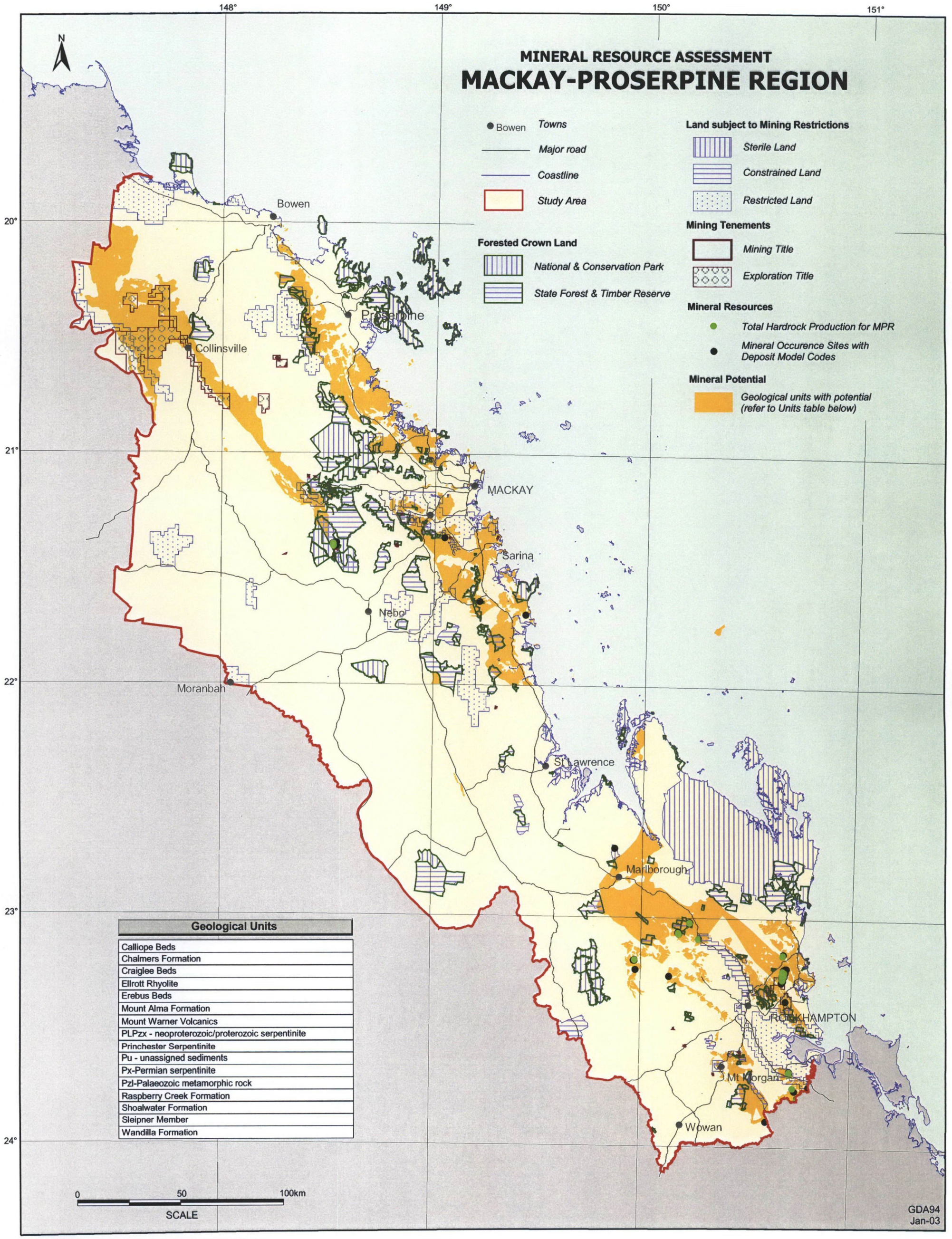

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Figure 14B Potential for Low Sulphide Gold Quartz Veins; Turbidite-hosted Gold; Low-angle Fault-hosted Gold Deposits

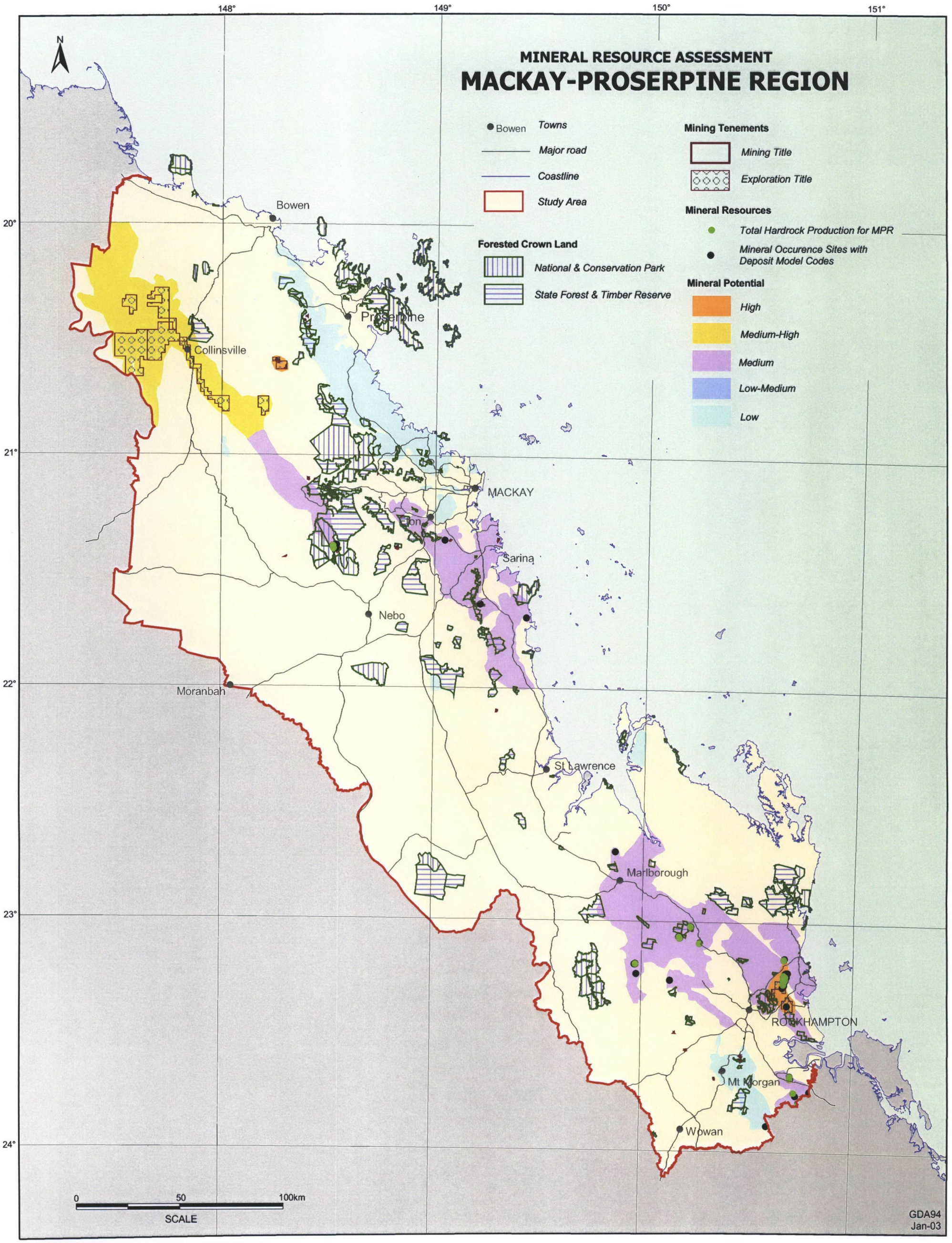

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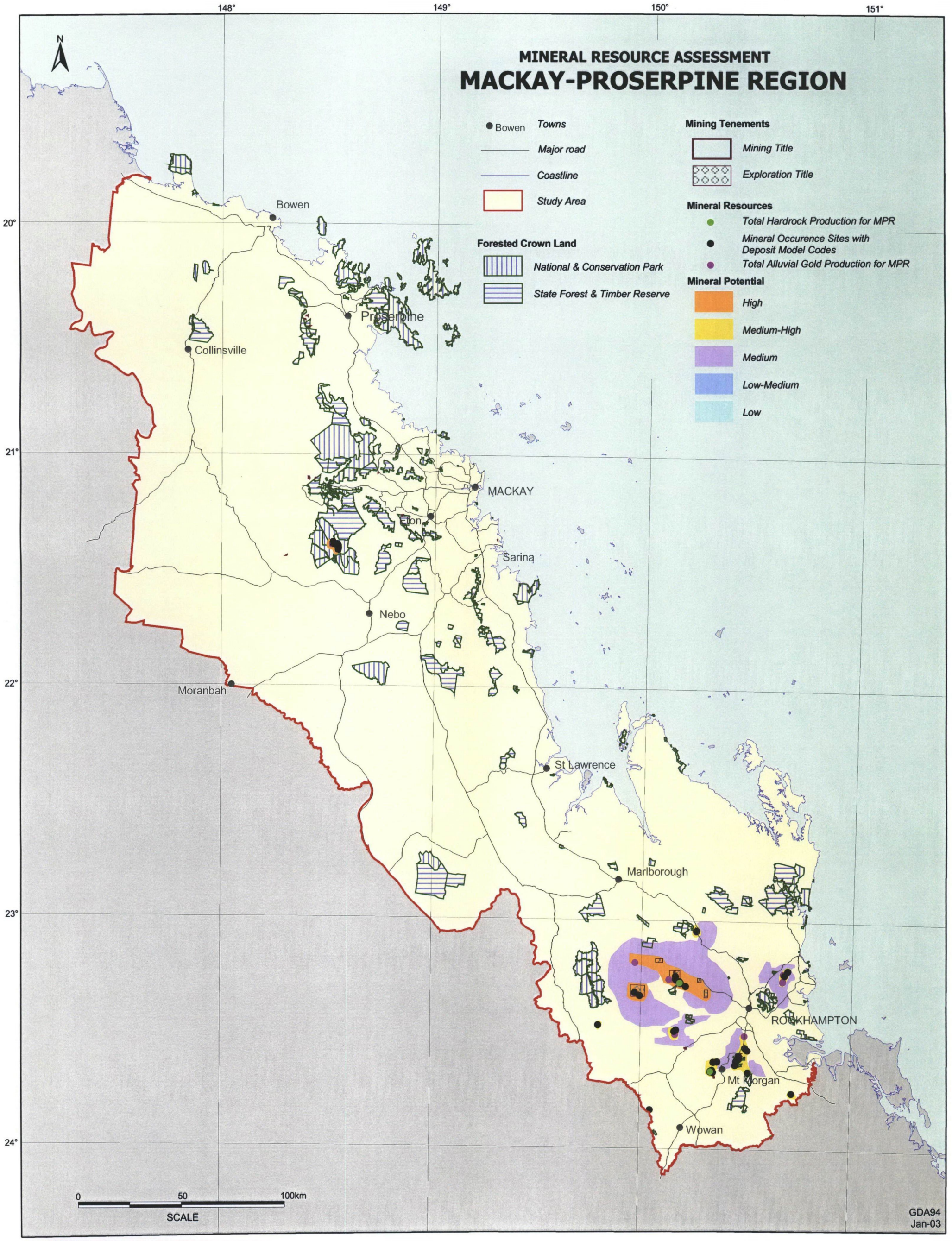
Figure 15 Potential for Alluvial Placer & Deep Lead/Placer Deposits



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Areas of known ***base metal*** mineralisation in the Mackay-Proserpine Region include the Mount Morgan area and the Yarrol Province. Significant volcanogenic deposits include the Mount Morgan Mine which produced 102Mt of ore and is hosted in Capella Creek Beds; Mount Chalmers which produced 1.2Mt ore (MLs 5571, 5789 and MDL 147, EPM 12720) and is hosted by the Berserker Beds; similar Kuroko style volcanogenic massive sulphide mineralisation is recorded in the Raspberry Creek Beds, Mount Warner Volcanics and Capella Creek Beds; the Develin Creek deposits (EPM 8388, 13664) occur in Rookwood Volcanics. Intrusive related skarns recorded in the area include O'Shanesy's and Ellrott.

There is potential for a number of base metal deposit types to occur that are as yet undiscovered in the Mackay-Proserpine Region. For example, Bowen Basin Cycle 1 volcanics are considered highly prospective for both epithermal gold and copper-lead-zinc volcanogenic deposits and these extend into the Mackay-Proserpine Region. Also disseminated copper mineralisation in the basal volcanic sequence along the eastern edge of the Bowen Basin has led to suggestions that the basin may contain sediment-hosted base metal deposits (Murray, 1990). Company exploration applications also indicate an interest in sediment hosted base metal deposits in units such as the Silver Hills Volcanics, which extend into the assessment region.

The most extensive identified resources of ***nickel and cobalt*** in Queensland are within the Mackay-Proserpine Region in the Marlborough district. They occur in a western zone extending discontinuously from about 7km south-west of Marlborough for about 40km in a south-easterly direction, and in an eastern zone comprising a series of small lateritic-capped hills extending north from Canoona for about 15km. Current tenement holdings in the region are dominated by Marlborough Nickel Pty Ltd, a wholly-owned subsidiary of Preston Resources Ltd. A major new development is proposed in the area (principally held under MLs 80060/62/65/73/74) and currently is awaiting funding approval. The project area, which is in the western zone of lateritised serpentinite, contains a global resource of 210Mt at 1.02 percent nickel and 0.06 percent cobalt in 10 separate deposits. This project is anticipated to employ approximately 1000 people during development with capital cost estimated at about $700 million and an expected mine life of over 20 years.
Also in the Marlborough district is the smaller and lower-grade South Slopeaway deposit held by Cobra Resources Ltd, which had been explored under a joint venture with Anaconda Nickel Ltd and is now retained by Cobra for chrysoprase, in addition to its lateritic nickel potential. Other exploration activity in the region is occurring in EPMs 11195, 5780, 5865, 5866, 80004, 80023, 80056-65, 80073-74.

Two other deposit types where the principal target in serpentinised peridotite are ***chromite and chrysoprase***. Chromite is recorded at the Racecourse occurrence (EPM 13467 and at MLs5872-74, 5877,6572, 6578) and chrysoprase in the Slopeaway region (MLs5769-70, 5781-82, 5791-92, 5795, 5802, 7197-98, 7577). In both cases production is small from patchy deposits.

A platinum-palladium occurrence has focused attention on the Bucknalla Gabbro at Westwood (MDL 258, MLs5815, 80021-22, EPM13305).

Table 6 summarises deposit models, associated rock units and source of the model.

Table 6: DEPOSIT MODELS AND PROSPECTIVE ROCK UNITS FOR BASE METAL MINERALISATION IN MACKAY-PROSERPINE

Deposit Model	***Rock Unit/type***	***Model Source***
Skarn	*Intrusives and calcareous/limestone surroundings (eg Balaclava Formation)*	*eg. O'Shanesy's (iron skarn)*
Potential skarn	*Permo-Triassic intrusives and calcareous surrounds*	*Company Exploration model* *Iron Knob – occurrences (iron skarn)* *Ellrott – occurrence (copper skarn)*
Potential Volcanic Massive Sulphide-Besshi	*Rookwood Volcanics, Mt Dick beds, Three Moon Conglomerate, Owl Gully Volcanics, Calliope beds, Raspberry Creek Formation, Marble Waterhole beds, Lochenbar Formation*	*eg Develin Creek prospect*
Potential Volcanogenic Massive Sulphide - Cyprus	*Ophiolite sequences*	*eg Company Exploration*
Potential Volcanogenic Massive Sulphide - Kuroko	*Berserker Group, Marble Waterhole beds, Pond Formation, Capella Creek Group, Craiglee Beds*	*eg Mount Morgan Mine – abandoned; Mount Chalmers*
Potential Blackbird Cobalt-Copper	*Rookwood Volcanics, Mt Dick beds, Three Moon Conglomerate, Owl Gully Volcanics, Calliope beds, Raspberry Creek beds; Marble Waterhole beds, Lochenbar Formation*	*Yarrol data*
Potential Copper-Zinc-Lead	*Marble Waterhole Formation, Bulgonunna Volcanics, Silver Hills Volcanics*	*Company exploration models*
Potential Basaltic Copper	*Mount Hoopbound Formation, Calliope beds, Alton Downs basalt, Camboon Volcanics*	*Anomaly B - occurrence*
Volcanogenic Manganese	*Wandilla Formation, Doonside Formation*	*Mount Barmoya – occurrence*
Hydrothermal/Polymetallic veins	*Surrounds and within intrusive bodies*	*eg Yellow Ore, Struck Oil, True Blue – abandoned mines*
Porphyry (Copper-Molybdenum-Gold; Copper; Copper-Gold)	*Surrounds and within intrusive bodies; eg Unnamed Granodiorites/Diorites;*	*eg Mount Joss, Dittmer – abandoned mine; Riverhead – outside study area but in Yarrol Province*
Potential Porphyry (Copper-	*eg Camboon Volcanics, Lizzie Creek*	*Company Exploration model*

Deposit Model	***Rock Unit/type***	***Model Source***
Molybdenum-Gold; Copper; Copper-Gold	*Volcanics, Connors Volcanics, Mount Wickham Rhyolite and potential intrusive bodies underlying*	
Potential PGE Ultramafics	*eg Eulogie Park Gabbro, Bucknalla Gabbro*	*eg Westwood Palladium - occurrence*
Podiform Chromite	*Serpentinite and serpentinised ultramafics and overlying weathering profile*	*eg Princhester, North Slopeaway*

Other deposits

Figures 16A-22A show the spatial relationship between prospective rock units, current EPMs (including applications), known mineral occurrences, and State Forest, Timber Reserve and Forest Reserve. Figures 16B-22B identify regions in terms of their prospectivity. Two deposit model groups have significant gold and base metal commodities, these are the porphyry copper-molybdenum-gold group and the hydrothermal/polymetallic vein group. Reference figures for these models are in the earlier gold section (Figures 12A&B, 13A&B).

Prospective regions are described as either:

1. High: areas of known resources that are considered to have the greatest exploration potential and highest potential for future developments or expansions (i.e. having identified resources or covered by granted mining tenures or applications) or where there are numerous indicators suggesting high potential for undiscovered resources (i.e. co-incidental mineral occurrences, EPs and prospective host rocks).
2. High-Medium: areas outside known deposits or mines but containing currently held EPs (including applications). These areas either contain or are near known mineral occurrences.
3. Medium: areas that are outside known deposits but contain prospective rock units, and either have coverage by EPs or are closely associated with known mines or mineral occurrences; or where isolated EPMs occur at considerable distance from what are identified as prospective rock units in this report; or where magnetic interpretation suggest prospective rock units under cover that considered to be under-explored.
4. Low: areas that contain prospective rock units but have no other indicators of mineralisation.

Conclusions:

- Intersections between areas of high and/or high-medium potential for epithermal gold (including ML4756, 4782, 4785, 6516, 6520, 6948, 5878, 80031 and EPMs 12277, 12579) and State Forest/Reserves are as follows: Proserpine State Forest (5073, 5091, 5105, 5113-17, 5124-25, 5127, 5132-33, 5139), Sonoma State Forest (5078-84, 5086-87, 5107, 5111-12), Cathu State Forest (5191), Macartney State Forest (5204, 5207, 5212), Lacy Timber Reserve (5209, 5214, 5233, 5243), Saint Helens State Forest (5235), Mia Mia State Forest (5421, 5425, 5439-40, 5442, 5444, 5468, 5482-84), Ben Mohr Timber Reserve (5443, 5446-48, 5455-56, 5464, 5466-67, 5472), Eton State Forest (5452, 5454), Mount Bridgeman State Forest (5457), Spencer Gap State Forest (5469-71, 5479), Epson State Forest 1 (5537), Epson State Forest 2 (5489, 5493-94, 5496), Epson State Forest 3 (5543, 5545, 5575), Kelvin State Forest (5564, 5568, 5571-73, 5584, 5586-88, 5591, 5593-96, 5599, 5605-06, 5608, 5610, 5613-14, 5624-25, 5627, 5634-35, 5638-39), Koumala State Forest (5612), Carminya State Forest (5631), Rosedale State Forest (5632, 5654, 5656), West Hill State Forest

(5636, 5642, 5646-47, 5649-52, 5655), Tierawoomba State Forest (5665-66, 5668), Collaroy State Forest 1 (5669), Porphyry Hill State Forest (5684, 5687-88, 5690), Glencoe State Forest (5757, 5760-61, 5764), Mount Buffalo State Forest (5791), Develin State Forest (6142), Gamma State Forest (5272, 5277), Bluff Hill State Forest (5280, 5315), Pelion State Forest (5282,5209, 5314, 5325), Credition State Forest (5322, 5329-30, 5340-41, 5348, 5387-96, 5401, 5403-18, 5436), Homevale Resources Reserve (5450, 5451, 5485-87, 5493-5511, 5519, 5522), Mount Archer State Forest (131-32, 139-40, 143-155), Gogango Range State Forest (235-36). Areas of high and/or high-medium potential also extend into Cape Upstart National Park (4869), Andromache Conservation Park (5135, 5143), Eungella National Park (5218, 5232, 5240, 5252, 5260, 5308, 5313, 5326-28, 5331-39, 5342-53, 5355, 5357-64, 5367-80, 5382-83, 5385-86, 5397, 5399, 5419, 5426, 5435), St Helens Gap Conservation Park (5257-58, 5261-62), Mount Kinchant Conservation Park (5438), Homevale National Park (5451, 5473-74, 5478, 5511-12, 5515-16, 5524, 5532-34, 5536, 5540-41, 5546-47, 5549), West Hill National Park (5663), Goodedulla National Park (6150, 6188, 6191-92, 6196-97, 6202-03, 6211-14, 6229-30, 6234-35, 6244-47, 6265-66, 6270-71, 6290-91), Mount Etna Caves National Park (106-08, 111-13, 117-18), Limestone Creek Conservation Park (141), Mount Archer National Park (157, 162-68).

- Intersections between areas of high and/or high-medium potential for mesothermal gold (including MDL 272, ML4726, 4756, 4764, 80097, 80099 and EPM 12239) and State Forest/Reserves are as follows: MiaMia State Forest (5482), Homevale Resources Reserve (5485, 5495, 5504, 5507), Lake Learmouth State Forest (77), Sonoma State Forest (5078, 5083, 5086, 5107, 5124-25, 5127), Mount Archer State Forest (131-32, 134, 13940, 142-155), Flat Top Range Resources Reserve (169). Areas of high and/or medium-high potential also intersect Mount Archer National Park (134).

- Intersections between areas of high and/or high-medium potential for hydrothermal vein style deposits – gold and base metal (areas include ML4726, 6520, 4775, 5887, 80001, 80006-7, MDL272 and EPM 13761, 12579, 11779, 13421, 13007, 11507, 9728, 7725, 11842, 11837) and State Forest/ Reserves are as follows: MiaMia State Forest (5482-83, 5482), Credition State Forest (5436), Ben Mohr State Forest (5447), Bouldercomb Gorge Resources Reserve (202), Proserpine State Forest (5073, 5091, 5105, 5111-13, 5115-17, 5127, 5132-33), Sonoma State Forest (5086), Homevale Resources Reserve (5450, 5485-87, 5493-94, 5495-96, 5498-5510), Bouldercombe Resources Reserve (210), Gelobera State Forest (229), Ulam Range State Forest (232). Areas of high and/or high-medium potential also extend into Mount Aberdeen National Park (4982, 4986), Andromache Conservation Park (5135), Homevale National Park (5473-74, 5478), North Pointer Conservation Park (74).

- Intersections between areas of high and/or high-medium potential for porphyry style deposits (including ML1017-19, 1072-73, 1080, 1020-23, 6516 and EPM 11779, 11759, 13761, 13007, 11535, 11744-45, 12277, 13127, 12579, 13593-95, 11901, 13591, 13734, 11738, 13482, 13799, 11483, 9937, 11134, 13481, 10132, 12947, 13491, 12218) and State Forest/ Reserves are as follows: Proserpine State Forest (5073, 5091, 5105, 5111-14, 5116-117, 5124-25, 5127, 5132-33, 5139), Homevale Resources Reserve (5450, 5485-87, 5493-96, 5498-5510), Bouldercombe Gorge Resources Reserve (200-203, 207, 210), Bouldercombe State Forest (198), Credition State Forest (5322, 5436, 5329-30, 5340-41, 5387-96, 5401, 5403-18), Mia Mia State Forest (5421, 5439-40, 5442, 5444-45, 5450, 5468, 5482-83), Ben Mohr Timber Reserve (5443, 5446, 5448), Ben Mohr State Forest (5447, 5455-56, 5464, 5466-67, 5472), Eton State Forest (5452, 5454), Mount Bridgeman State Forest (5457), Spencer Gap State Forest (5470-71, 5479), Epson State Forest 1 (5537), Epson State Forest 3 (5543, 5575), Kelvin State Forest (5564, 5568, 5571-73, 5584, 5587-88, 5591, 5593-95, 5599, 5605-06, 5608, 5610, 5613-14, 5624-25, 5627, 5634-35, 5638-39), Connors State Forest (5596), Carminya State

Forest (5631), Rosedale State Forest (5632, 5654, 5656), West Hill State Forest (5636, 5642, 5646-47, 5649-52, 5655), Tierawoomba State Forest (5657, 5665-66, 5668), Collaroy State Forest (5669), Porphyry Hill State Forest (5684, 5687-88, 5690),Glencoe State Forest (5761, 5764), Mount Buffalo State Forest (5791), Sonomia State Forest (5078-84, 5086-87, 5107, 5111-12), Cathu State Forest (5191), Macartney State Forest (5204, 5207, 5212), Lacy Timber Reserve (5209, 5214, 5233, 5243), St Helens State Forest (5235), Gamma State Forest (5272, 5277), Bluff Hill State Forest (5280, 5315-17), Pelion State Forest (5282, 5309-11, 5325), Gelobera State Forest (221-224, 228-29), Ulam Range State Forest (230-234), Don River State Forest (238). Areas of high and/or high-medium potential also extend into Mount Aberdeen National Park (4982, 4986), Andromache Conservation Park (5135, 5143), Eungella National Park (5218, 5232, 5240, 5252, 5283, 5285-97, 5301, 5304-08, 5313, 5319-21, 5326-28, 5331-39, 5342-53, 5355, 5357-63, 5367867, 5397, 5399-400, 5419-20, 5423-33), St Helens Gap Conservation Park (5257-58, 5261-62), Homevale National Park (5451), Mount Martin National Park (5298-300), Bakers Creek Conservation Park (5434), Mount Kinchant Conservation Park (5438), Mount Hector Conservation Park (5449), Cape Palmerston National Park (5582, 85, 5604, 5607), Dipperu National Park (5667), Mount Hopeful Conservation Park (226).

- Areas of high and/or high-medium potential for volcanogenic massive sulphides deposits (including ML5861, 5889 and EPM 11840, 13637, 9937, 12720, 12339, 7940, 7725, 11841, 13491, 11839, 12218, 11842, 11837, 10097, 10677) intersect : Sonoma State Forest (5078-79, 5081, 5083, 5086, 5107, 5124-25, 5127), Marlborough State Forest (5908-09), Alligator Creek State Forest (27, 35-36), Eugene State Forest (6014), Canal Creek State Forest (73), Lake Learmouth State Forest (77-80, 82-90, 94-98), Aricia State Forest (101), Mount Archer State Forest (131,132, 134, 139-140, 143-155), Flat Top Range Resources Reserve (169-70, 192), Bouldercombe Resources Reserve (200-03, 207, 210), Gelobera State Forest (221-24, 228-29), Ulam State Forest (230-34), Don River State Forest (238). Areas of High and/or high-medium potential also extend into North Pointer Conservation Park (74), Princhester Conservation Park (76), Goodedulla National Park (6229, 6317), Limestone Conservation Park (141-42), Keppel Sands Conservation Park (156, 159-60), Mount Archer National Park (157-58, 162-68. 171), Mackenzie Island Conservation Park (196), Mount Hopeful Conservation Park (226-27).

- Intersections between areas of high potential for alluvial gold deposits (including ML4782, 4785,70039, 70089-90, 7418-26) and State Forest/Reserves are as follows: Homevale Resources Reserve (5450, 5485-87, 5493, 5496, 5500-01, 5505, 5508-10), Lake Learmouth State Forest (77,89,90), Mornish State Forest (130), Bouldercombe State Forest (198), Bouldercombe Gorge Resources Reserve (200-203, 207, 210).

- Areas of high-medium potential for base metal and gold skarn deposits (including EPM 11901, 13491, 12218, 10677) cover or intersect the following State Forests: Carminya State Forest (5631), Bouldercombe Gorge Reserve (200-203, 207, 210), Gelobera State Forest (221-224), Ulam Range State Forest (230-232), Aricia State Forest (101), Mornish State Forest (130, 138), Bouldercombe State Forest (198). Areas of high-medium potential also extend into Cape Palmerston National Park (5607), Dipperu National Park (5667), Mount Etna Caves National Park (106-08, 110-113, 117-18).

- Areas of high-medium potential for volcanogenic copper-nickel-zinc-lead deposits (including EPM7940) cover or intersect the following State Forests/Reserves: Bouldercombe Gorge Reserves Reserve (210), Gelobera State Forest (222).

- Areas of high-medium potential for nickel-chromite deposits (including EPM 13465) Flat Top Range Resources Reserve (4083, 4124), Aricia State Forest (3948), Lake Learmouth State Forest (3917-21), Eugene State Forest (3869), Marlborough State Forest (3781-82), Alligator Creek State Forest (3848). Areas of high-medium potential also extend into Princhester Conservation Park (3916), North Pointer Conservation Park (3912), Mount Jim Crow National Park (3980), Mount O'Connel National Park (3764).

- There are no intersections with forested areas for sediment-hosted gold, basaltic copper, volcanic hosted manganese; PGE deposit types.

Figure 16A Geological Units with Potential for Base Metal Skarn and Polymetallic Replacement Deposits

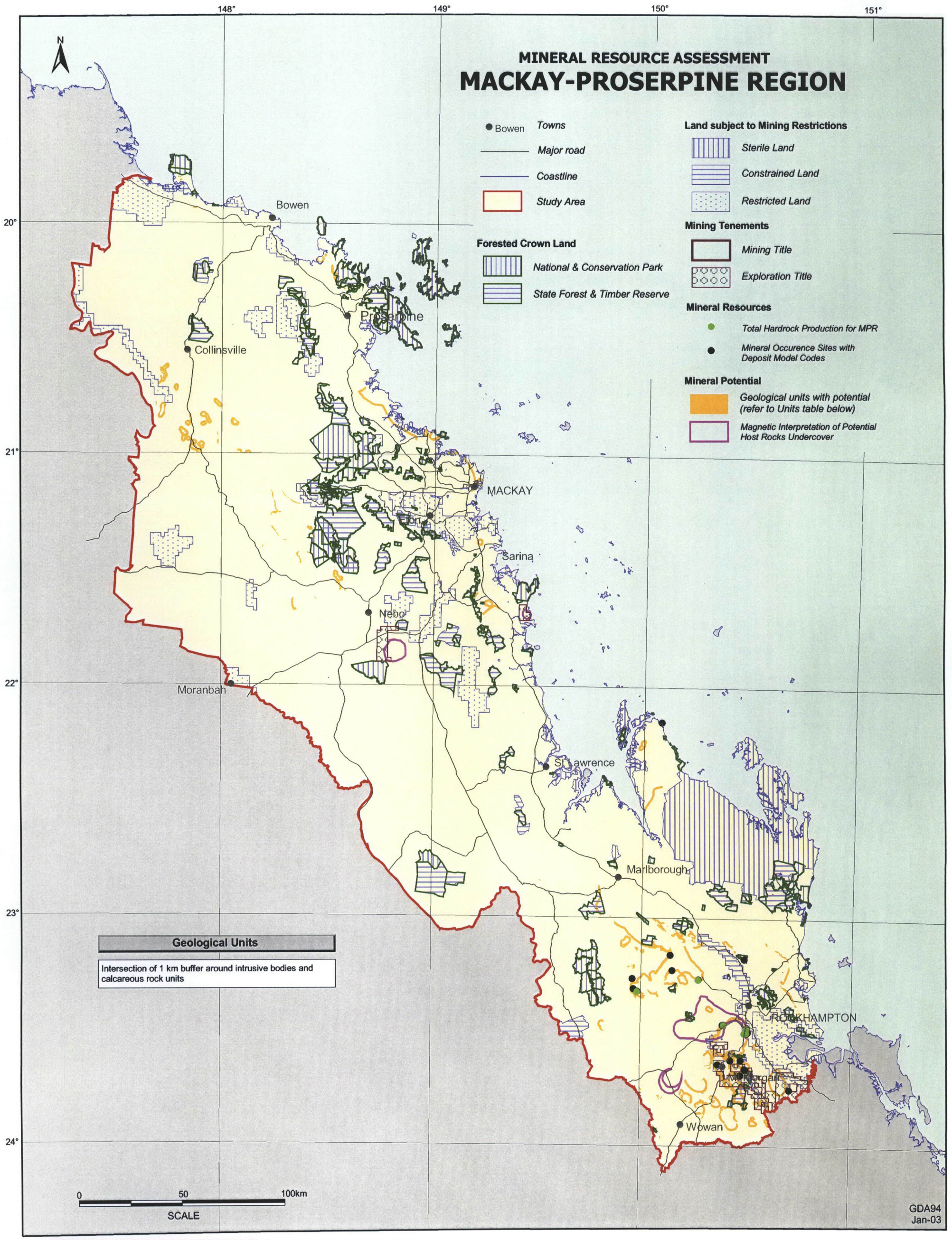

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Figure 16B Potential for Base Metal Skarn and Polymetallic Replacement Deposits

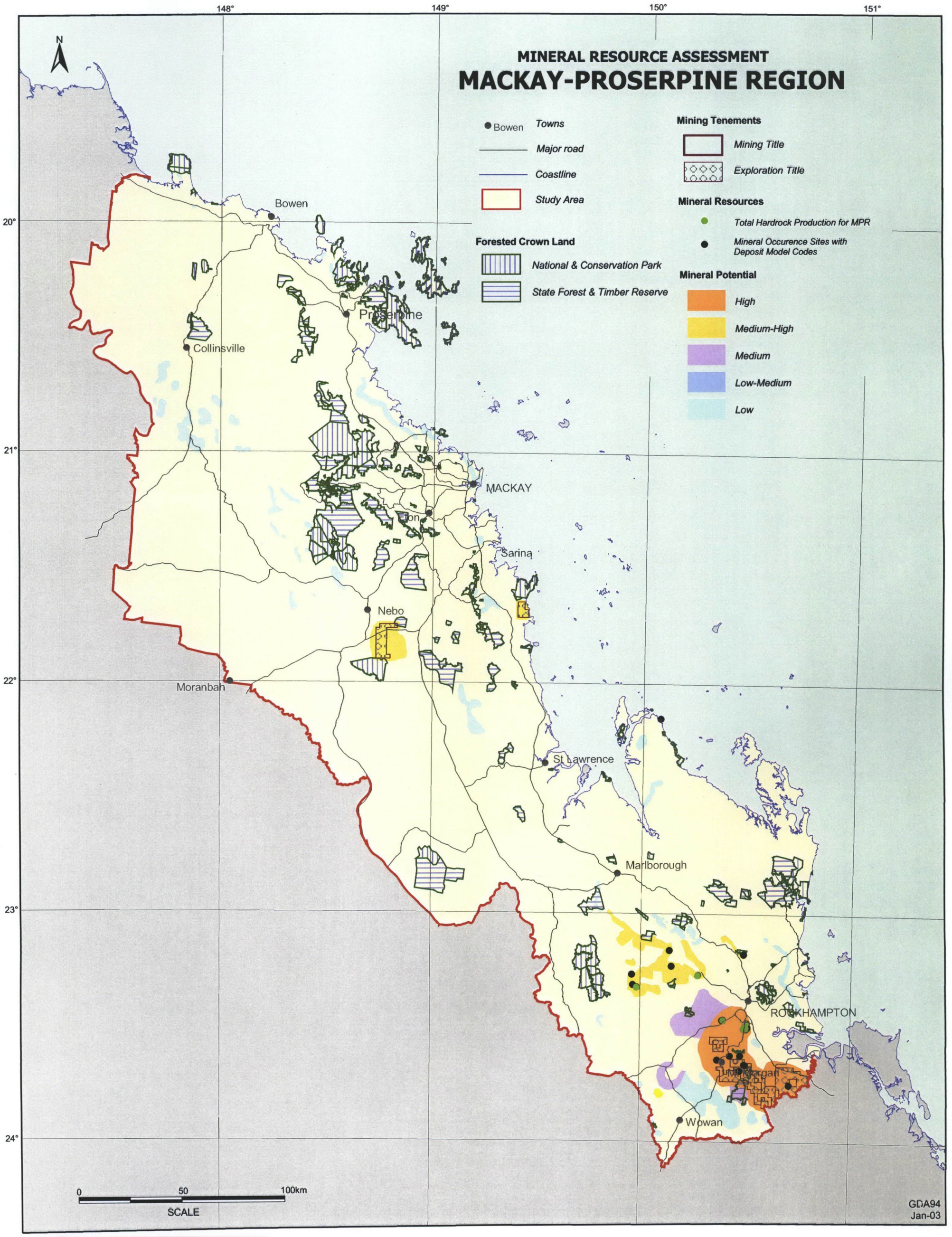

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Figure 17A Geological Units with Potential for Volcanogenic Massive Sulphide Deposits

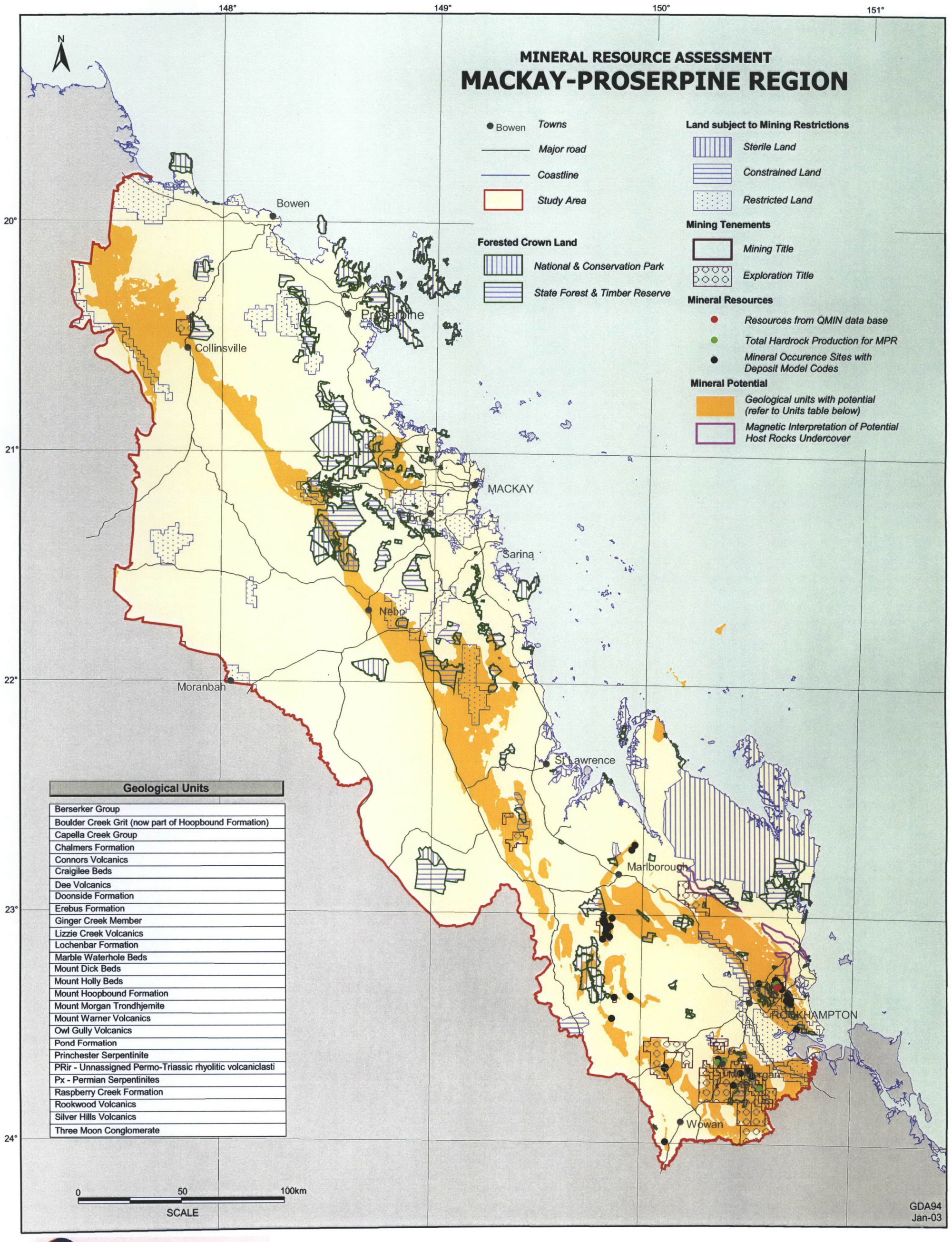

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Figure 17B Potential for Volcanogenic Massive Sulphide Deposits

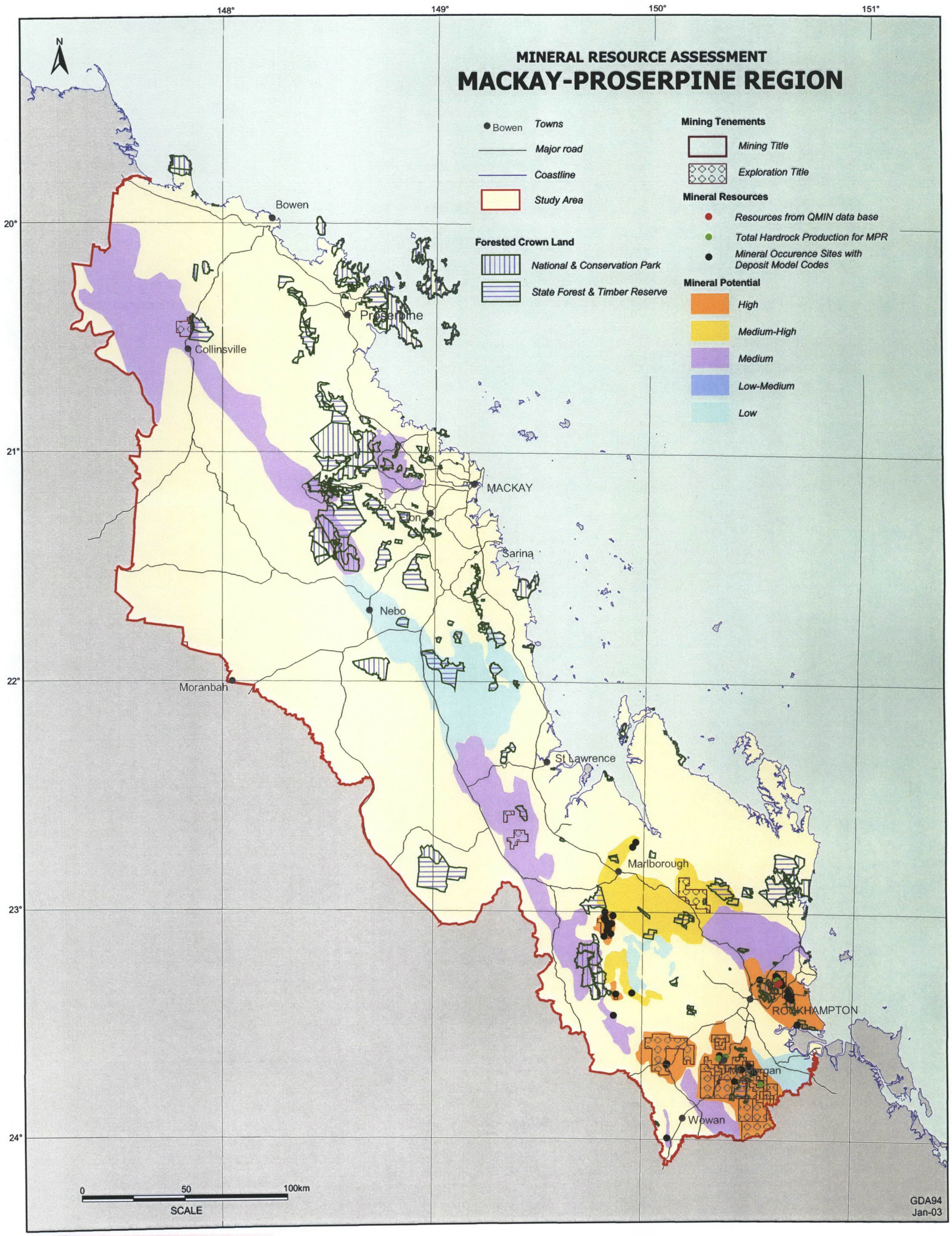

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Figure 18A Geological Units with Potential for Volcanogenic Cu-Ni-Zn-Pb / Basaltic Copper Deposits

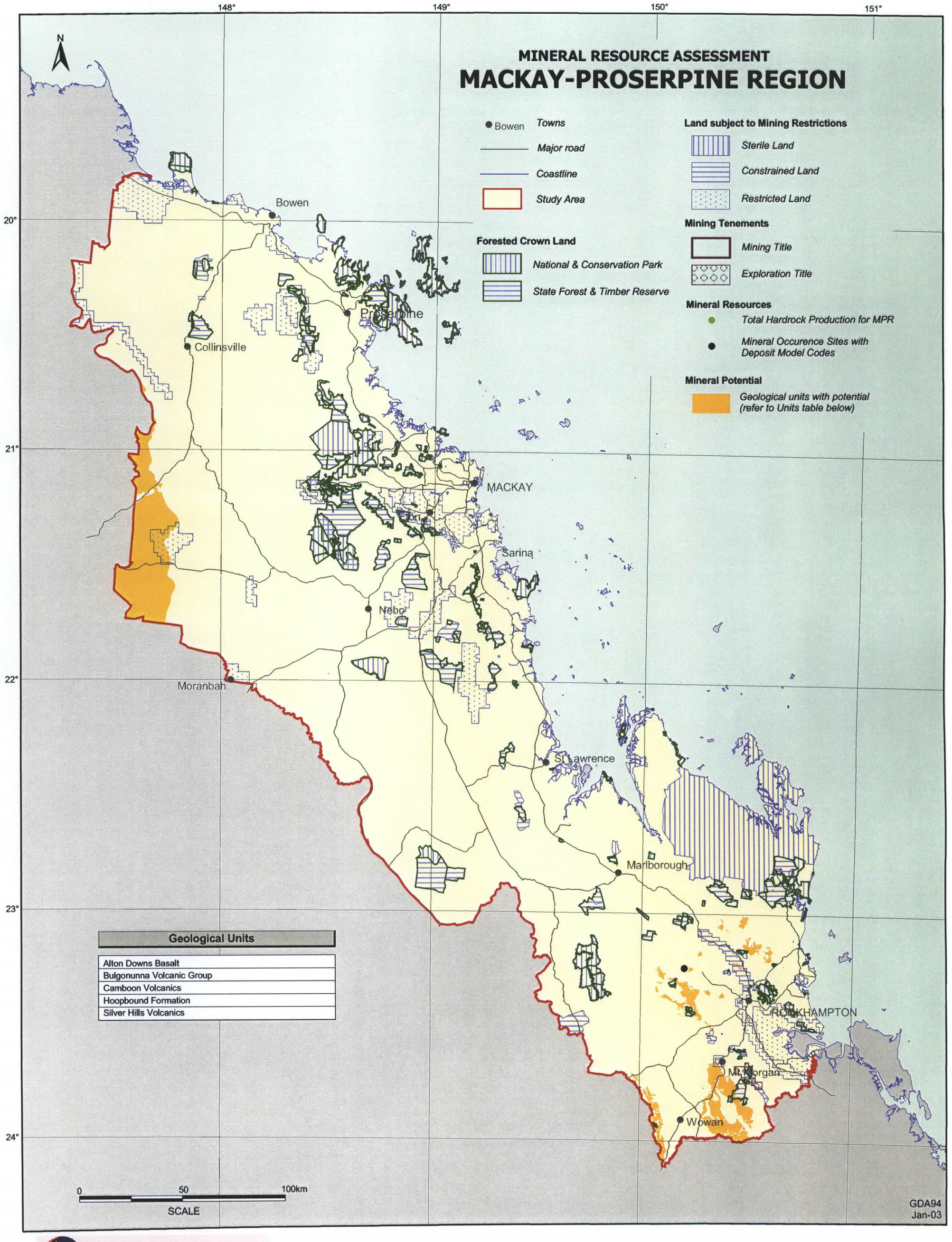

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Figure 18B Potential for Volcanogenic Cu-Ni-Zn-Pb / Basaltic Copper Deposits

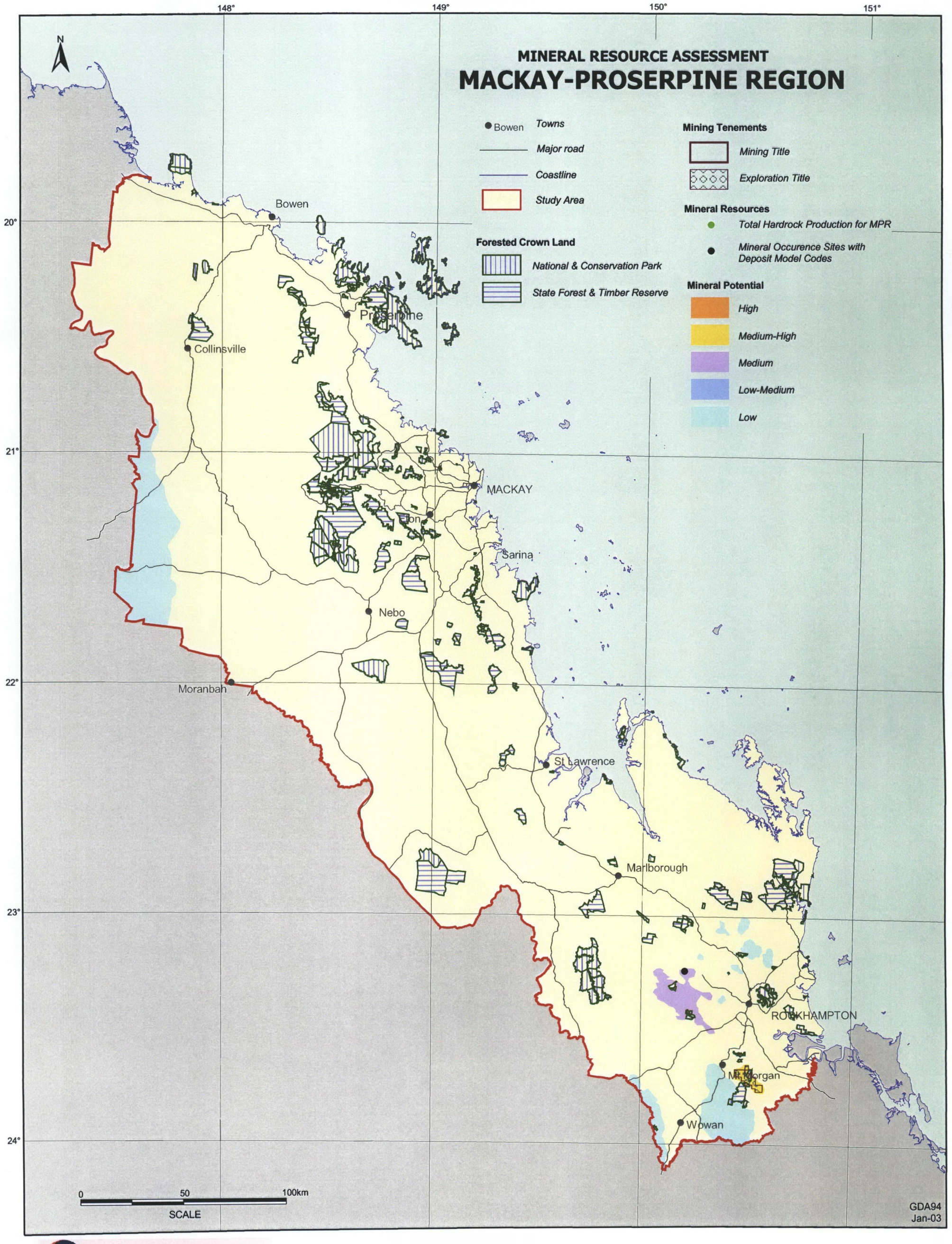

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Figure 19A Geological Units with Potential for Volcanogenic Manganese Deposits

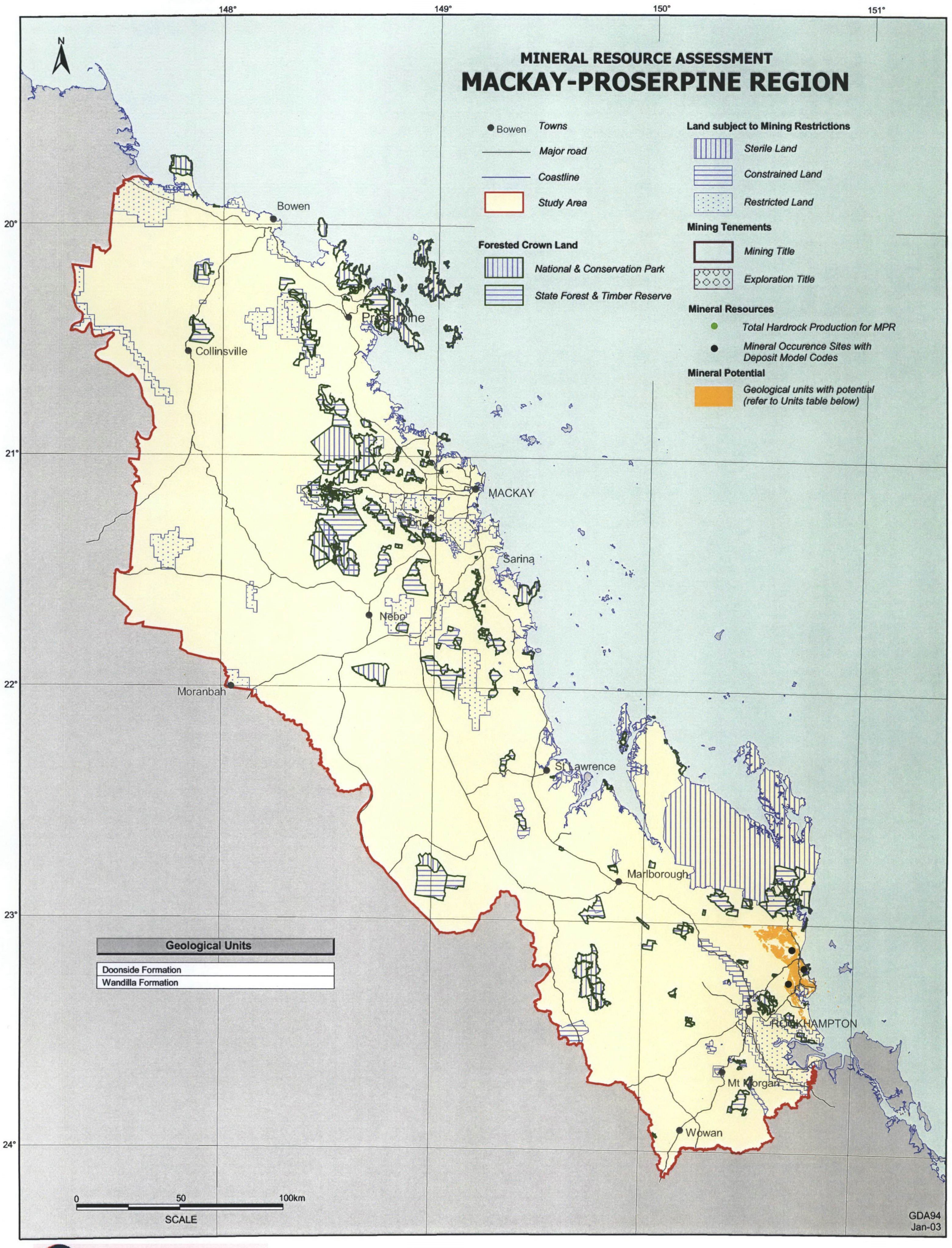

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Figure 19B Potential for Volcanogenic Manganese Deposits

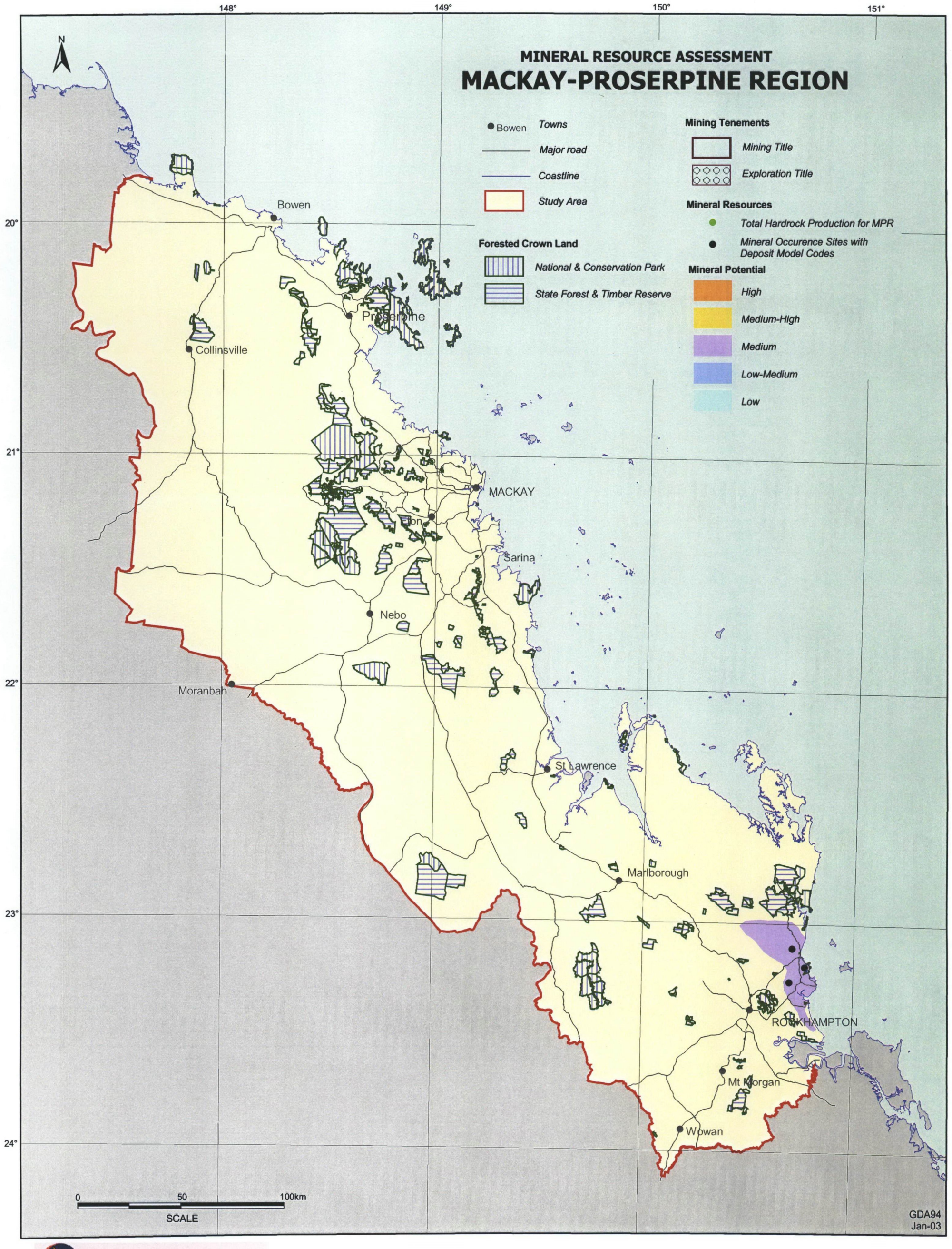

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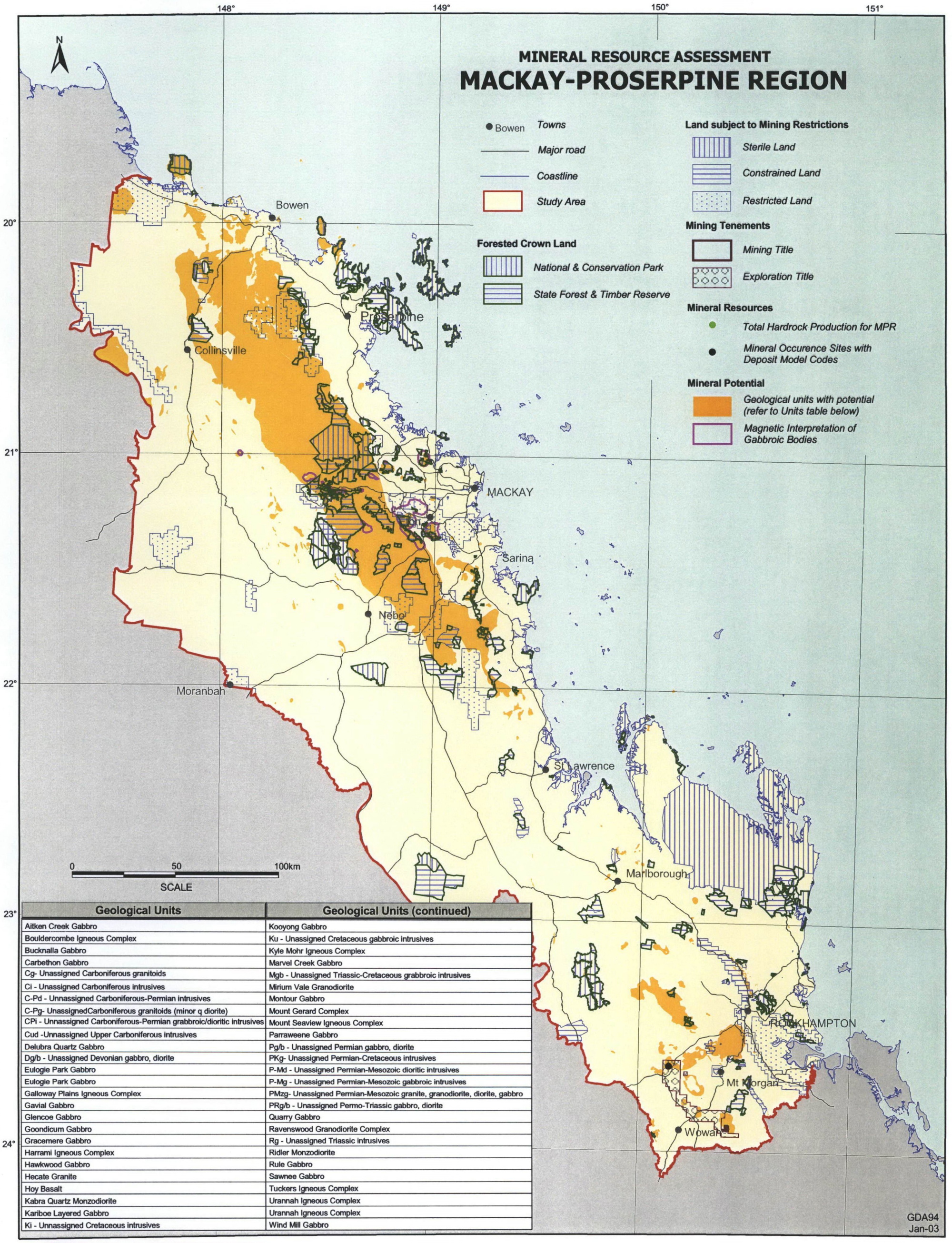
Figure 20A Geological Units with Potential for Ultramafic Platinum Group Elements (PGE)



Geological Units	Geological Units (continued)
Aitken Creek Gabbro	Kooyong Gabbro
Bouldercombe Igneous Complex	Ku - Unassigned Cretaceous gabbroic intrusives
Bucknalla Gabbro	Kyle Mohr Igneous Complex
Carbethon Gabbro	Marvel Creek Gabbro
Cg- Unassigned Carboniferous granitoids	Mgb - Unassigned Triassic-Cretaceous grabbroic intrusives
Ci - Unassigned Carboniferous intrusives	Mirium Vale Granodiorite
C-Pd - Unnassigned Carboniferous-Permian intrusives	Montour Gabbro
C-Pg- UnassignedCarboniferous granitoids (minor q diorite)	Mount Gerard Complex
CPi - Unnassigned Carboniferous-Permian grabbroic/dioritic intrusives	Mount Seaview Igneous Complex
Cud -Unnassigned Upper Carboniferous intrusives	Parraweene Gabbro
Delubra Quartz Gabbro	Pg/b - Unassigned Permian gabbro, diorite
Dg/b - Unassigned Devonian gabbro, diorite	PKg- Unassigned Permian-Cretaceous intrusives
Eulogie Park Gabbro	P-Md - Unassigned Permian-Mesozoic dioritic intrusives
Eulogie Park Gabbro	P-Mg - Unassigned Permian-Mesozoic gabbroic intrusives
Galloway Plains Igneous Complex	PMzg- Unassigned Permian-Mesozoic granite, granodiorite, diorite, gabbro
Gavial Gabbro	PRg/b - Unassigned Permo-Triassic gabbro, diorite
Glencoe Gabbro	Quarry Gabbro
Goondicum Gabbro	Ravenswood Granodiorite Complex
Gracemere Gabbro	Rg - Unassigned Triassic intrusives
Harrami Igneous Complex	Ridler Monzodiorite
Hawkwood Gabbro	Rule Gabbro
Hecate Granite	Sawnee Gabbro
Hoy Basalt	Tuckers Igneous Complex
Kabra Quartz Monzodiorite	Urannah Igneous Complex
Kariboe Layered Gabbro	Urannah Igneous Complex
Ki - Unnassigned Cretaceous intrusives	Wind Mill Gabbro

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Figure 20B Potential for Ultramafic Platinum Group Elements (PGE)

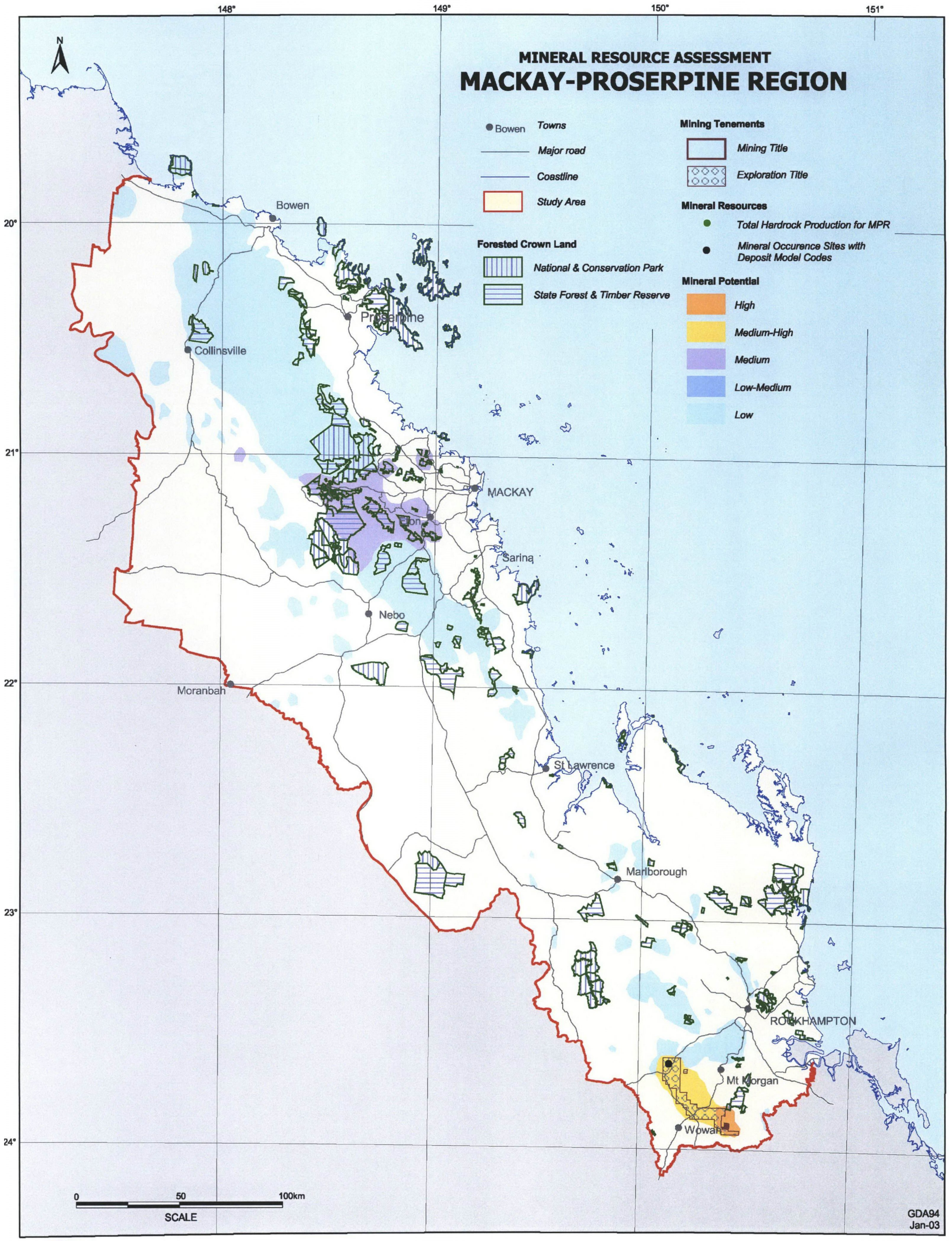

Figure 21A Geological Units with Potential for Cobalt, Chromite and Chrysoprase Deposits

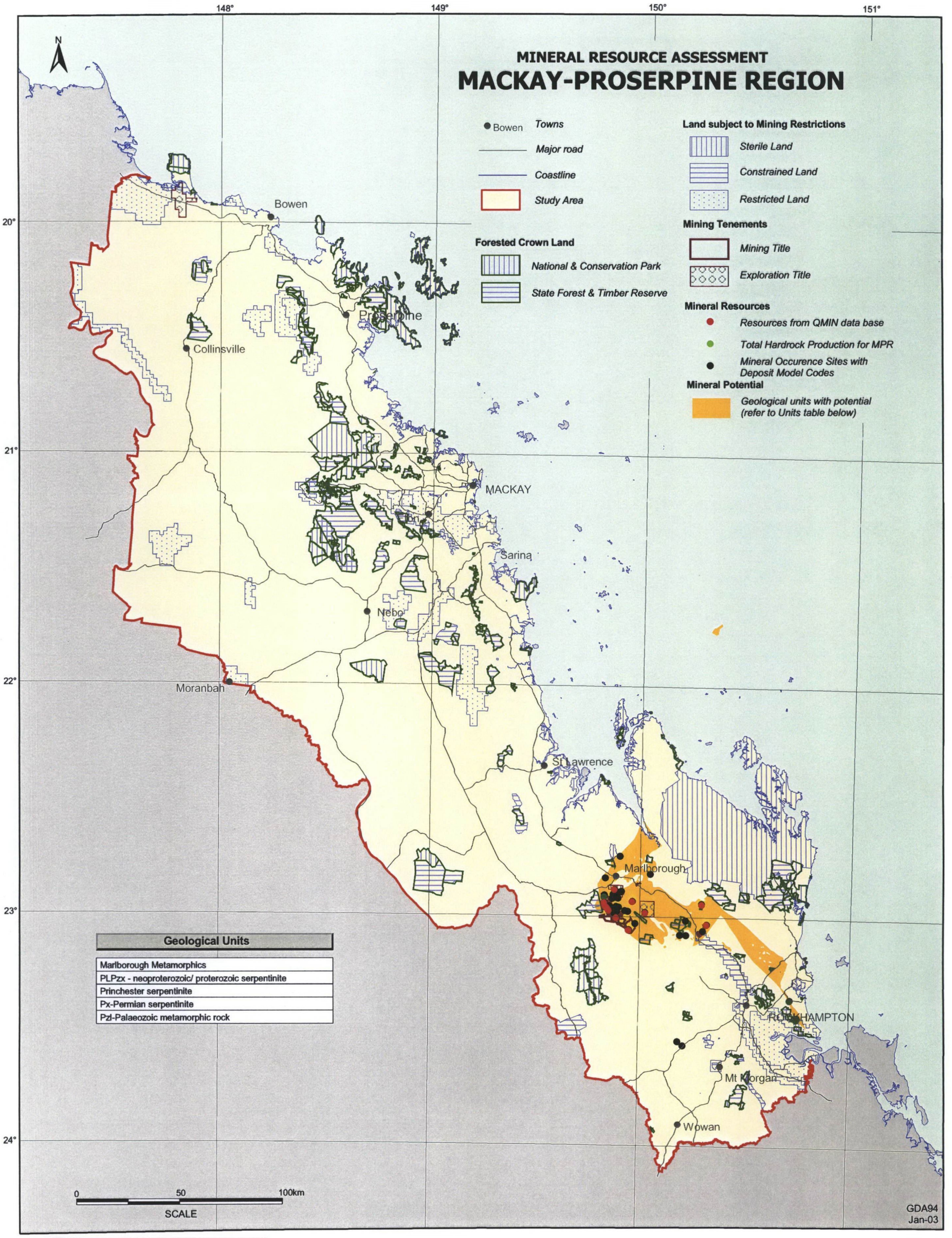

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Figure 21B Potential for Cobalt, Chromite and Chrysoprase Deposits

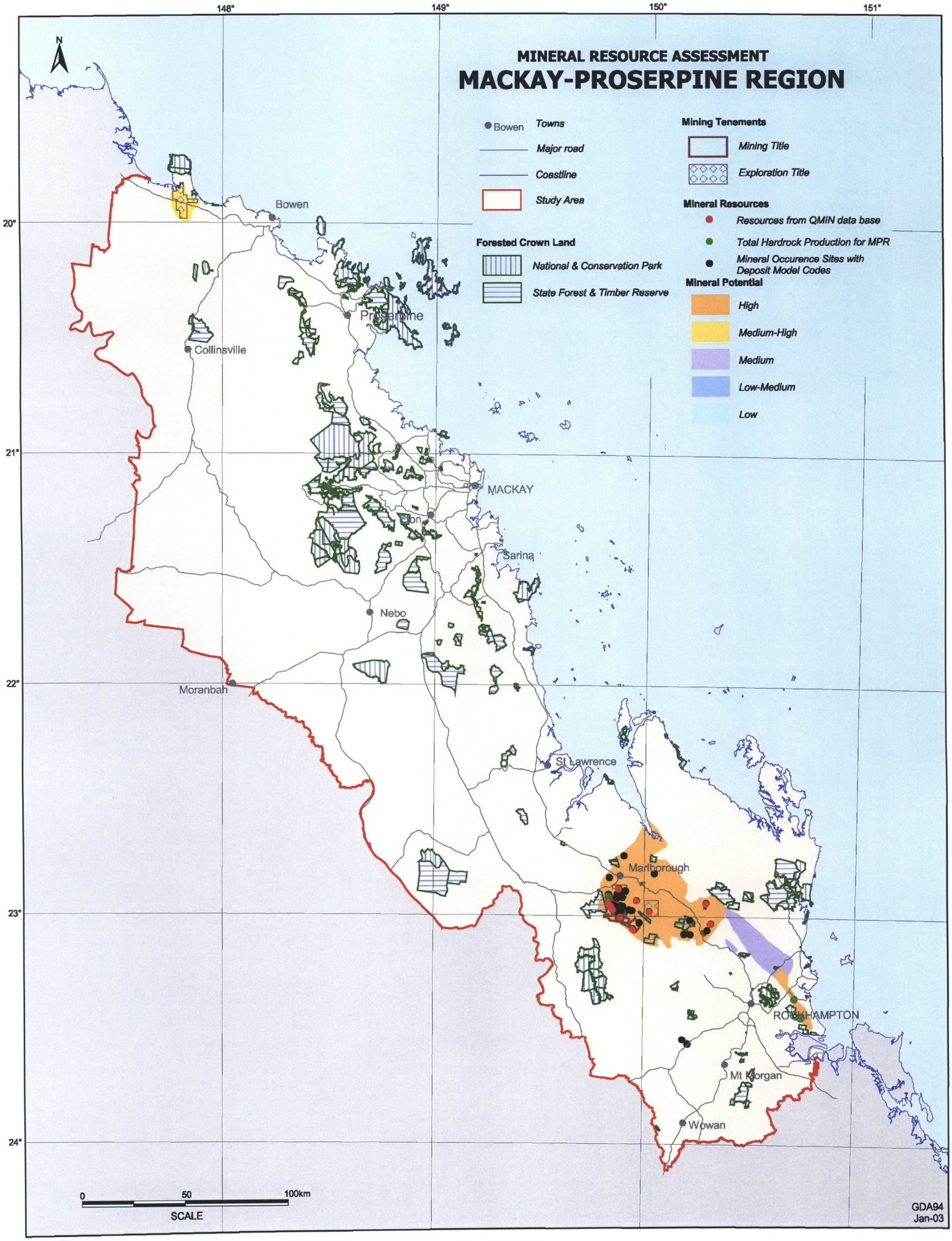

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Figure 22A Geological Units with Potential for Brine and Phosphate Deposits

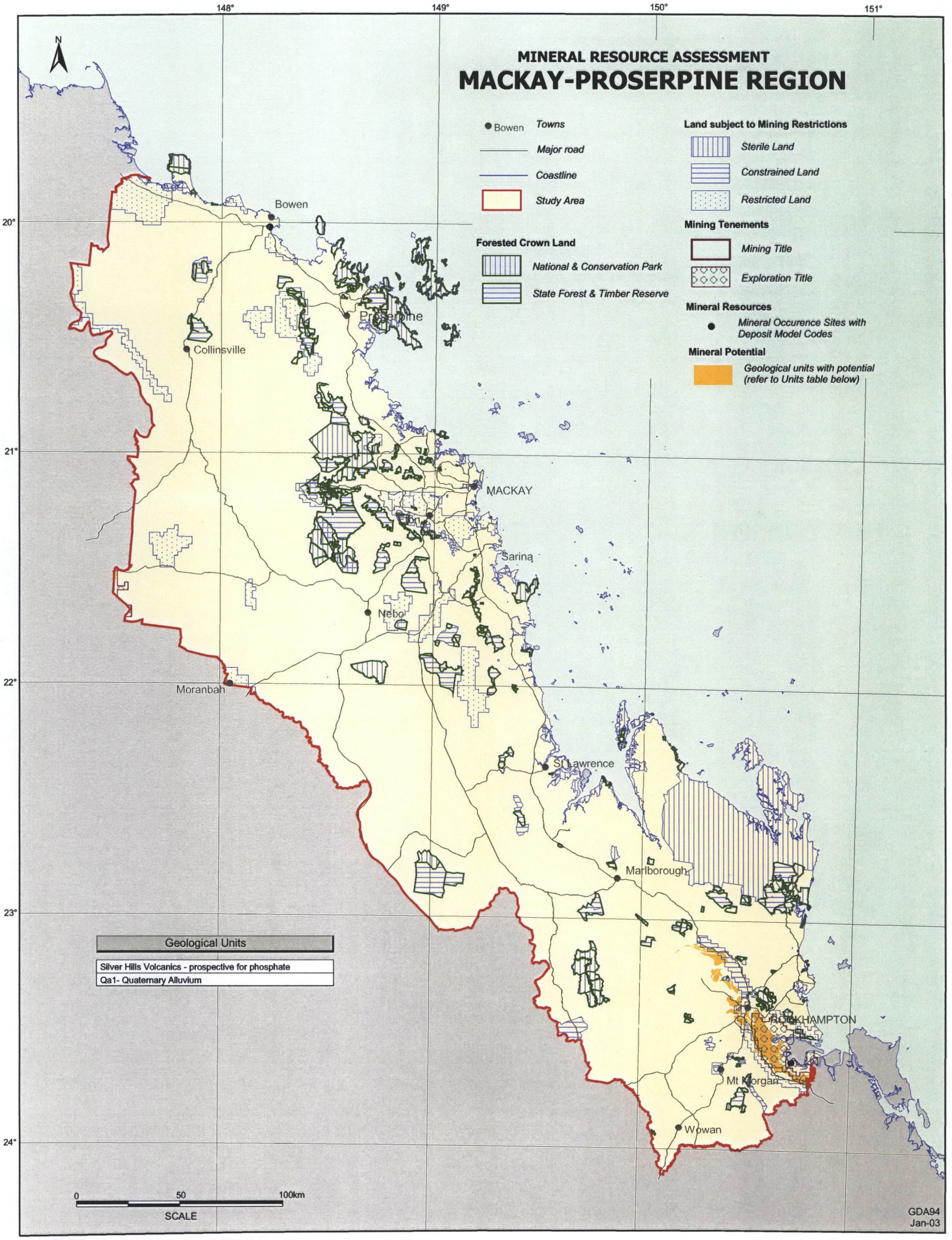

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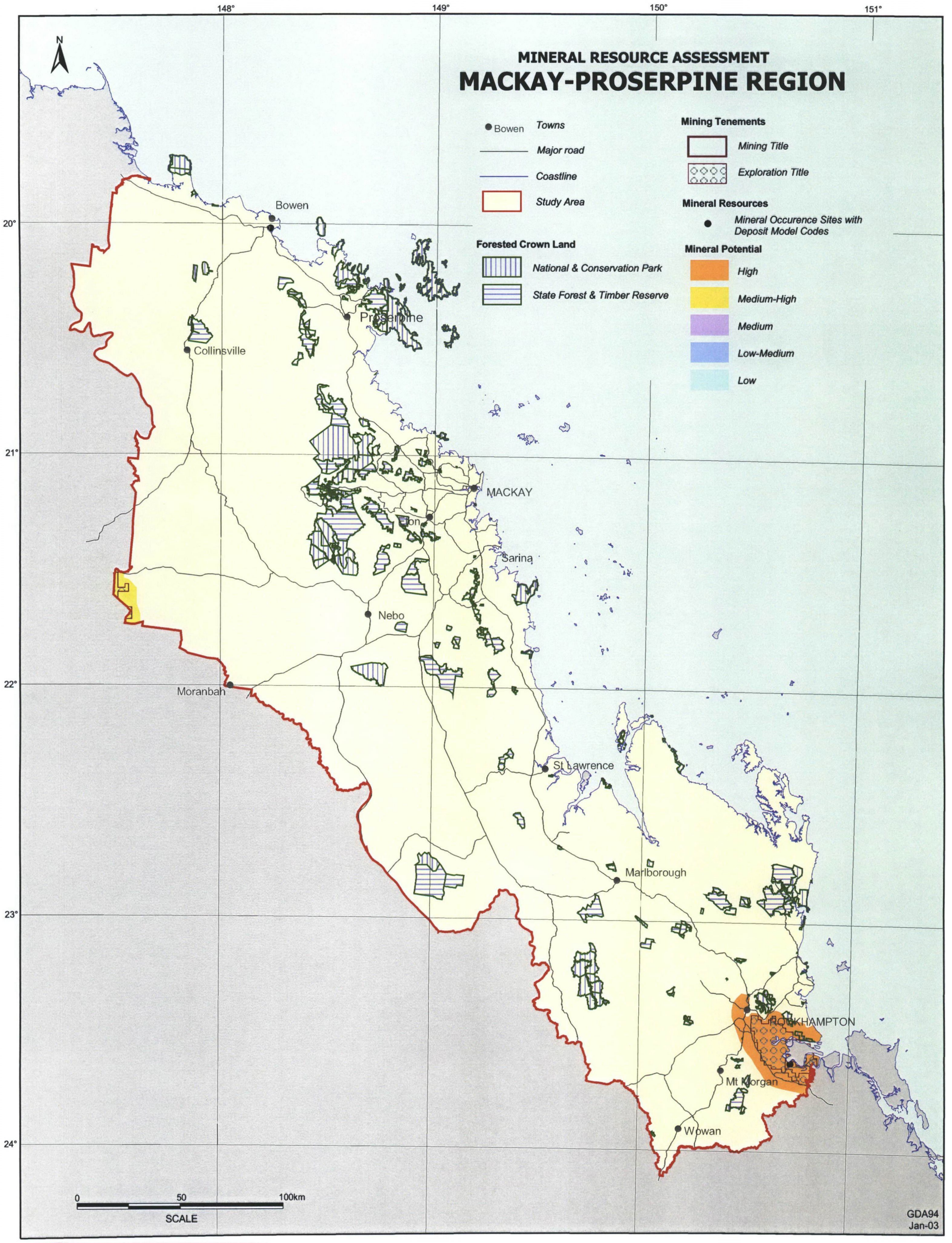
Figure 22B Potential for Brine and Phosphate Deposits



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GLOSSARY OF TERMS

alluvium

Rocks consisting of unconsolidated or poorly consolidated gravels, sands, clays, and formed from stream and river activity.

basalt

A general term for dark-coloured mafic igneous rocks, commonly extrusive but locally intrusive (eg dykes), composed chiefly of calcic plagioclase and clinopyroxene; the fine-grained equivalent of gabbro.

basic

An igneous rock having a relatively low silica content, sometimes delimited arbitrarily as 44 to 51% to 45 to 52% SiO_2; e.g. gabbro, basalt. Basic rocks are relatively rich in iron, magnesium, and/or calcium, and thus include most mafic rocks as well as other rocks. "Basic" is one of four subdivisions of a widely used system for classifying igneous rocks based on their silica content: acidic, intermediate, basic, and ultrabasic.

basin

Bent down or settled part of the earth's crust in the form of a basin.

Cambrian

The earliest period of the Palaeozoic era, thought to have covered the span of time between 570 and 500 million years ago.

Carboniferous

Period of late Palaeozoic time, ranging from about 360 to about 295 million years ago; also, the corresponding system of rocks.

Cretaceous

The final period of the Mesozoic era (after the Jurassic and before the Tertiary period of the Cenozoic era), thought to have covered the span of time between 135 and 65 million years ago; also, the corresponding system of rocks.

Devonian

A period of the Paleozoic era (after the Silurian and before the Carboniferous), thought to have covered the span of time between 410 and 360 million years ago; also, the corresponding system of rocks.

epithermal

A hydrothermal mineral deposit formed within about 1 kilometre of the earth's surface and in the temperature range of 50°-200°C, occurring mainly as veins.

EPC

Exploration permit for coal.

EPM

Exploration permit for minerals.

EPP

Exploration permit for petroleum

fault

A fracture or a zone of fractures along which there has been displacement of the sides relative to one another parallel to the fracture.

formation

A body of rock identified by lithic characteristics and stratigraphic position; it is prevailingly but not necessarily tabular, and is mappable at the earth's surface or traceable in the subsurface.

gabbro

A group of dark-coloured, basic intrusive igneous rocks composed principally of basic plagioclase (commonly labradorite or bytownite) and clinopyroxene (augite), with or without olivine and orthopyroxene; also, any member of that group. It is the approximate intrusive equivalent of basalt. Apatite and magnetite or ilmenite are common accessory minerals.

granite

A plutonic rock in which quartz constitutes 10 to 50 percent of the felsic components and in which the alkali feldspar/total feldspar ratio is more than 35 percent..

hydrothermal

Of or pertaining to hot water, to the action of hot water, or to the products of this action, such as a mineral deposit precipitated from a hot aqueous solution, with or without demonstrable association with igneous processes.

intrusive

A rock formed at considerable depth by crystallization of magma and/or by chemical alteration. It is characteristically medium- to coarse-grained, of granitoid texture.

Jurassic

The second period of the Mesozoic era (after the Triassic and before the Cretaceous), thought to have covered the span of time between 200 and 135 million years ago; also, the corresponding system of rocks.

laterite

An intrazonal, hydromorphic group of soils having an A2 horizon containing concretions that is underlain by a hardpan composed of iron and aluminium compounds. These soils are formed in warm-temperate to tropical climates in response to a fluctuating water table.

LTOM

Litres per tonne at zero moisture.

mafic

Said of an igneous rock composed chiefly of one or more ferromagnesian, dark-coloured minerals in its mode; also, said of those minerals.

Marble

Metamorphic rock type derived originally from limestone.

MC

Mining claim.

MDL

Mineral Development Licences.

mesothermal

A hydrothermal mineral deposit formed at considerable depth and in the temperature range of 200°-300°C.

metamorphic rock

Any rock derived from pre-existing rocks by mineralogical, chemical, and/or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment, generally at depth in the earth's crust.

mineral deposit model

Systematically arranged information describing the essential attributes of a class of mineral deposit. The model may be empirical (descriptive), in which case the various attributes are recognised as essential even though their relationships are unknown; or it may be theoretical (genetic), in which case the attributes are interrelated through some fundamental concept.

mineral occurrence

Any ore or economic mineral in any concentration found in bedrock or as float; a valuable mineral in sufficient concentration to suggest further exploration.

ML

Mining lease

Naphtha

A vague name for the liquid inflammable distillates from oil shale, especially the light gasoline like fraction.

Neoproterozoic

The upper geochronometric subdivision of the Proterozoic, including the rocks between 1000 and 570Ma.

Permian

The last period of the Palaeozoic era (after the Carboniferous), thought to have covered the span of time between 295 and 250 million years ago; also, the corresponding system of rocks.

Permo-Triassic

The last period of the Palaeozoic era extending into the first period of the Mesozoic era.

PL

Petroleum lease.

placer

A surficial mineral deposit formed by mechanical concentration of mineral particles from weathered debris. The common types are beach placers and alluvial placers. The mineral concentrated is usually a heavy mineral such as gold, cassiterite, or rutile.

porphyry

An igneous rock of any composition that contains conspicuous phenocrysts in a fine-grained groundmass; a porphyritic igneous rock. The rock name descriptive of the groundmass composition usually precedes the term, e.g. diorite porphyry.

prospective

Potential or likely occurrence of an economic deposit.

pyroclastic

Clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic vent.

sedimentary rock

A rock resulting from the consolidation of loose sediment that has accumulated in layers; e.g. a clastic rock (such as conglomerate) consisting of mechanically formed fragments of older rock transported from its source and deposited in water or from air or ice; or a chemical rock (such as rock salt or gypsum) formed by precipitation from solution; or an organic rock (such as certain limestones) consisting of the remains or secretions of plants and animals.

serpentinite

A rock consisting almost wholly of serpentine-group minerals, (antigorite, chrysotile, lizardite) derived from the alteration of ferromagnesian silicate minerals such as olivine and pyroxene. Accessory chlorite, talc, and magnetite may be present.

shale gas

Gas derived from shale rock units. Classified as continuous natural gas plays – accumulations that are pervasive throughout large geographic areas and offer long-lived reservoirs.

skarn

Old Swedish mining term for silicate gangue (amphibole, pyroxene, garnet, etc.) of certain iron-ore and sulphide deposits, particularly those that have replaced limestone and dolomite. Its meaning has been generally expanded to include lime-bearing silicates, derived from nearly pure limestone and dolomite with the introduction of large amounts of Si, Al, Fe and Mg.

source rock

Sedimentary rock in which organic material under pressure, heat, and time was transformed to liquid or gaseous hydrocarbons. Source rock is usually shale or limestone.

tectonic setting

Described by geological features such as depositional environment, structural controls, rock type, and magmatic history. The mutual relationships and historical evolution of these features determining the type of mineral deposits formed.

Tertiary

The first period of the Cenozoic era (after the Cretaceous of the Mesozoic era and before the Quaternary), thought to have covered the span of time between 65 and three to two million years ago.

Triassic

The first period of the Mesozoic era (after the Permian of the Palaeozoic era, and before the Jurassic), thought to have covered the span of time between 250 and 200 million years ago; also, the corresponding system of rocks.

ultramafic

Said of an igneous rock composed chiefly of mafic minerals, e.g. monomineralic rocks composed of hypersthene, augite, or olivine.

volcanic rock

A generally finely crystalline or glassy igneous rock resulting from volcanic action at or near the earth's surface, either ejected explosively or extruded as lava; e.g. basalt. The term includes near-surface intrusions that form a part of the volcanic structure.

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APPENDIX 1

DESCRIPTION OF DATA SETS USED IN THE MACKAY PROSERPINE REGION MINERAL RESOURCE ASSESSMENT (POTENTIAL)

DATA SET NAME	DESCRIPTION	CURRENCY	COMMENTS SOURCE
Exploration Permit Minerals (EPM)	Defines the extent (by one minute square subblocks) on the ground for exploration title		Natural Resources and Mines (NRM) Mining Tenure Database
Exploration Permit Coal (EPC)	Defines the extent (by one minute square subblocks) on the ground for exploration title		Natural Resources and Mines (NRM) Mining Tenure Database
Exploration Permit Petroleum (EPP)	Defines the extent (by five minute square blocks) on the ground for exploration title		Natural Resources and Mines (NRM) Mining Tenure Database
Mineral Development Licences (MDL)	Defines the extent (by one minute square subblocks) on the ground for the licence		Natural Resources and Mines (NRM) Mining Tenure Database
Mining Lease (MDL)	Defines the extent on the ground for the mining lease		Natural Resources and Mines (NRM) Mining Tenure Database
Petroleum License (PL)	Defines the extent on the ground for the petroleum license		Natural Resources and Mines (NRM) Mining Tenure Database
Mackay-Proserpine Region	Geographic Extent of the Mackay-Proserpine Region		Natural Resources and Mines (NRM)
Estates/Forested Crown Lands	State Forests and Timber Reserves, Conservation and National Parks		Environmental Protection Agency (EPA)
Bowen Basin Geology	Digital solid geology of the Bowen Region at a resolution/scale of 1:500 000	1986	Natural Resources and Mines (NRM) Compiled from original maps from 250 000 scale field mapping (1960/1970) GSQ and BMR
Bowen 1:250 000 Sheet Area Geology	Digital geology of the Bowen Region at a resolution/scale of 1:100 000	1971	Natural Resources and Mines (NRM) Compiled from original maps from 85000 scale field mapping (1965-70) GSQ
Proserpine 1:250 000 Sheet Area Geology	Digital geology of the Proserpine Region at a resolution/scale of 1:100 000	1971	Natural Resources and Mines (NRM) Compiled from original maps from 85000 scale field mapping (1967) GSQ
Ayr 1:250 000 Sheet Area Geology	Digital geology of the Ayr Region at a resolution/scale of 1:100 000	1968	Natural Resources and Mines (NRM) Compiled from original maps from 85000 scale field mapping (1964) GSQ
Mount Coolon 1:250 000 Sheet Area Geology	Digital geology of the Mount Coolon Region at a resolution/scale of 1:100 000	1997	Natural Resources and Mines (NRM) Compiled from field mapping/air photos (1990's) GSQ
Burdekin Area Geology	Digital geology of the Burdekin River Region at a resolution/scale of 1: 500 000	1971	Natural Resources and Mines (NRM) Compiled from original maps from 85000 scale field mapping (1980) GSQ
Marlborough 1:100 000 Sheet Area Geology	Digital geology of the Marlborough Region at a resolution/scale of 1: 100 000	2000	Natural Resources and Mines (NRM) Compiled from field mapping/air photos at 26500 scale (1990's) GSQ
Yarrol 1:100 000 Sheet Area Geology	Digital geology of the Yarrol Region at a resolution/scale of 1: 25 000 to 1:50 000	August 2001	Natural Resources and Mines (NRM) Compiled from field mapping/air photos (1990's) by GSQ

APPENDIX 2

APPENDIX 2: BOWEN BASIN – PROSPECTIVE COAL MEASURES AND OPERATING MINES

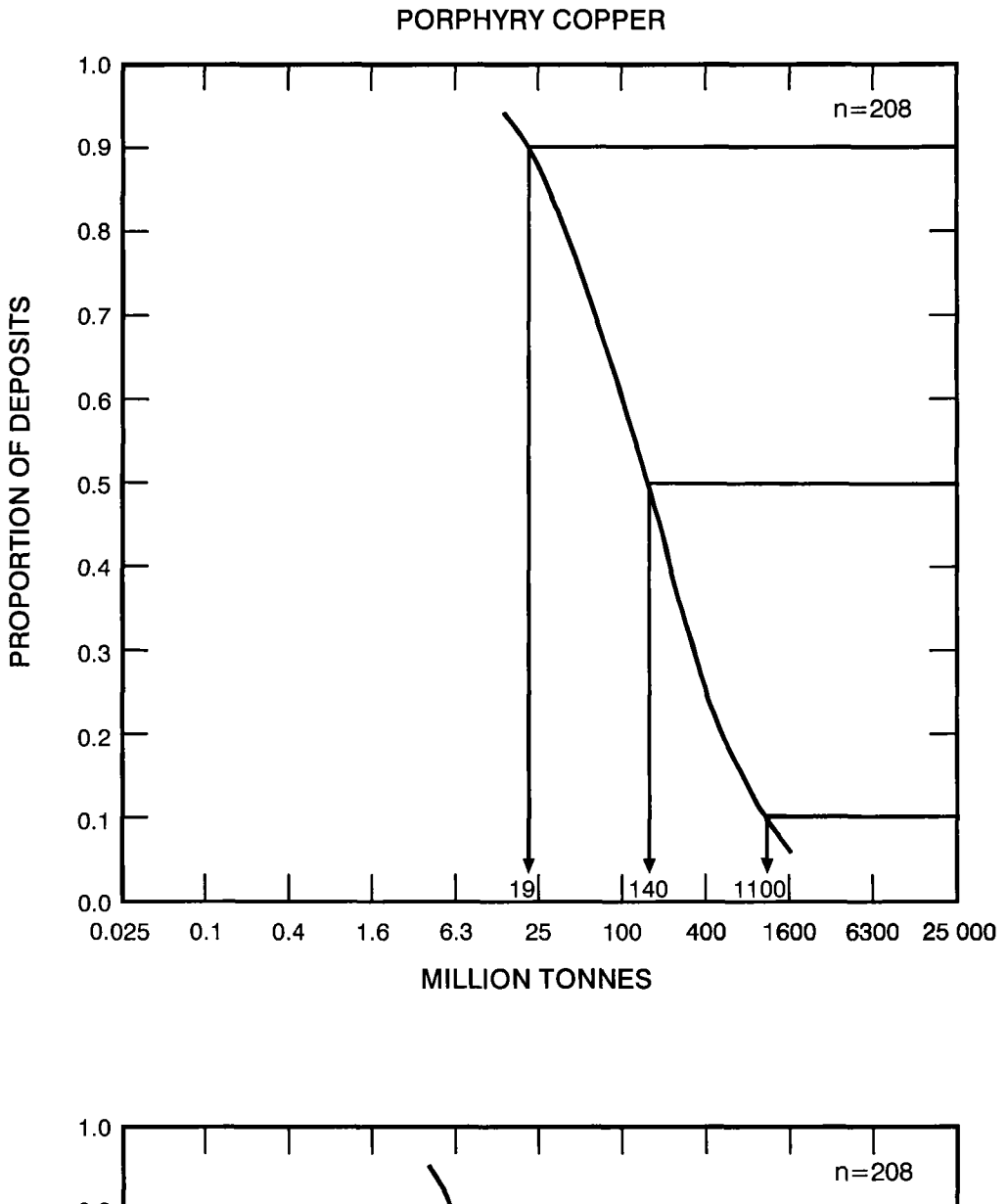
Coal Group	Age	Description	Coal Bearing Sequence	Operating Mines
IV	Late Permian	This is the most diverse group in terms of quality, and also the most widely distributed within the basin. Although the quality and rank of Group IV coals vary greatly, they are characterised by comparatively low reactives content and low levels of sulphur. They are of major economic importance as a source of both coking and non-coking coal, and have been extensively mined for many years.	Rangal Coal Measures	Moura O/C BlackwaterO/C Curragh O/C YarrabeeO/C Jellinbah East O/C Cook U/G Ensham O/C Foxleigh O/C *Coppabella O/C *Burton O/C *Newlands O/C *Newlands U/G *South Walker Creek O/C
III	Late Permian	Group III coal include major deposits of high grade coking coal which are mined, mainly by open cut methods, in a number of operations extending from Kestrel mine near Emerald, to Riverside north of Moranbah. These mines produce high quality coking coal. All production of Group III coal is currently exported.	German Creek Formation Moranbah Coal Measures	Kestrel U/G Crinum U/G Gregory O/C Oaky Creek O/C, Oaky North & No1 U/G German Creek East O/C Southern U/G Central U/G Norwich Park O/C Saraji O/C Peak Downs O/C Moranbah North U/G *Goonyella O/C & Riverside O/C *North Goonyealla U/G
II	Early Permian	Group II coal measure include several unconnected deposits around the northern and western margins of the basin: the Collinsville Coal Measures; the coal measures at Rugby; and a group of deposits in the Clermont area, including the Blair Athol and Wolfang Basins.	Collinsville Coal Measures Blair Athol Coal Measures	*Collinsville O/C Blair Athol O/C
I	Early Permian	Group I is represented by the Reids Dome beds, a unit of highly variable thickness and lithology. Distribution is restricted to the south-western part of the basin. In the southern Denison Trough, seams in the Reids Dome beds attain thicknesses in excess of 30m, but at considerable depth. Further north the seams are thinner but nearer the surface; shallow resources of good quality, non-coking coal have been delineated in the Capella area. No mining of Group I coal has yet occurred. Warrants further exploration.	Reids Dome beds	Nil

* within Mackay-Proserpine Project Area

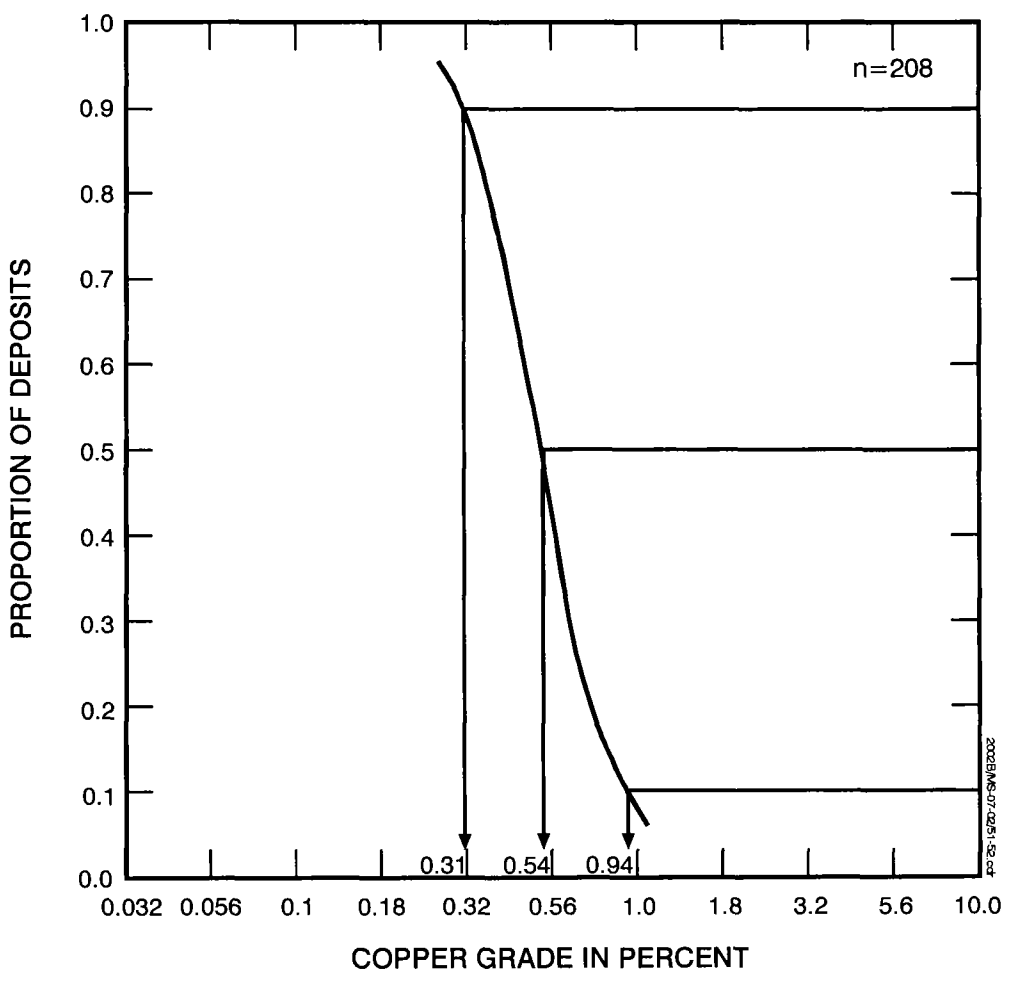
APPENDIX 3

GRADE AND TONNAGE MODELS

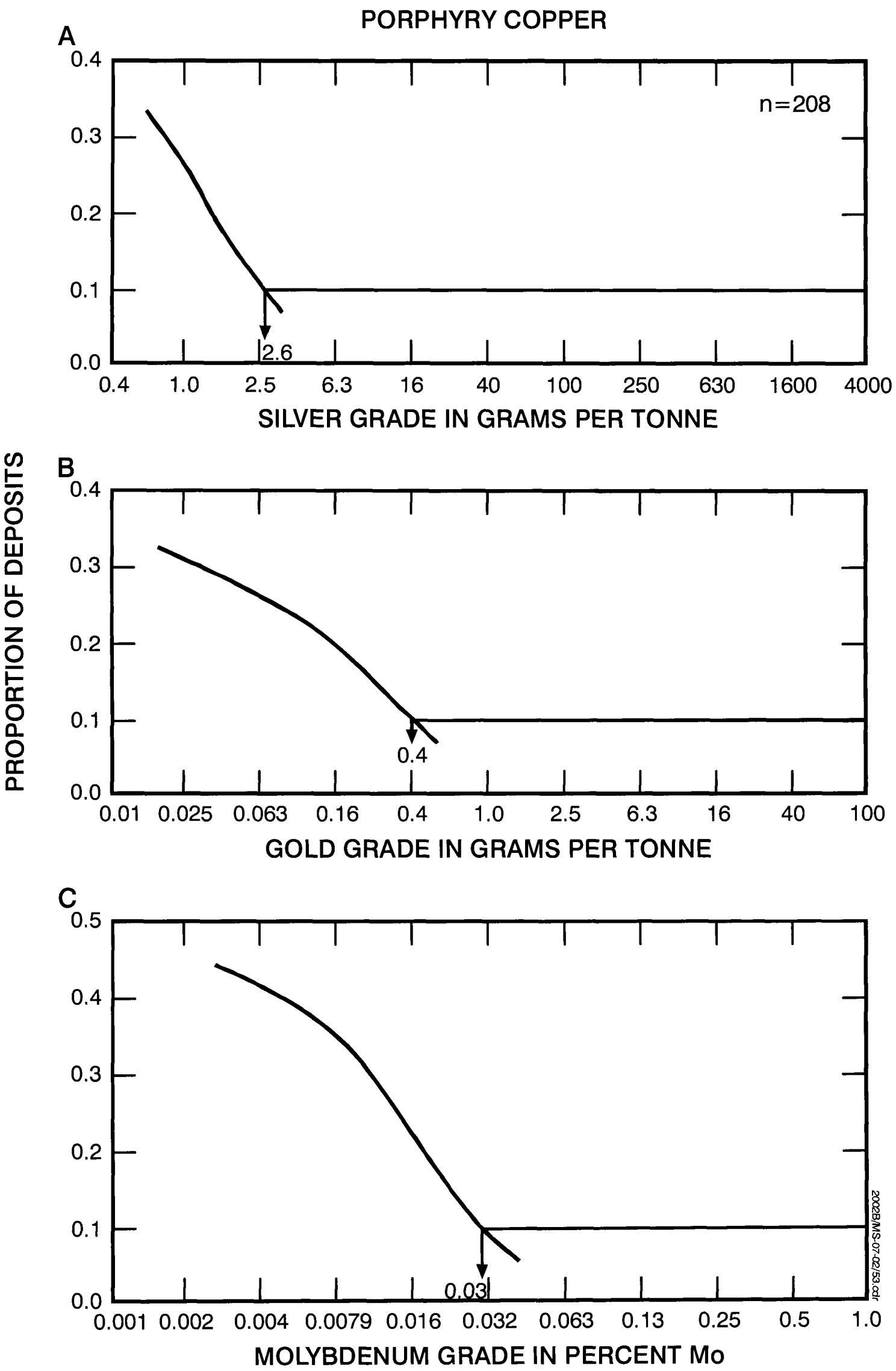
(Source USGS BULLETIN 1693)



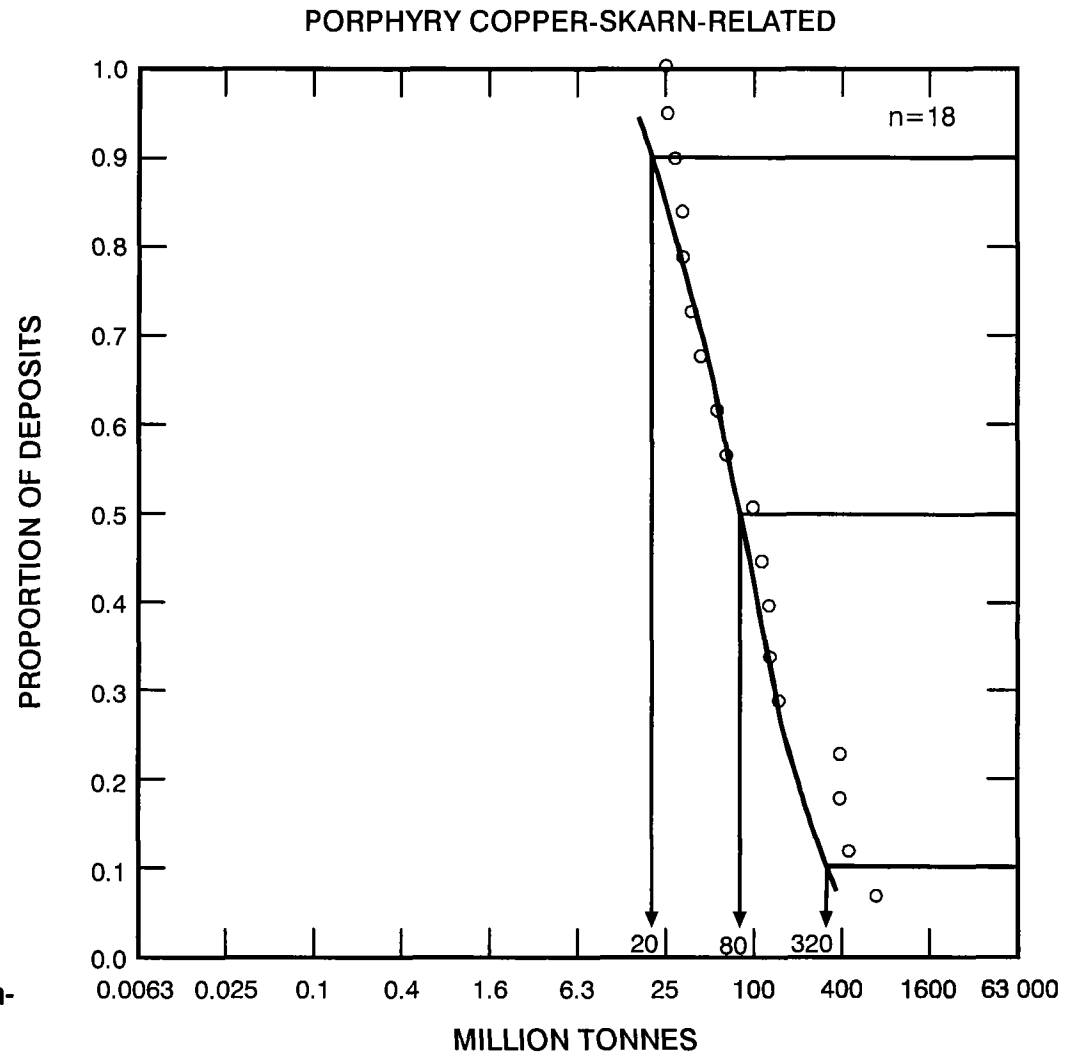
Tonnages of porphyry Cu deposits



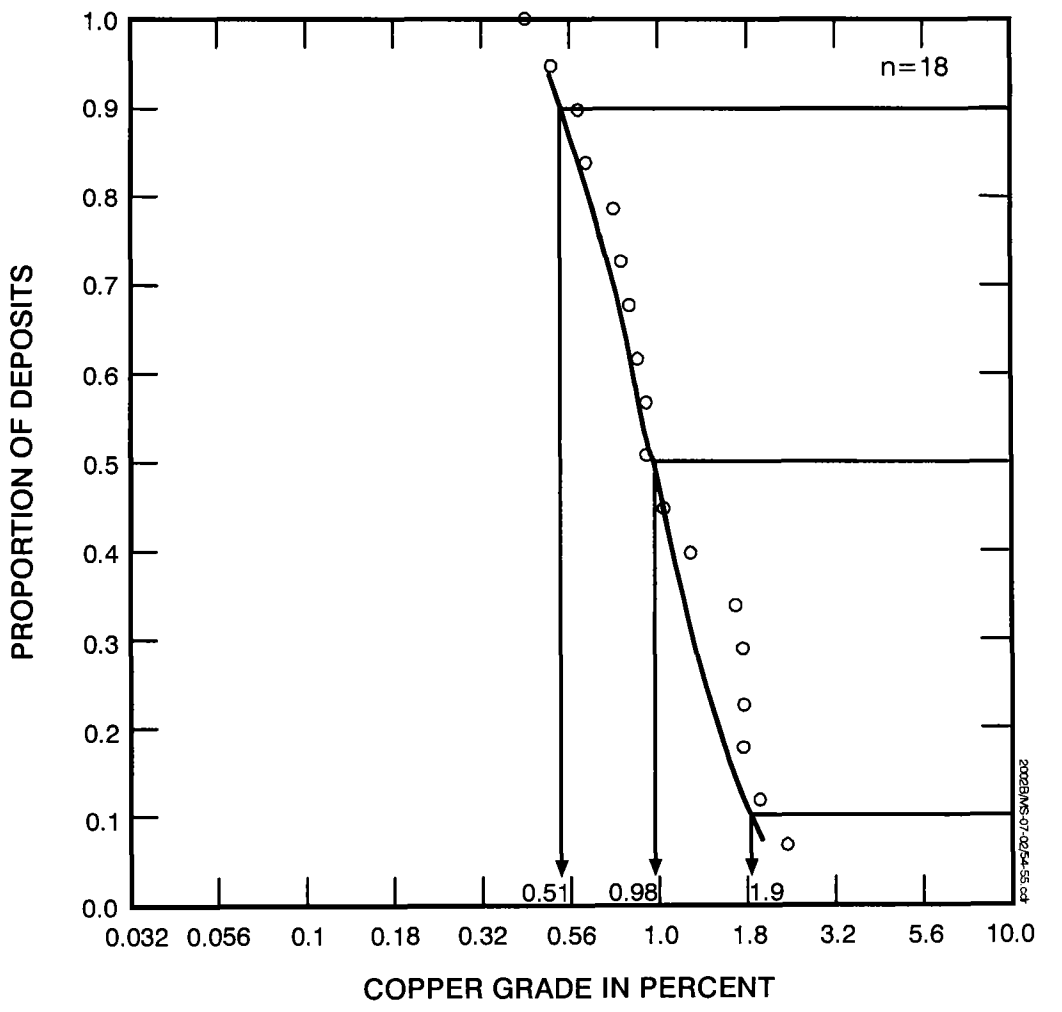
Copper grades of porphyry Cu deposits



By-product grades of porphyry Cu deposits
A, Silver; B, Gold; C, Molybdenum

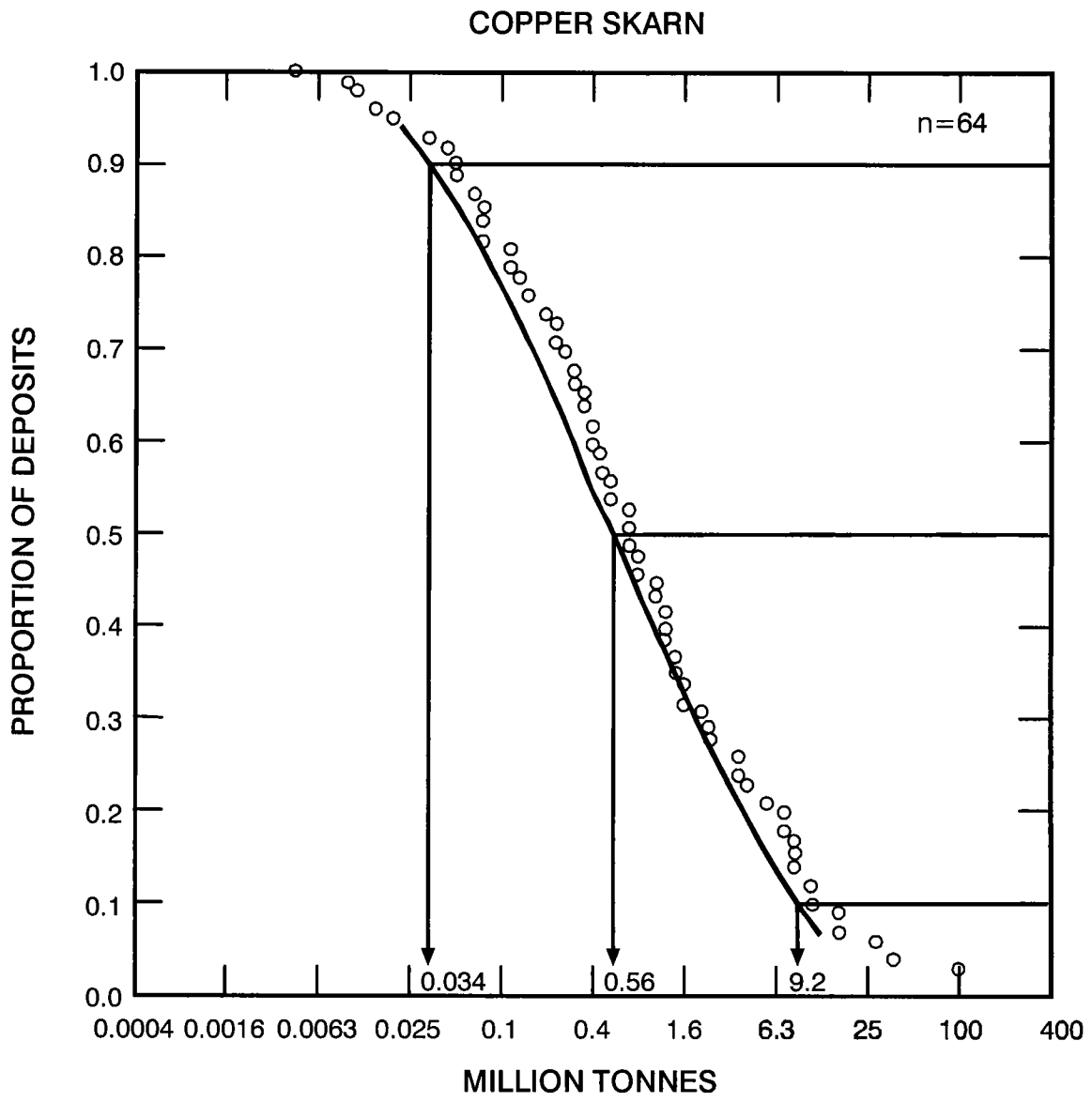


Tonnages of porphyry Cu-skarn-related deposits

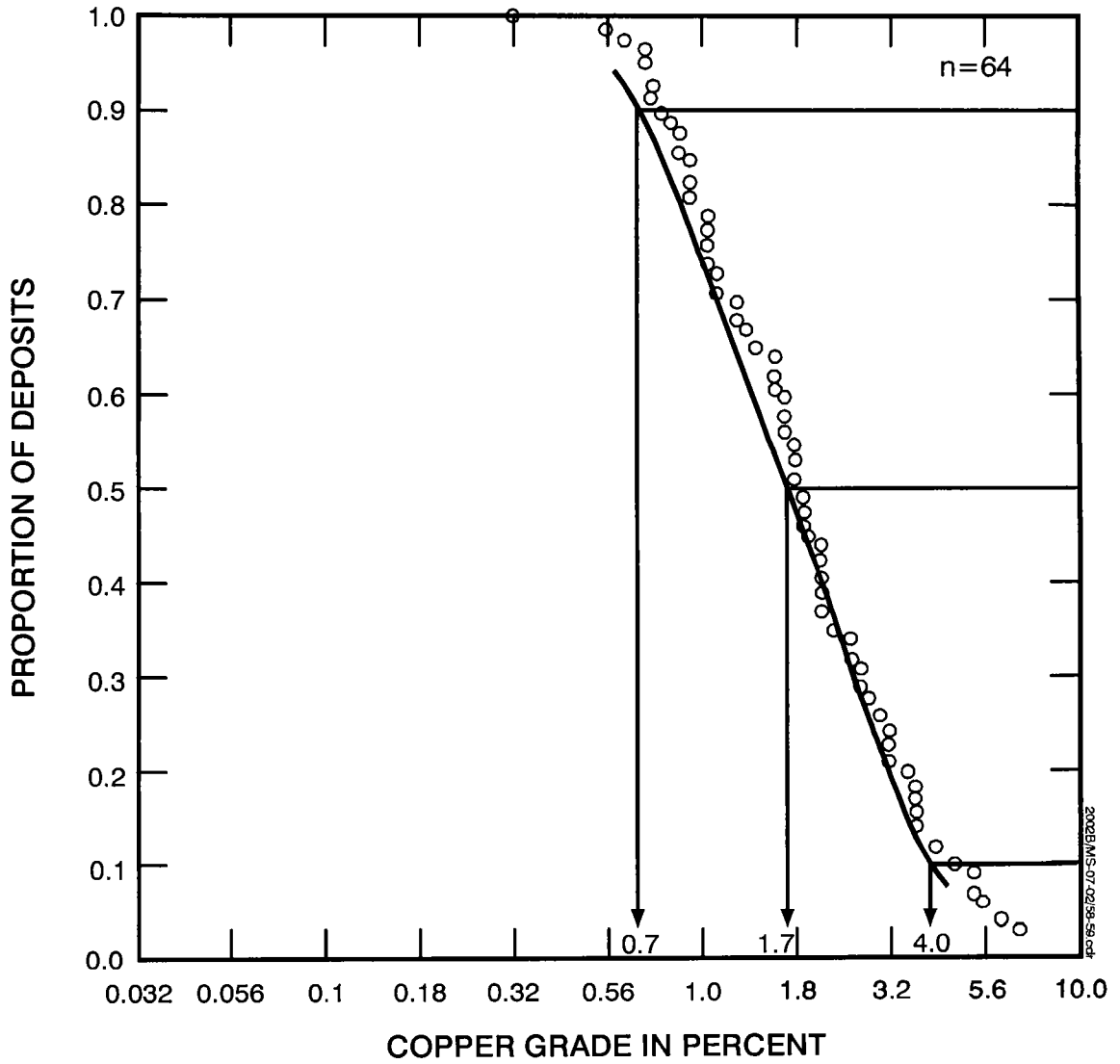


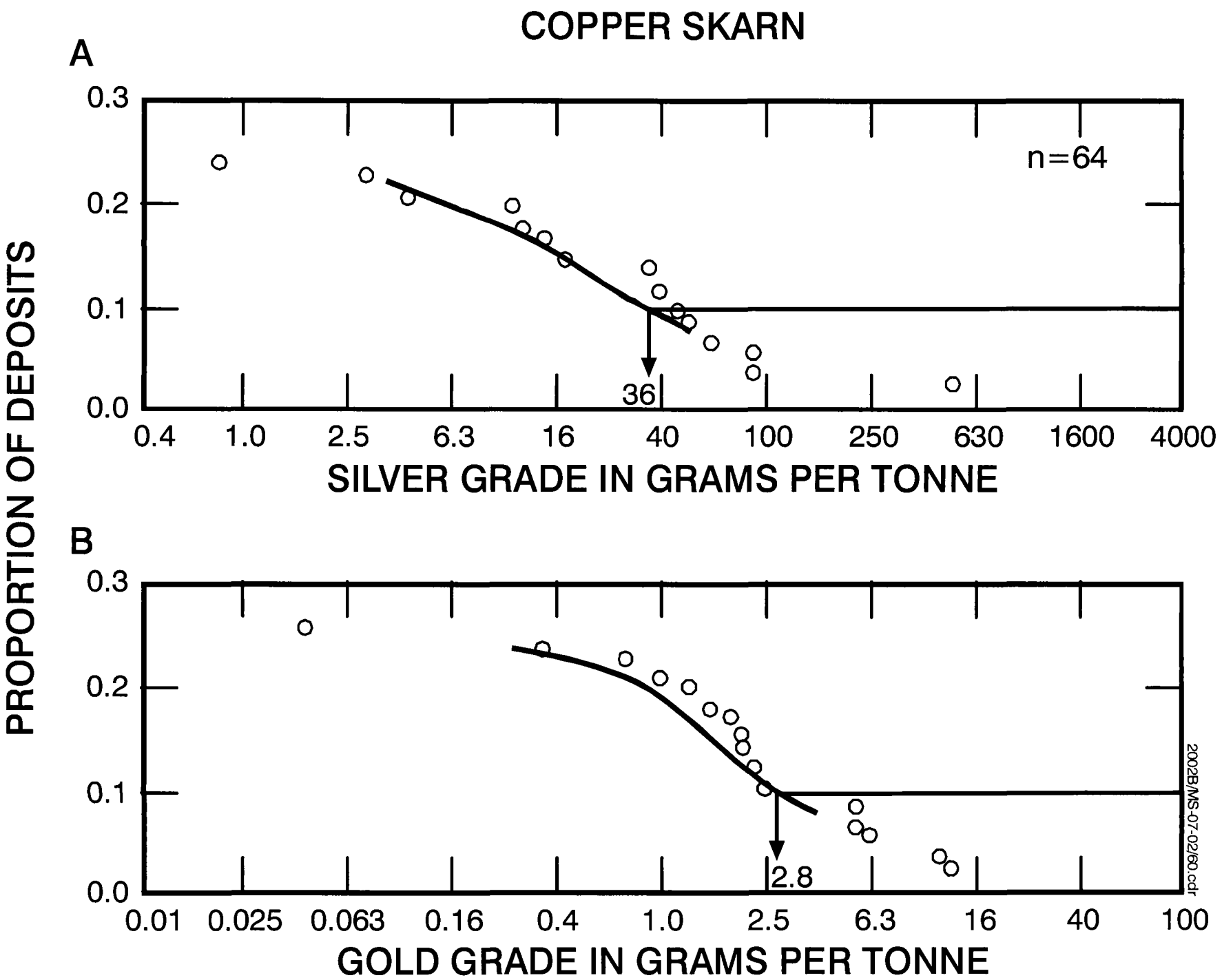
Copper grades of porphyry Cu-skarn-related deposits

Tonnages of Cu skarn deposits



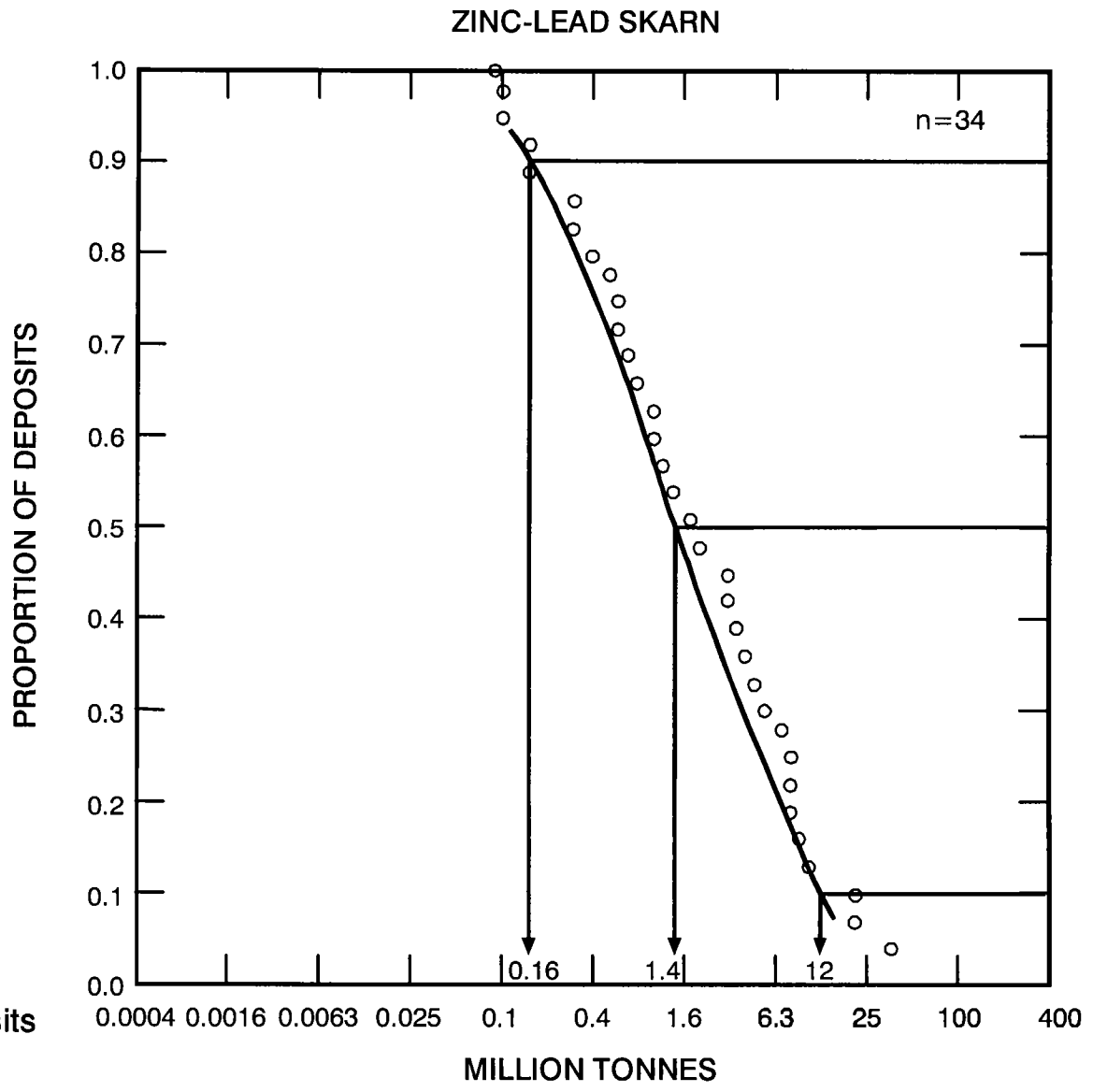
Copper grades of Cu skarn deposits



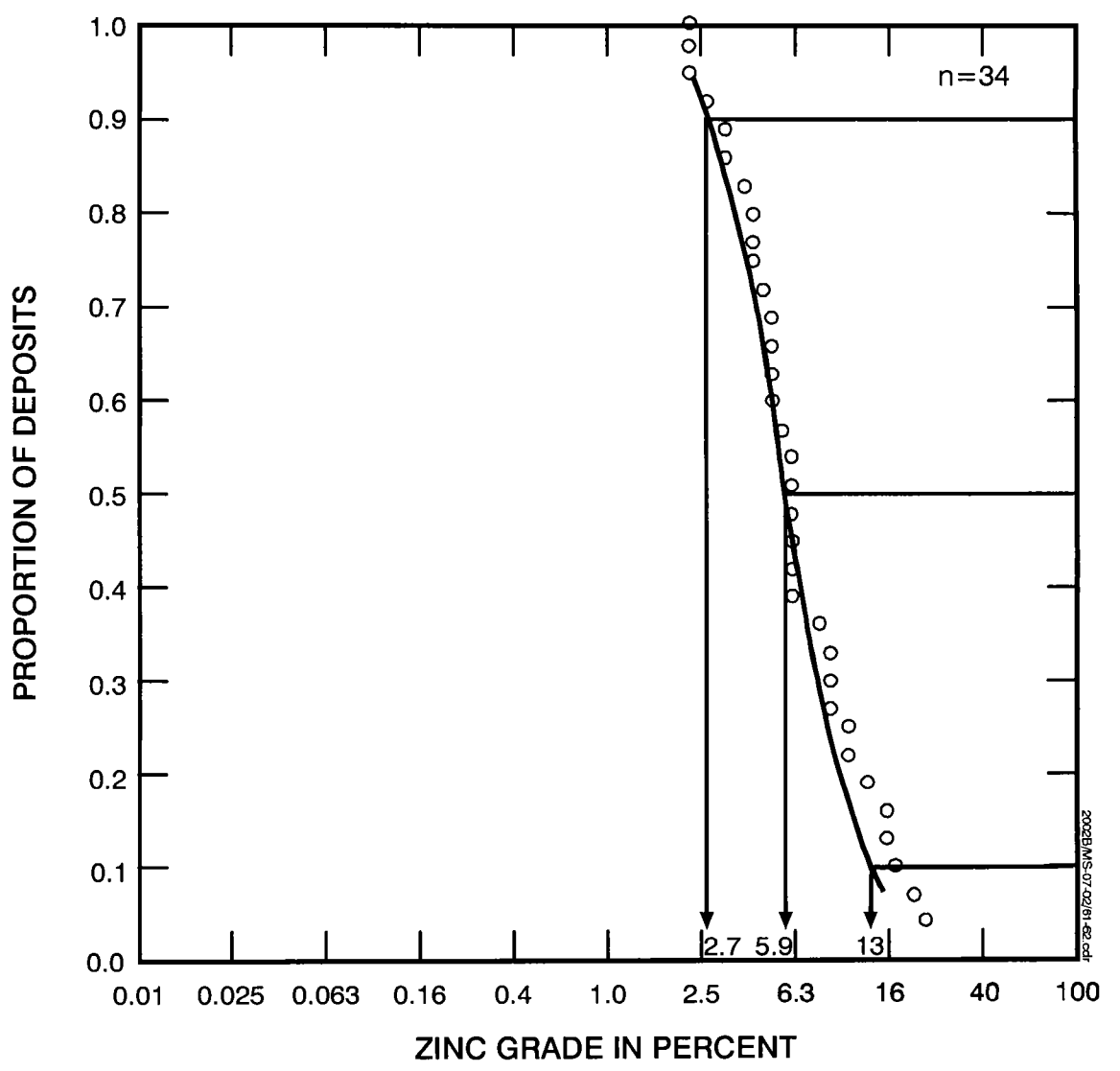


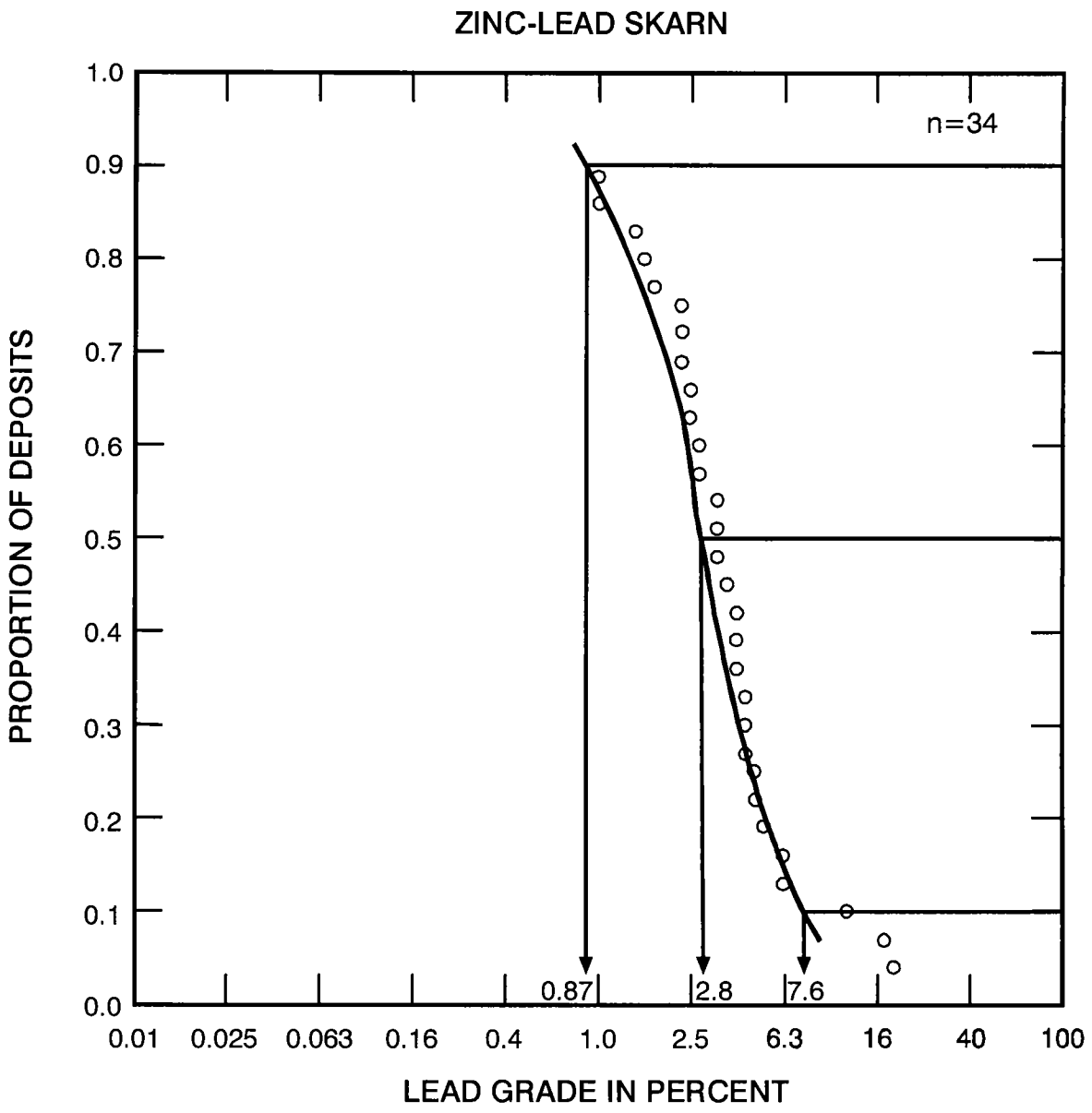
Precious-metal grades of Cu skarn deposits
A, Silver; B, Gold

Tonnages of Zn-Pb skarn deposits

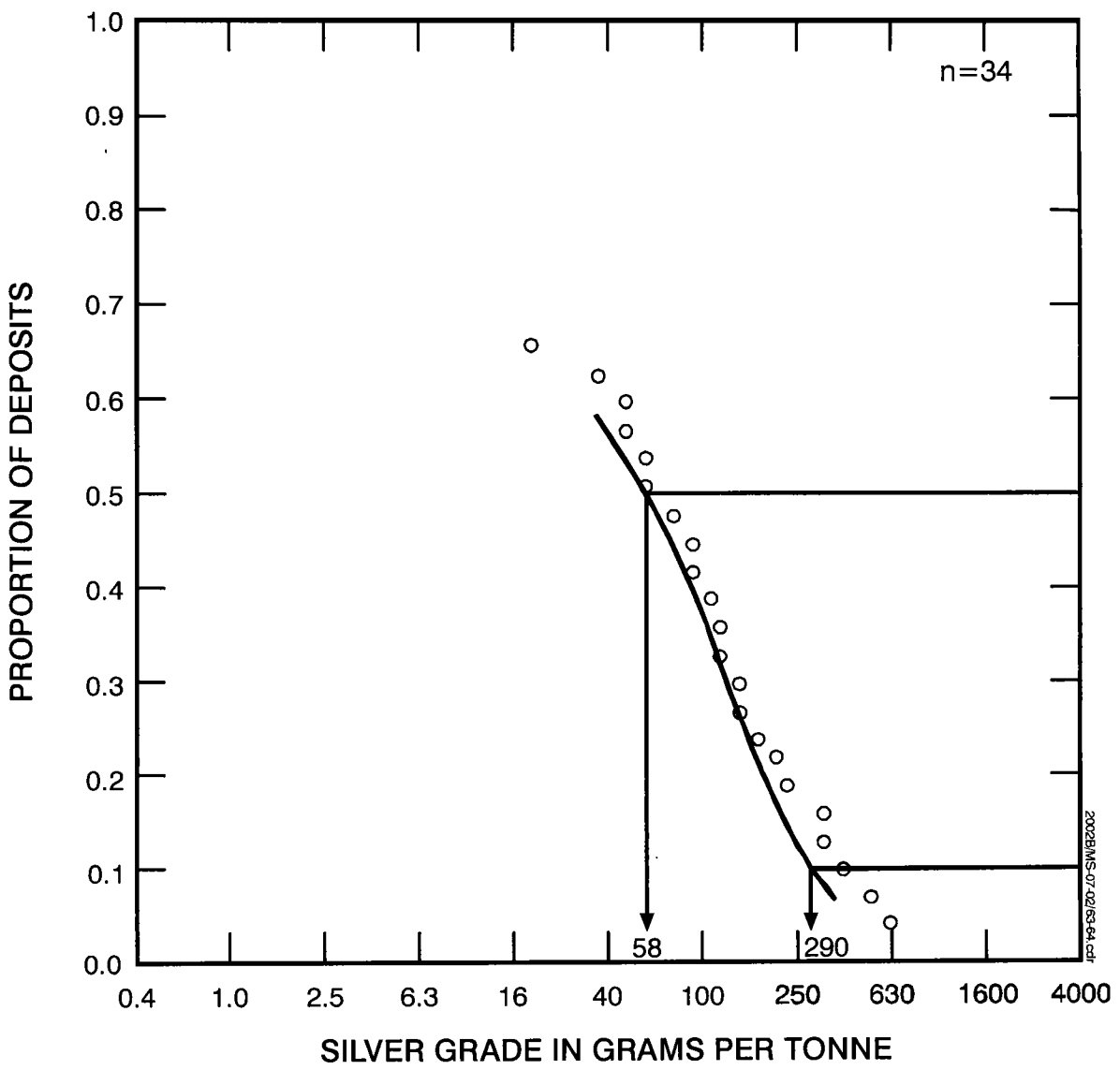


Zinc grades of Zn-Pb skarn deposits

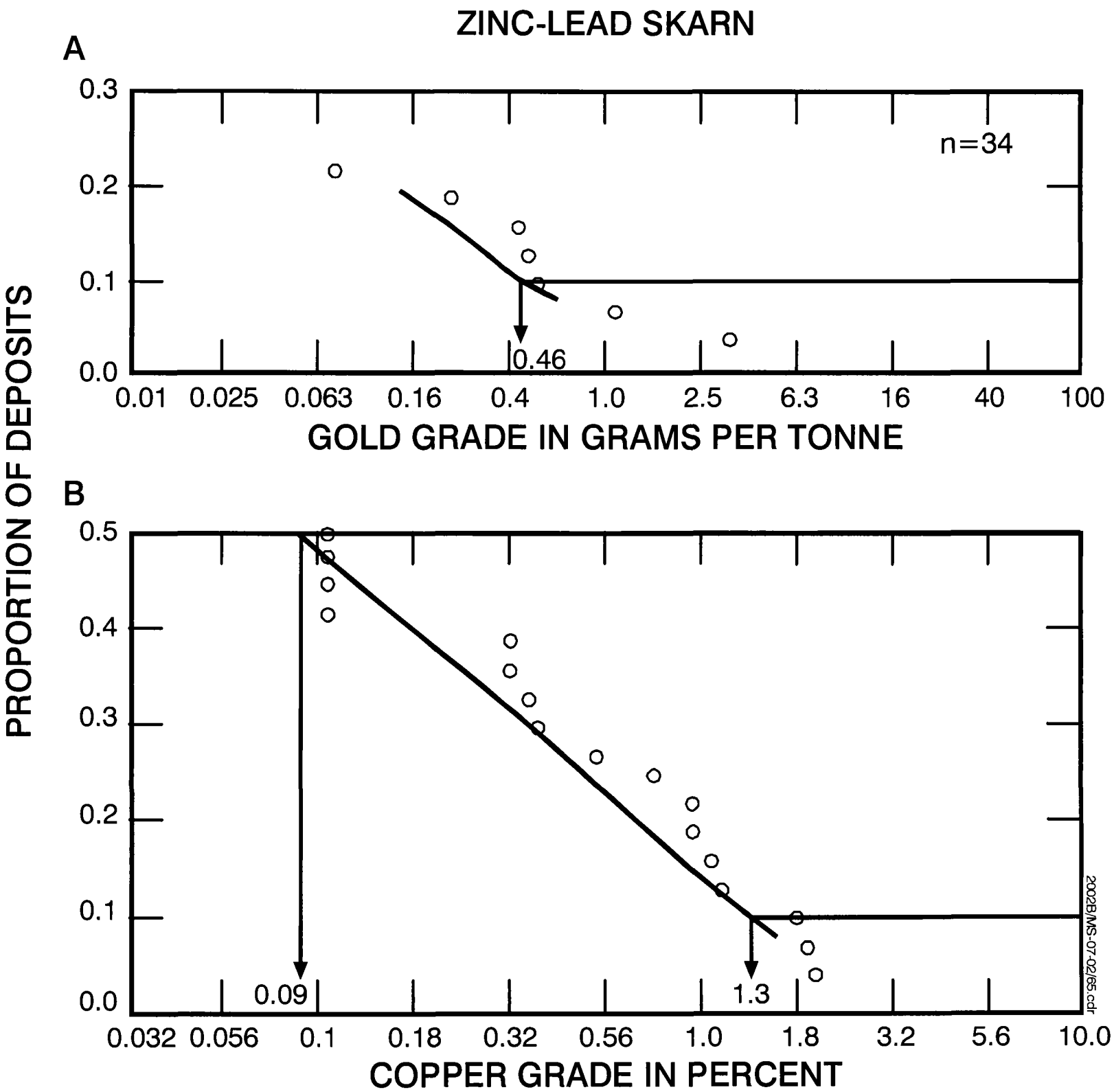




Lead grades of Zn-Pb skarn deposits

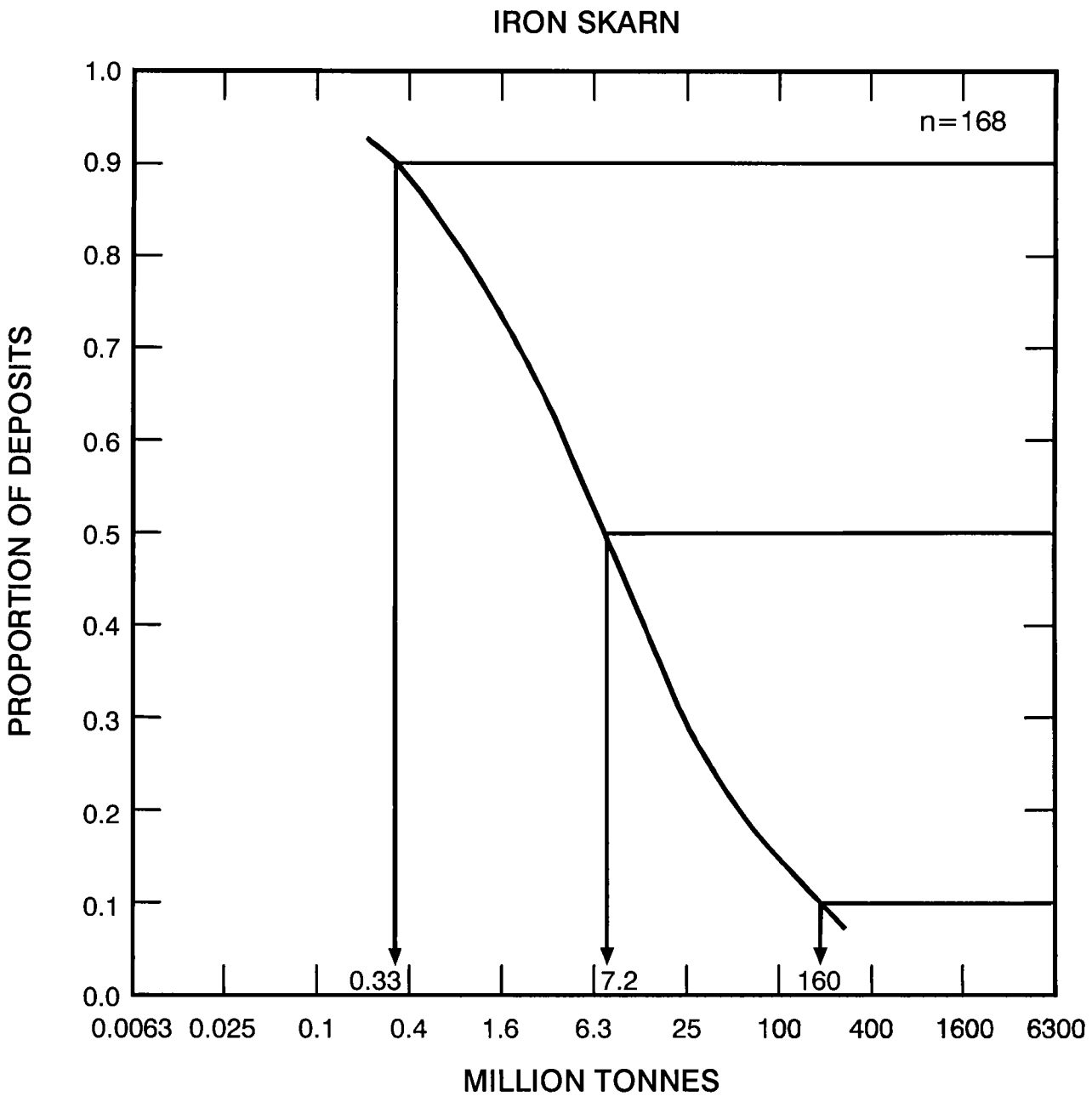


Silver grades of Zn-Pb skarn deposits

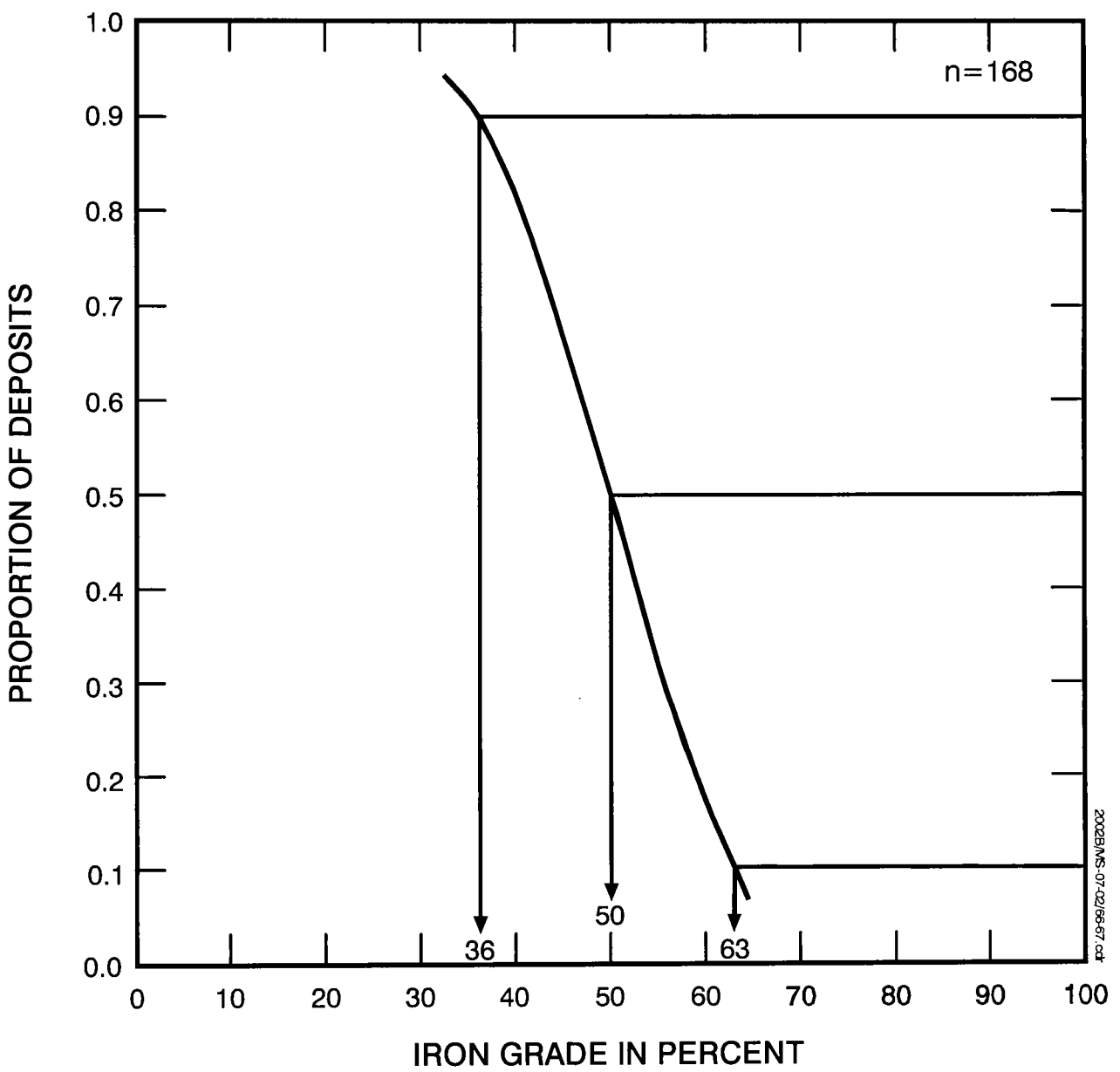


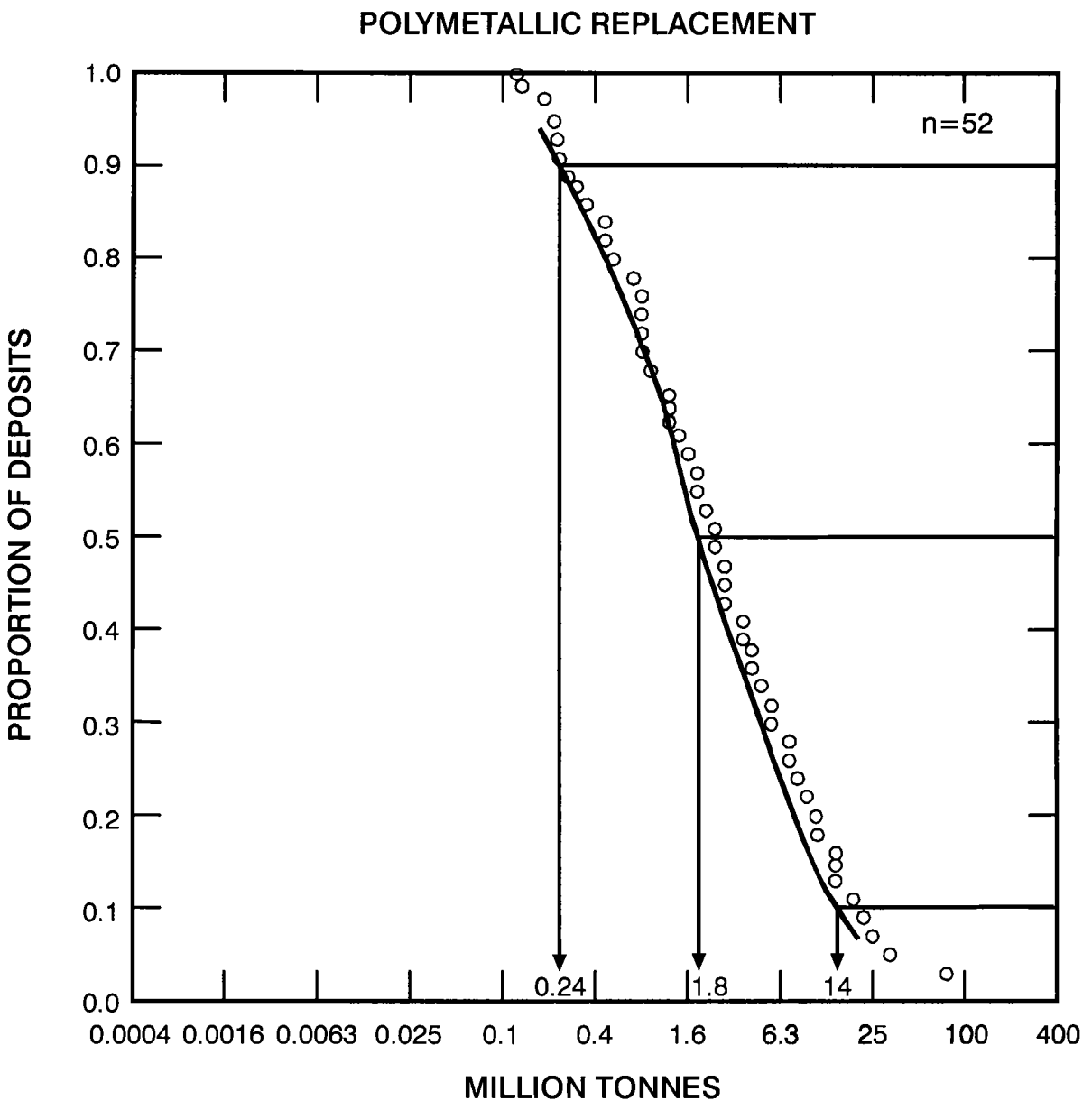
Metal grades of Zn-Pb skarn deposits
A, Gold; B, Copper

Tonnages of Fe skarn deposits

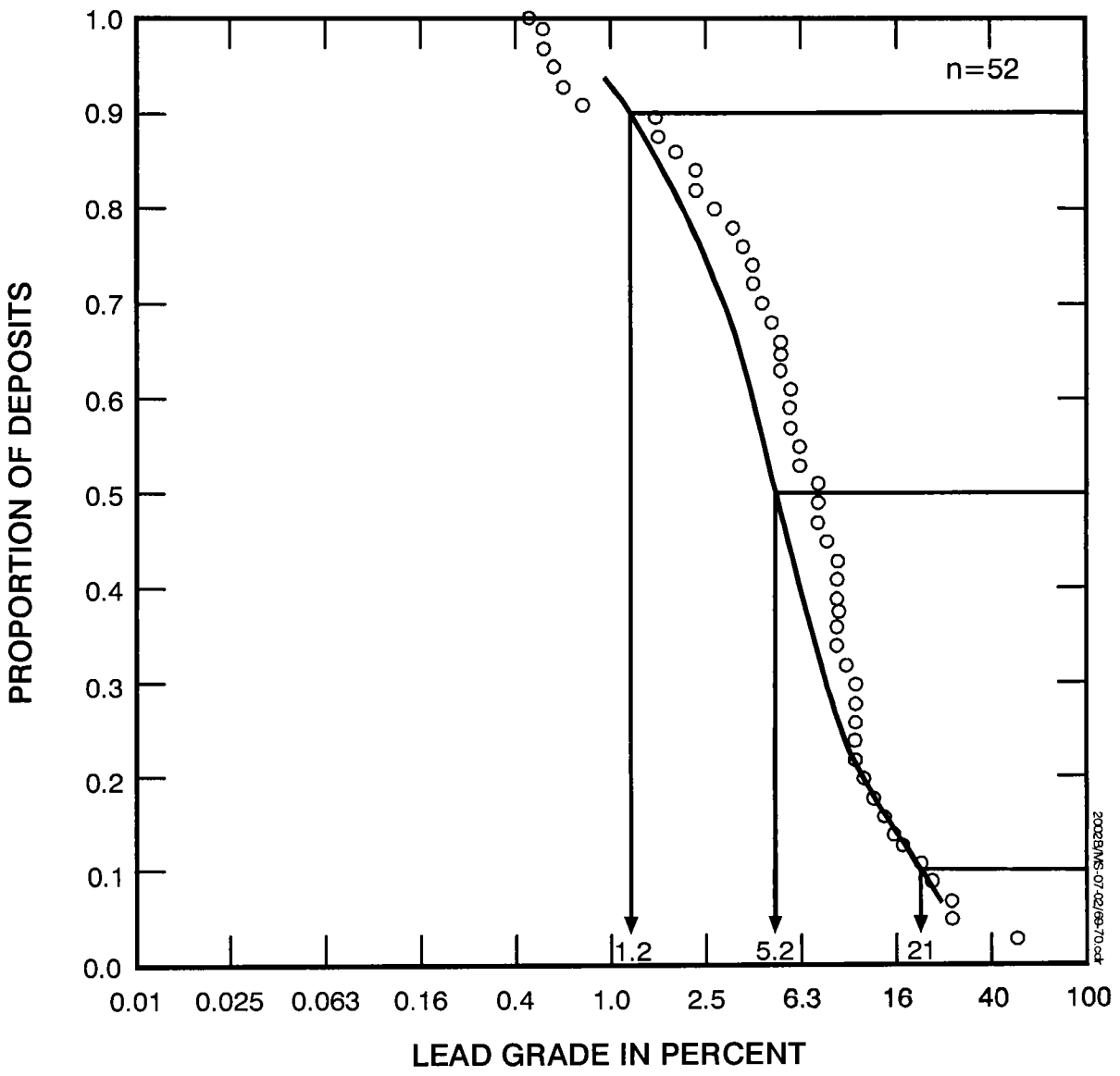


Iron grades of Fe skarn deposits

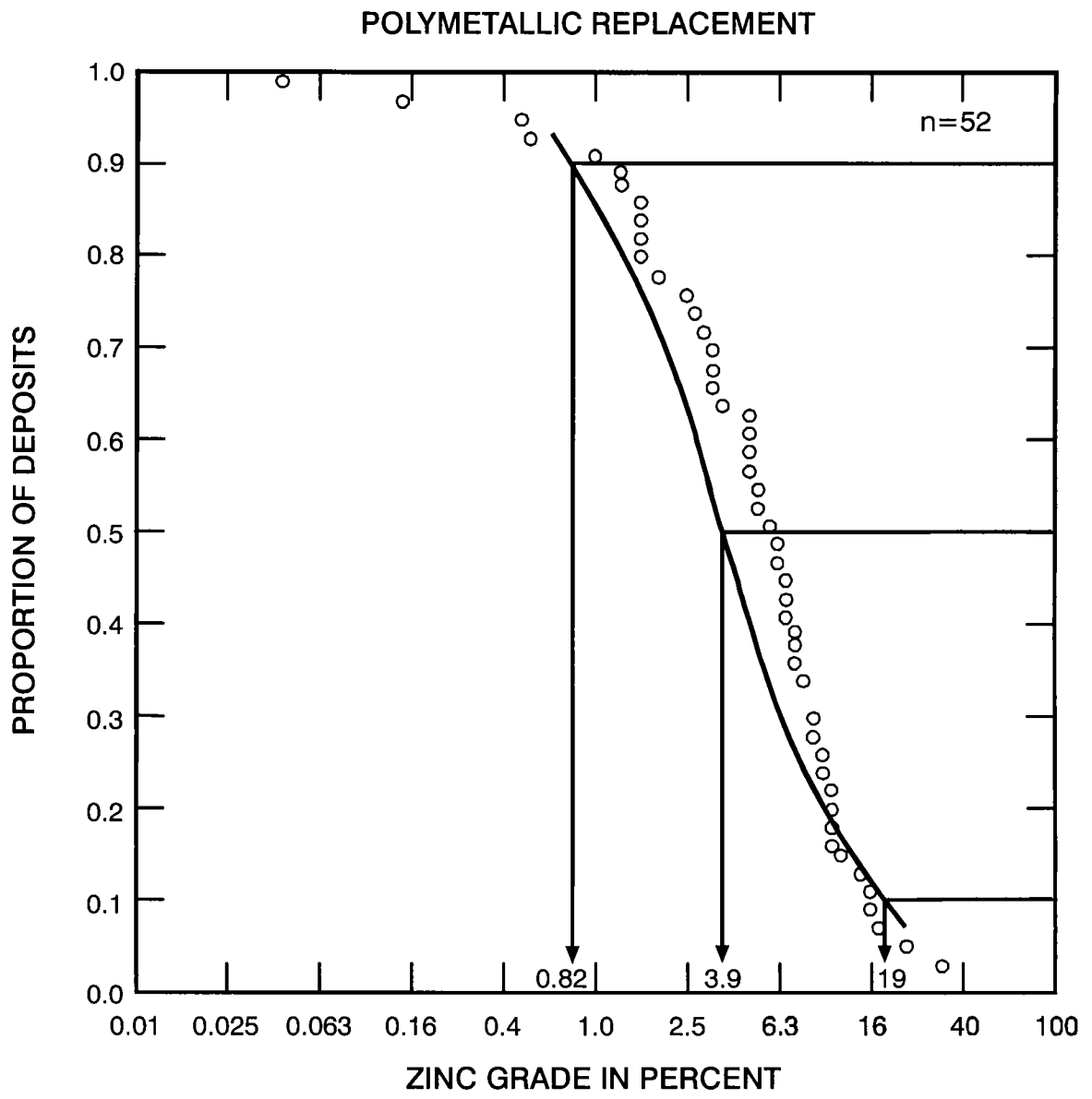




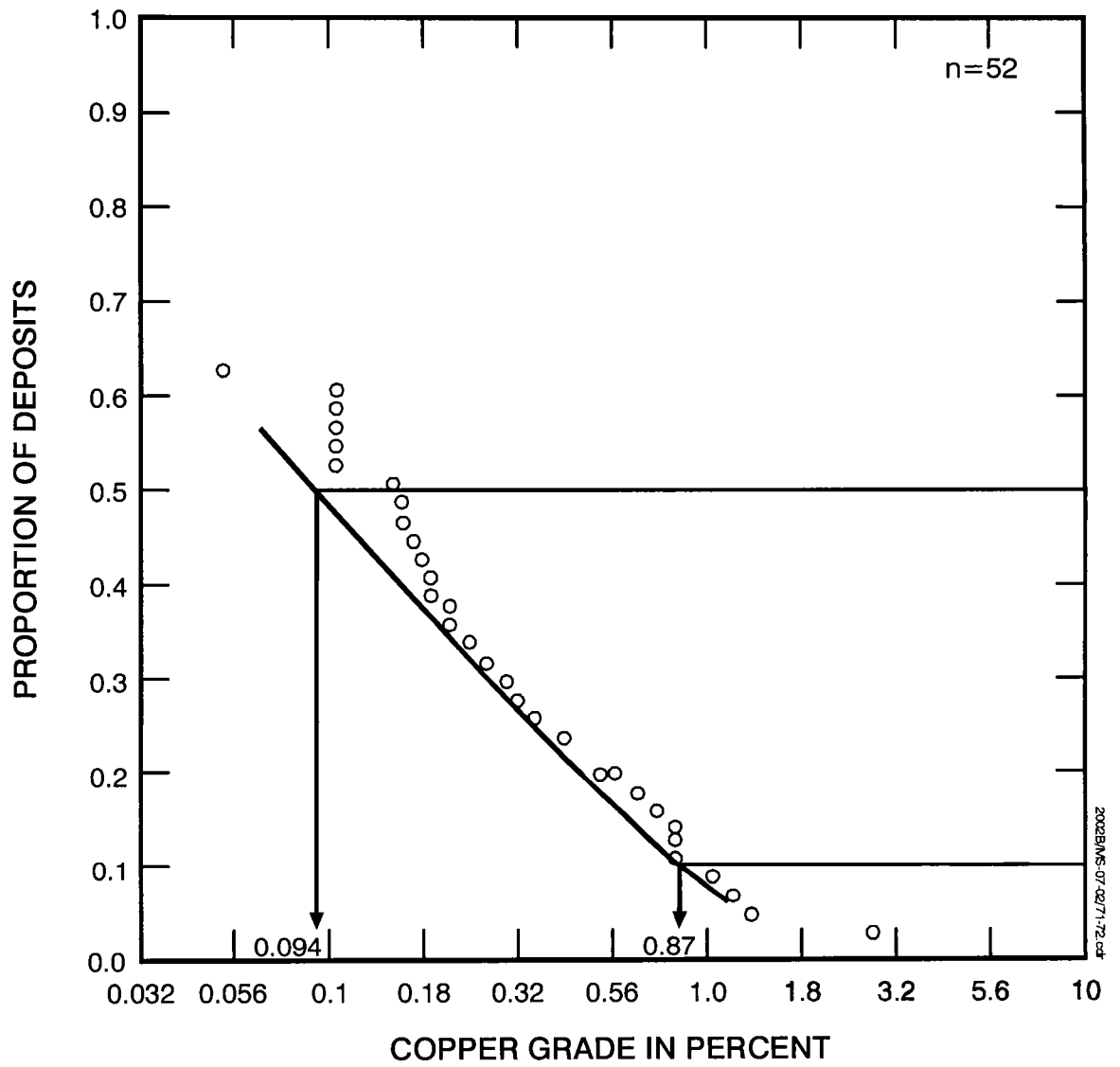
Tonnages of polymetallic replacement deposits



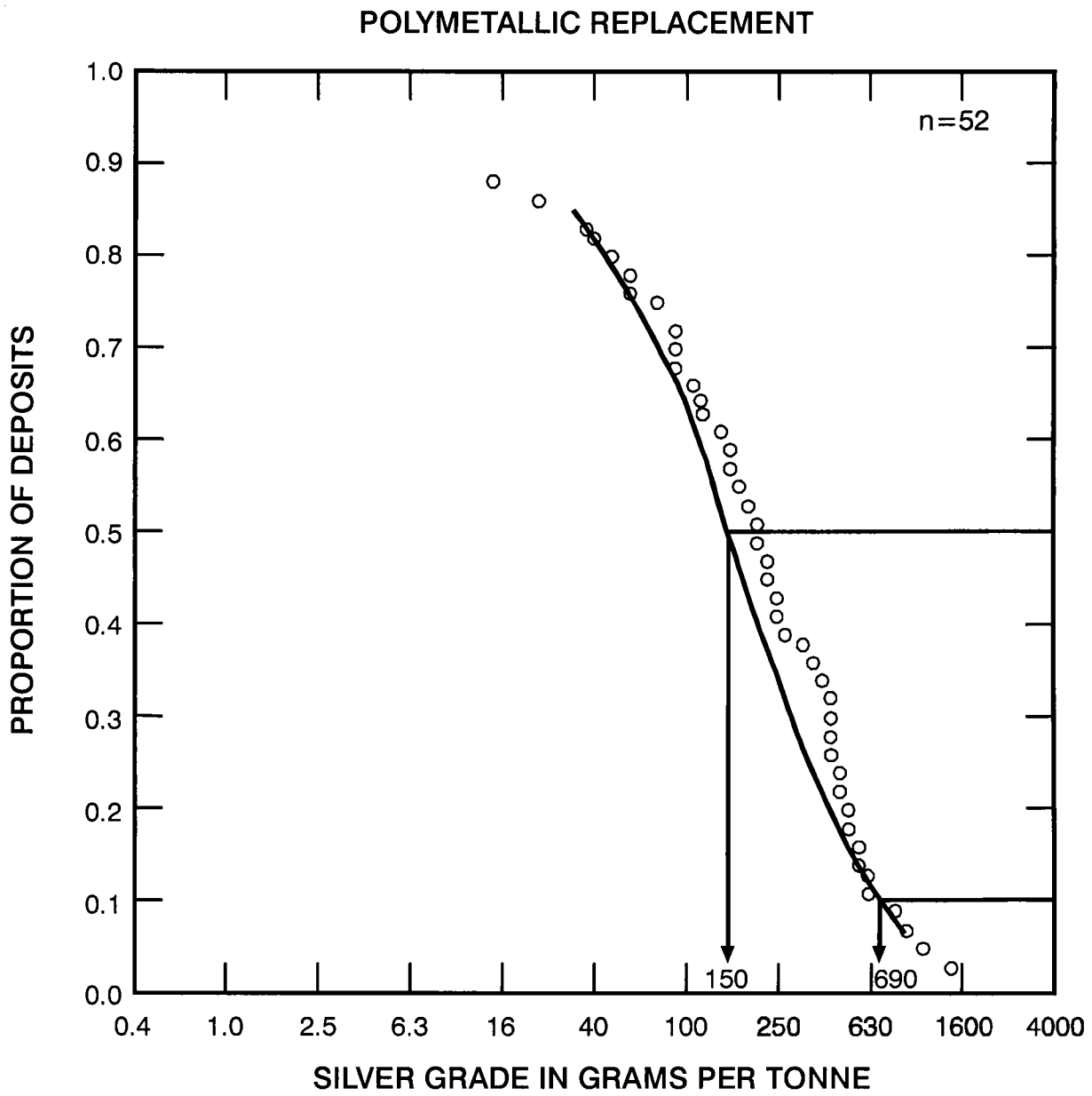
Lead grades of polymetallic replacement deposits



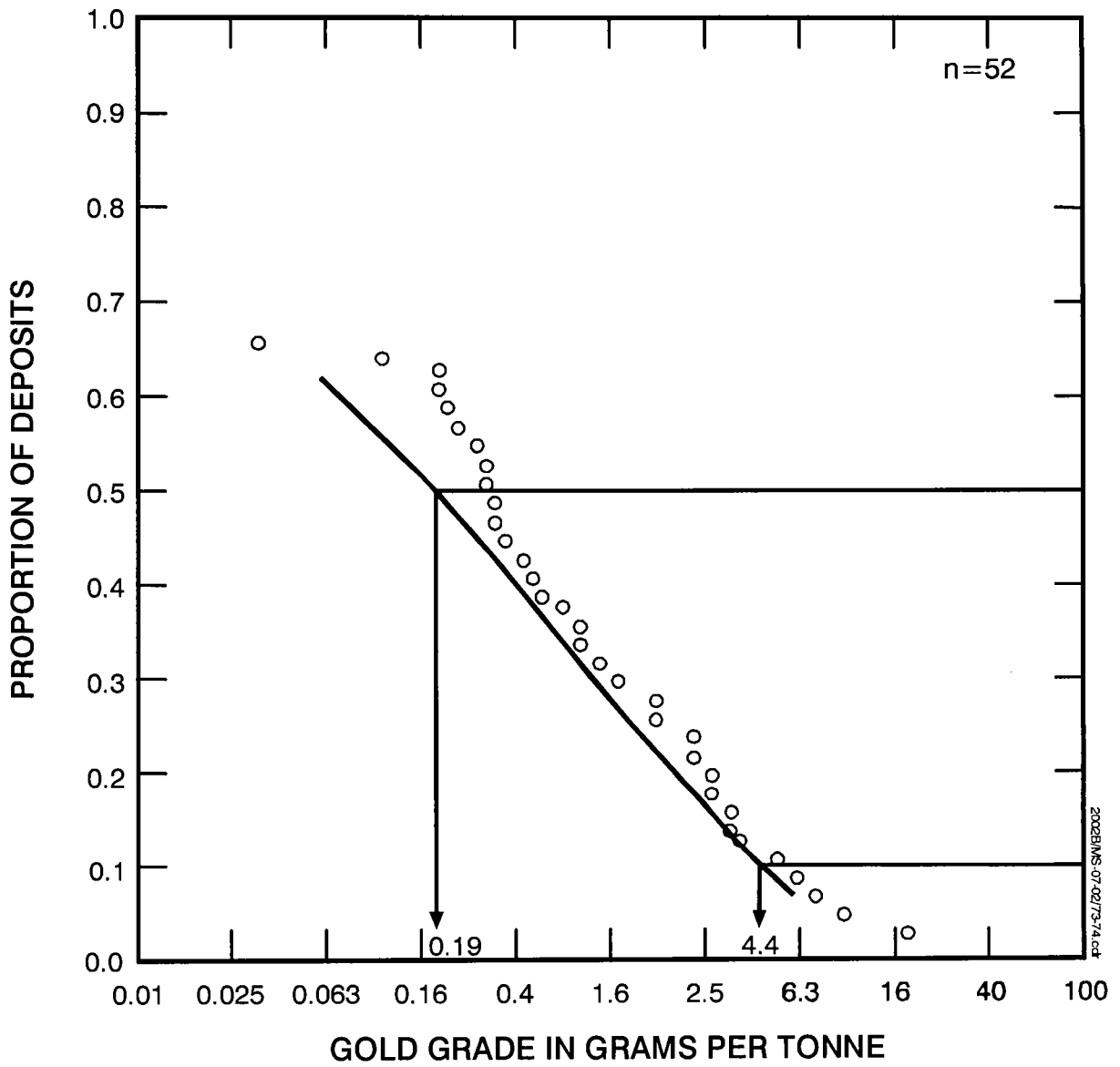
Zinc grades of polymetallic replacement deposits



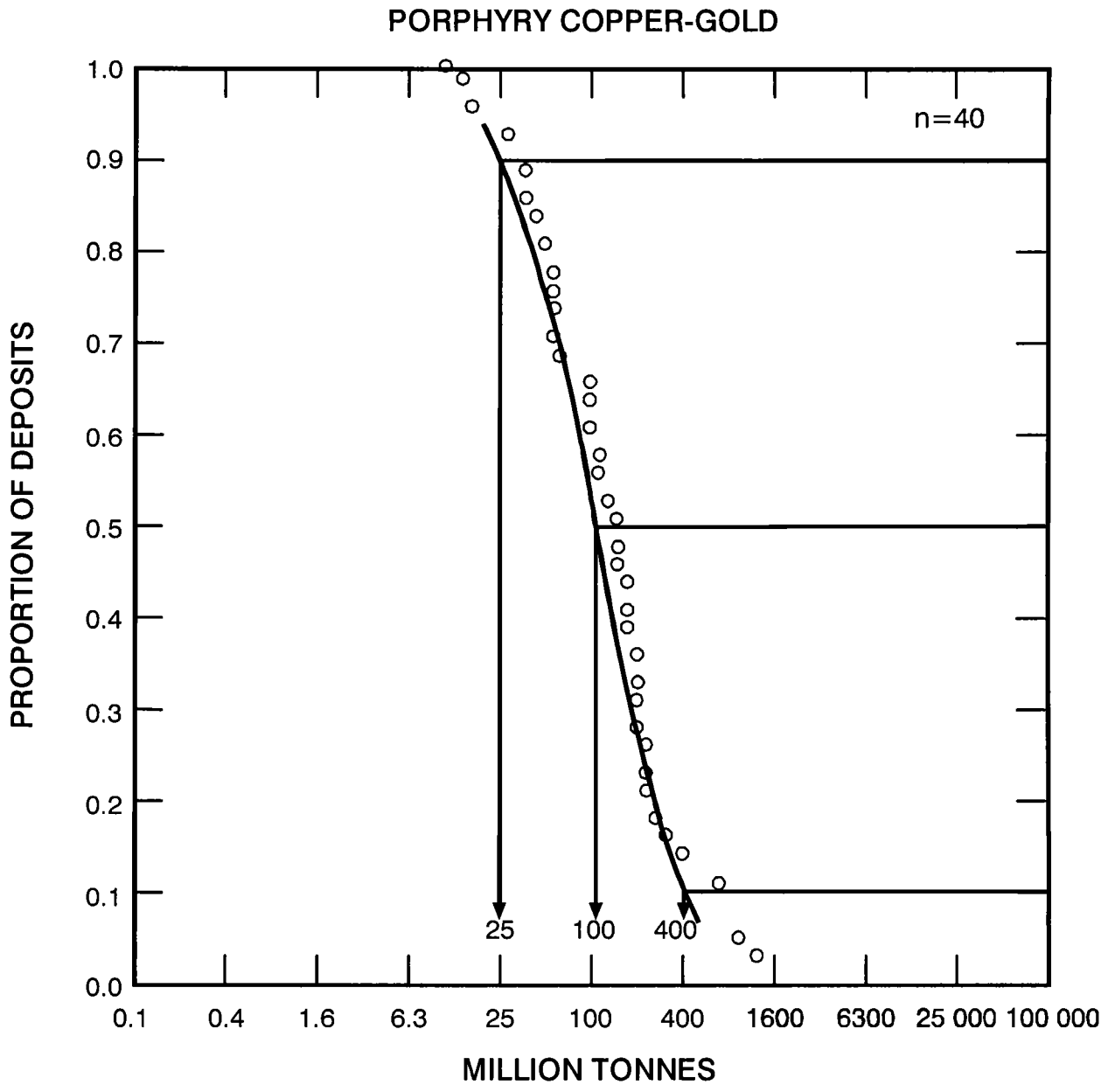
Copper grades of polymetallic replacement deposits



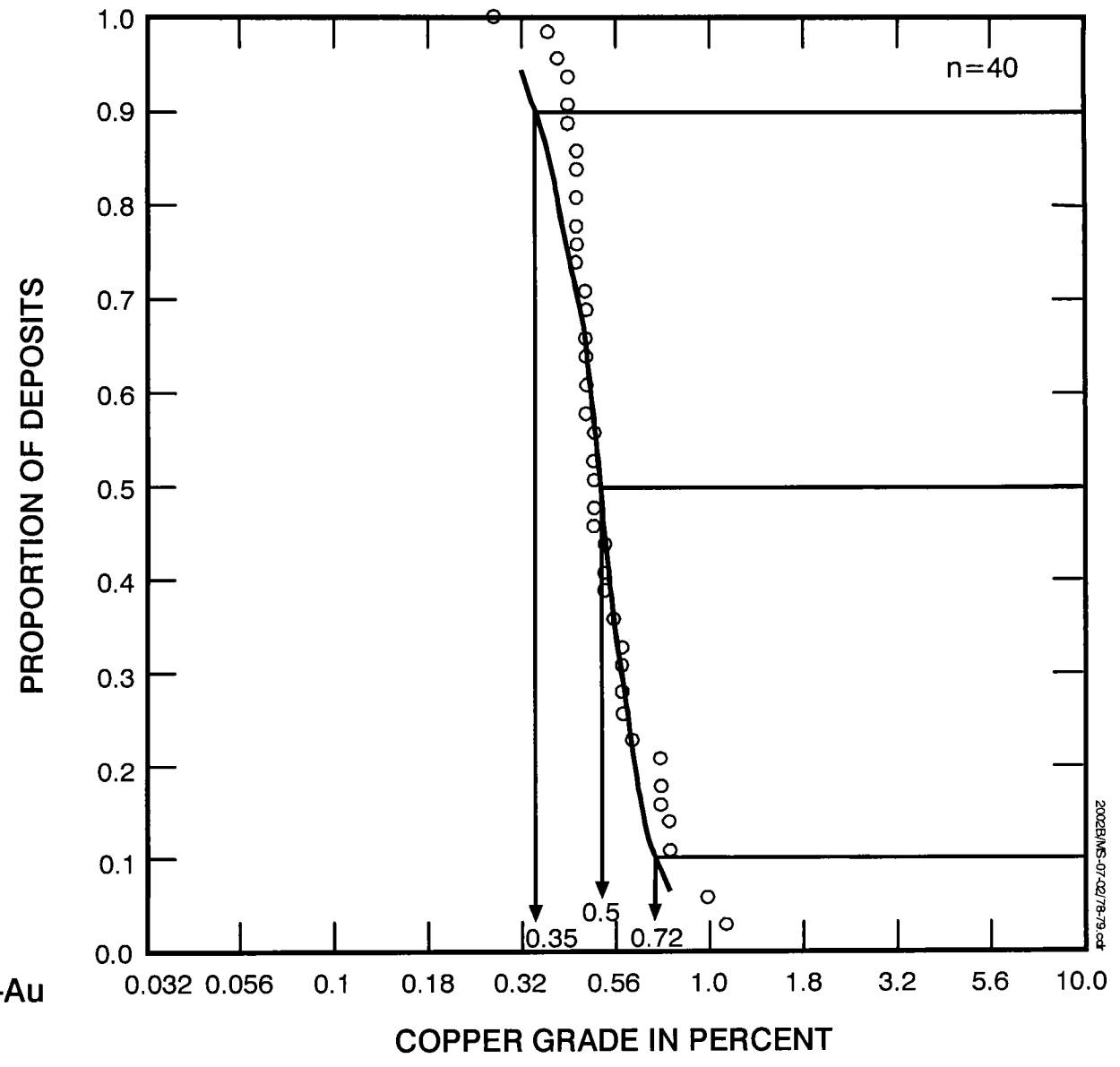
Silver grades of polymetallic replacement deposits



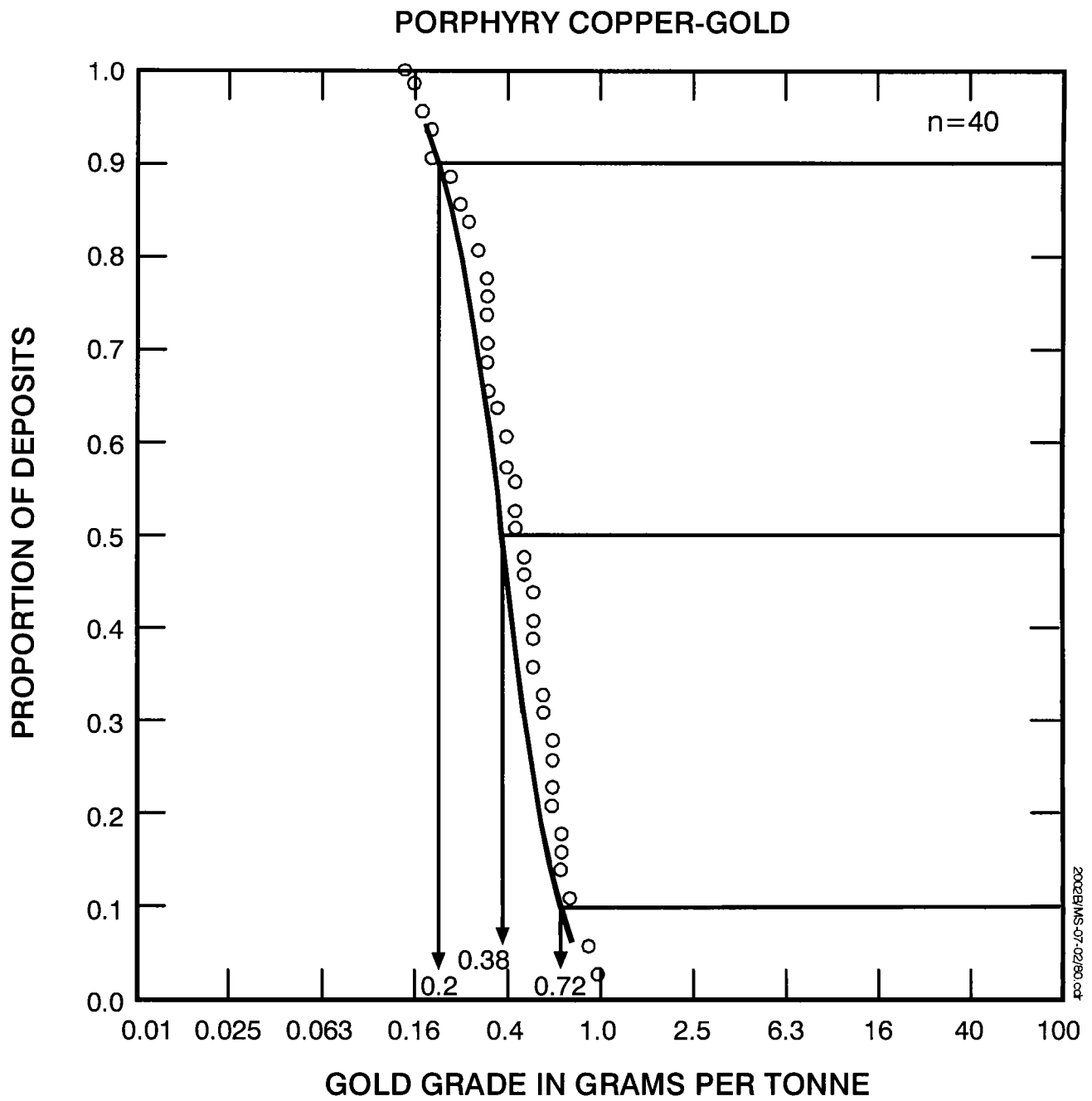
Gold grades of polymetallic replacement deposits



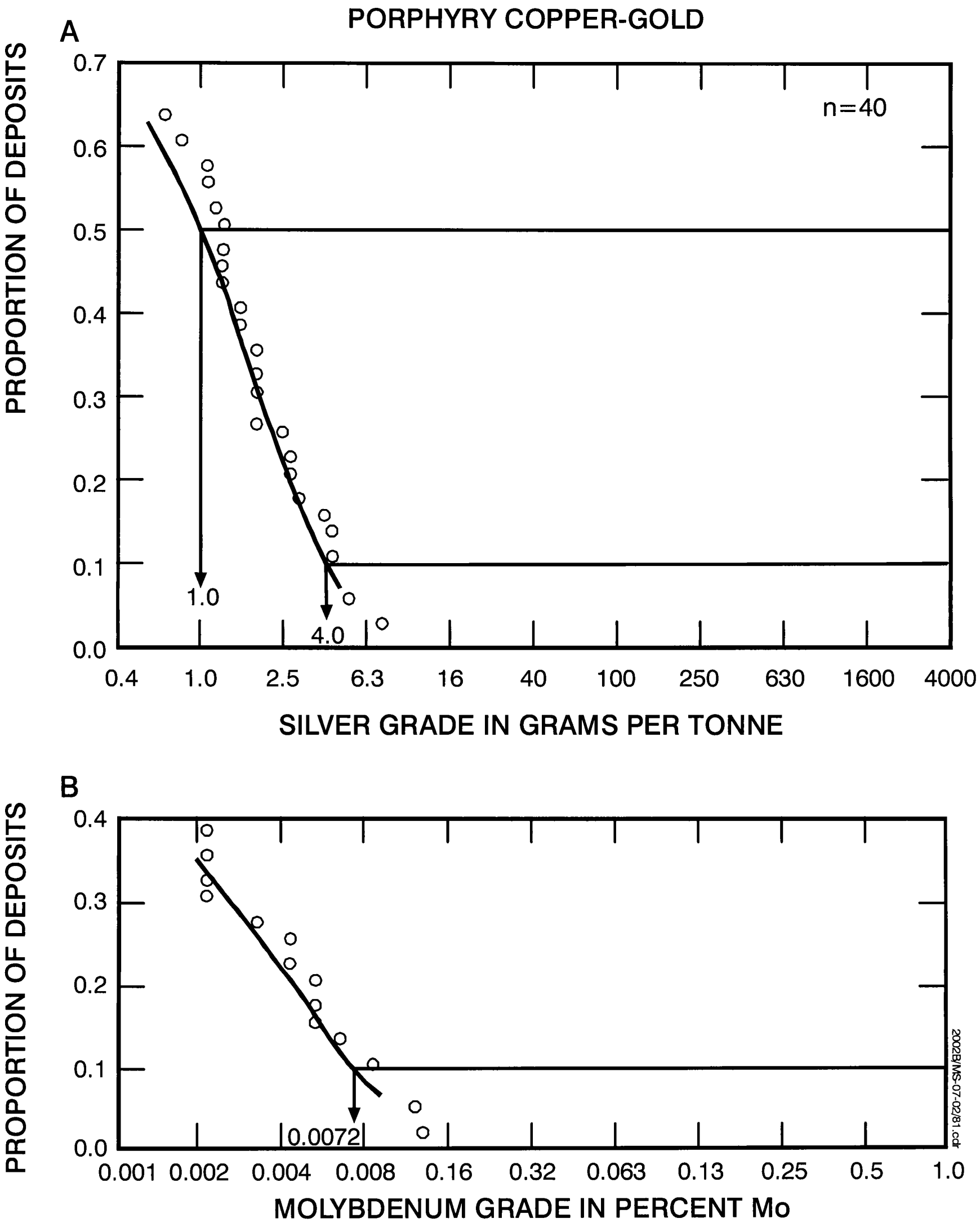
Tonnages of porphyry Cu-Au deposits



Copper grades of porphyry Cu-Au deposits

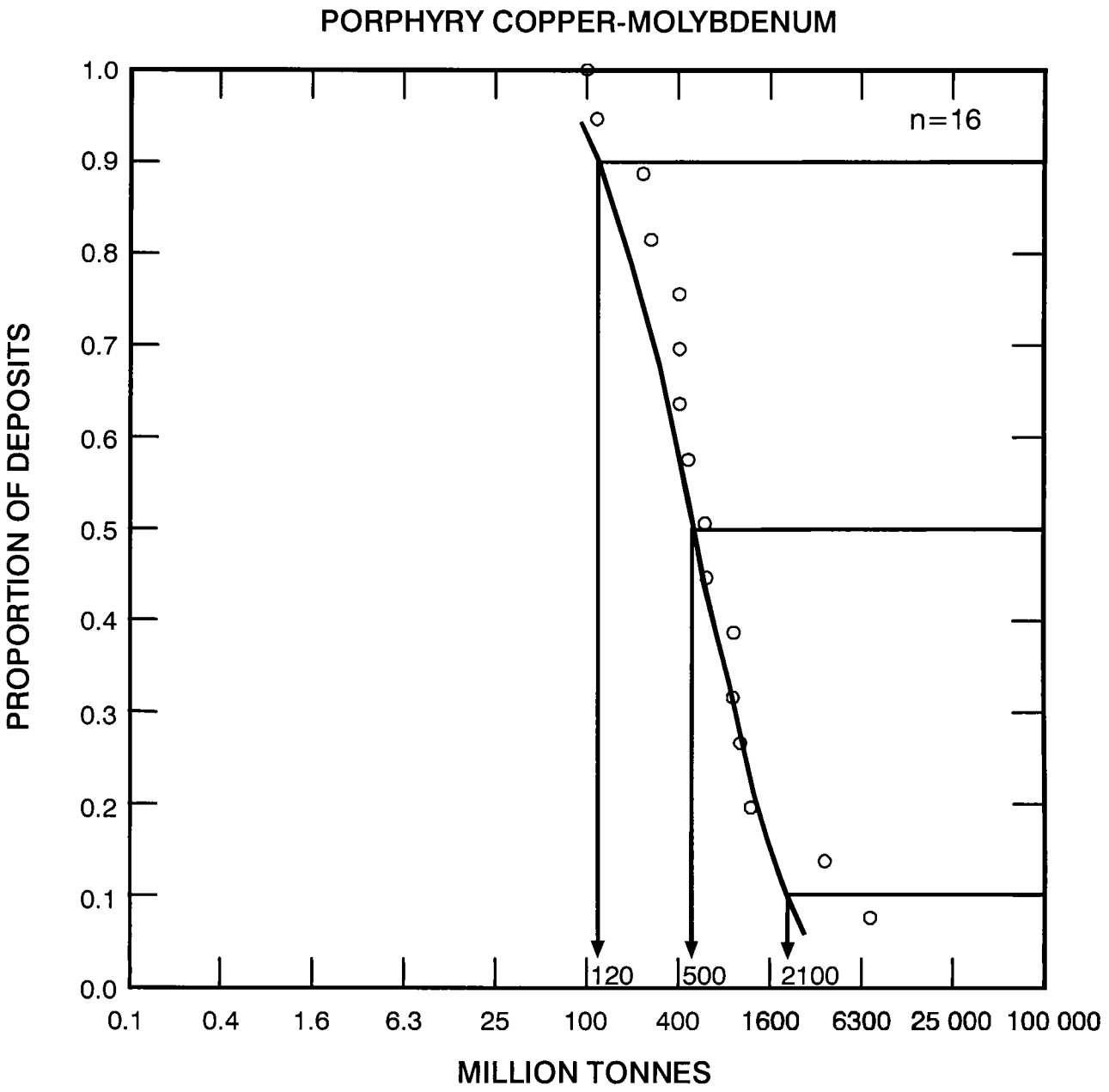


Gold grades of porphyry Cu-Au deposits

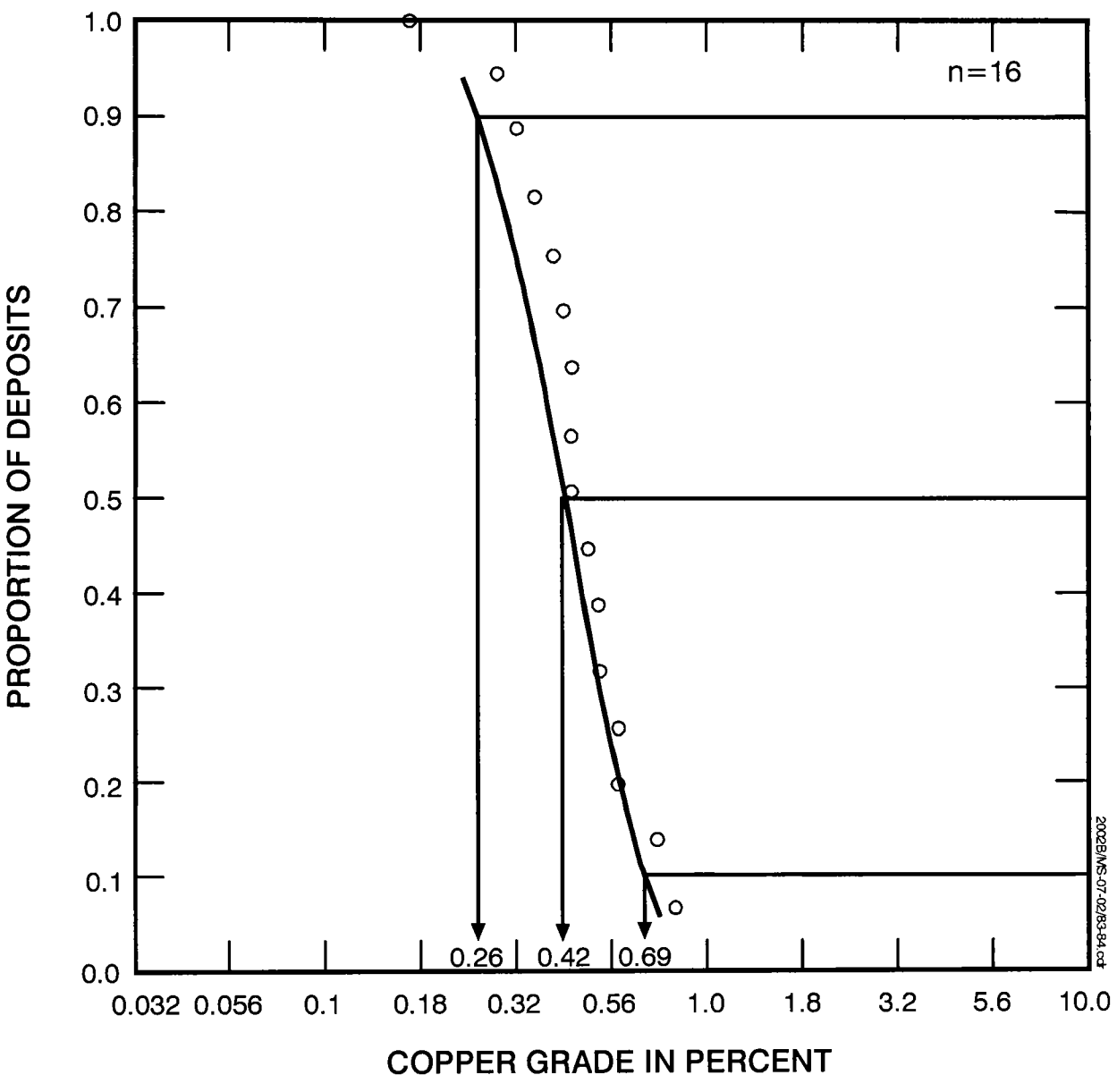


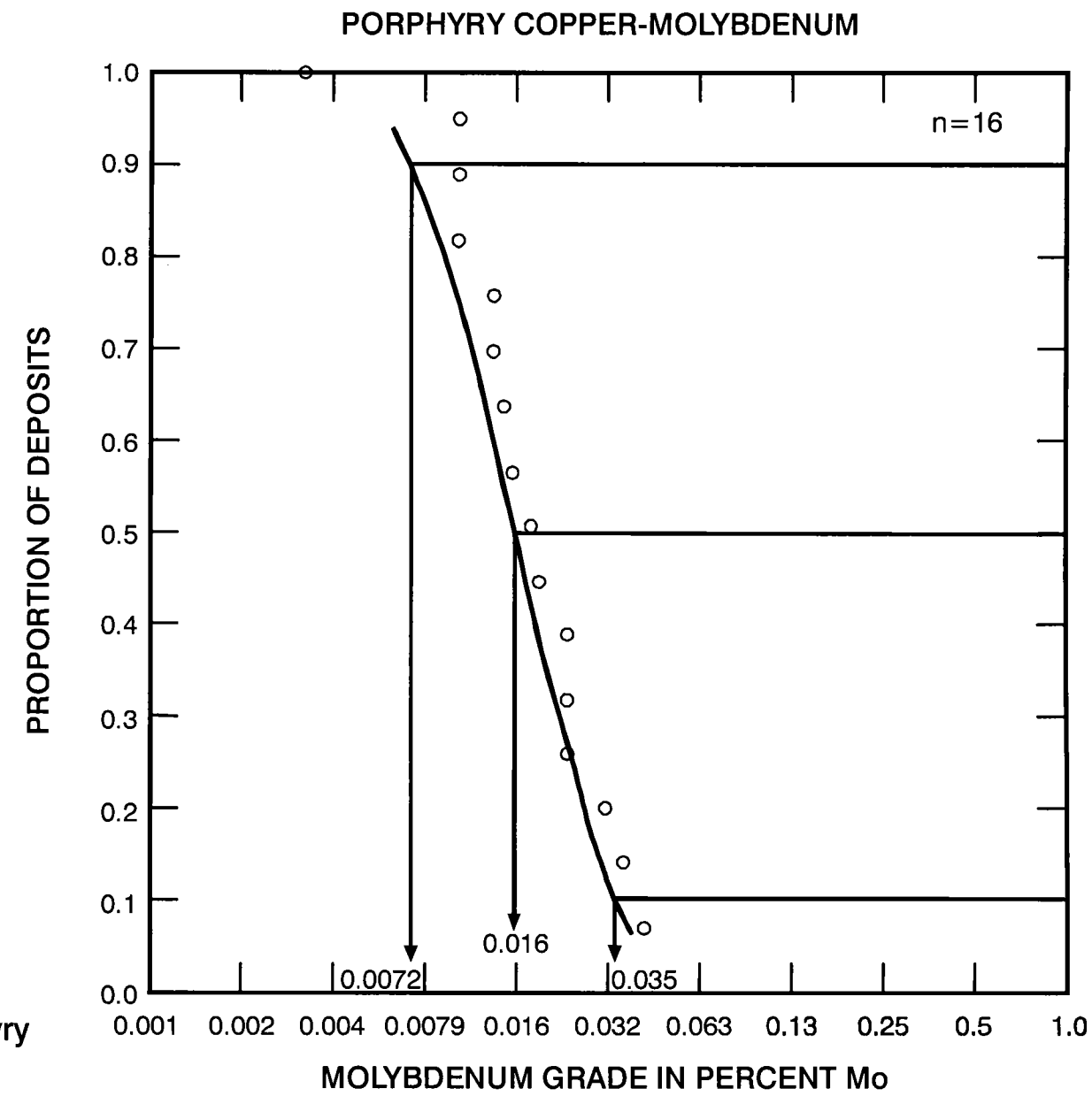
By-product grades of porphyry Cu-Au deposits
A, Silver; B, Molybdenum

Tonnages of porphyry Cu-Mo deposits

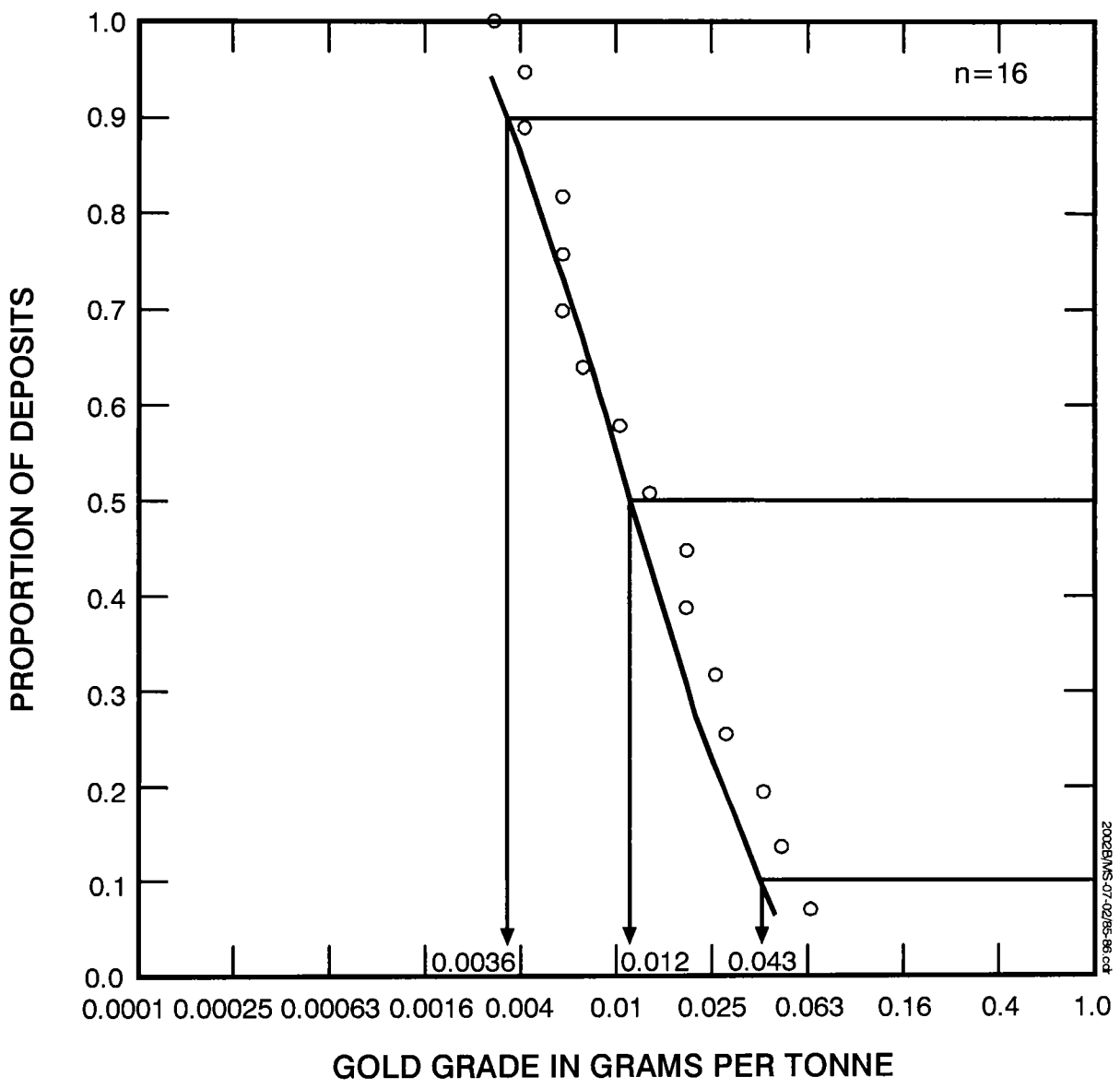


Copper grades of porphyry Cu-Mo deposits

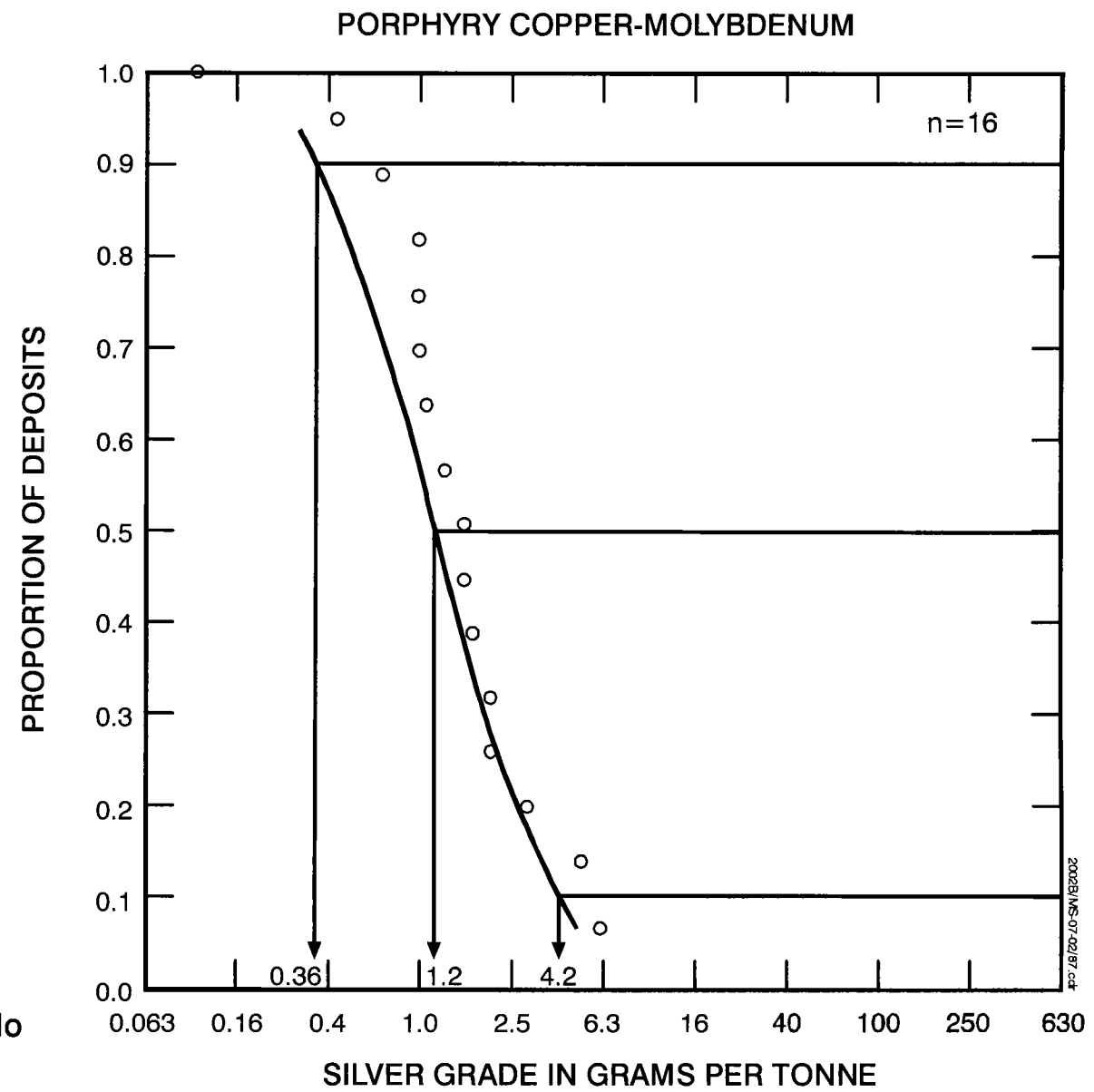




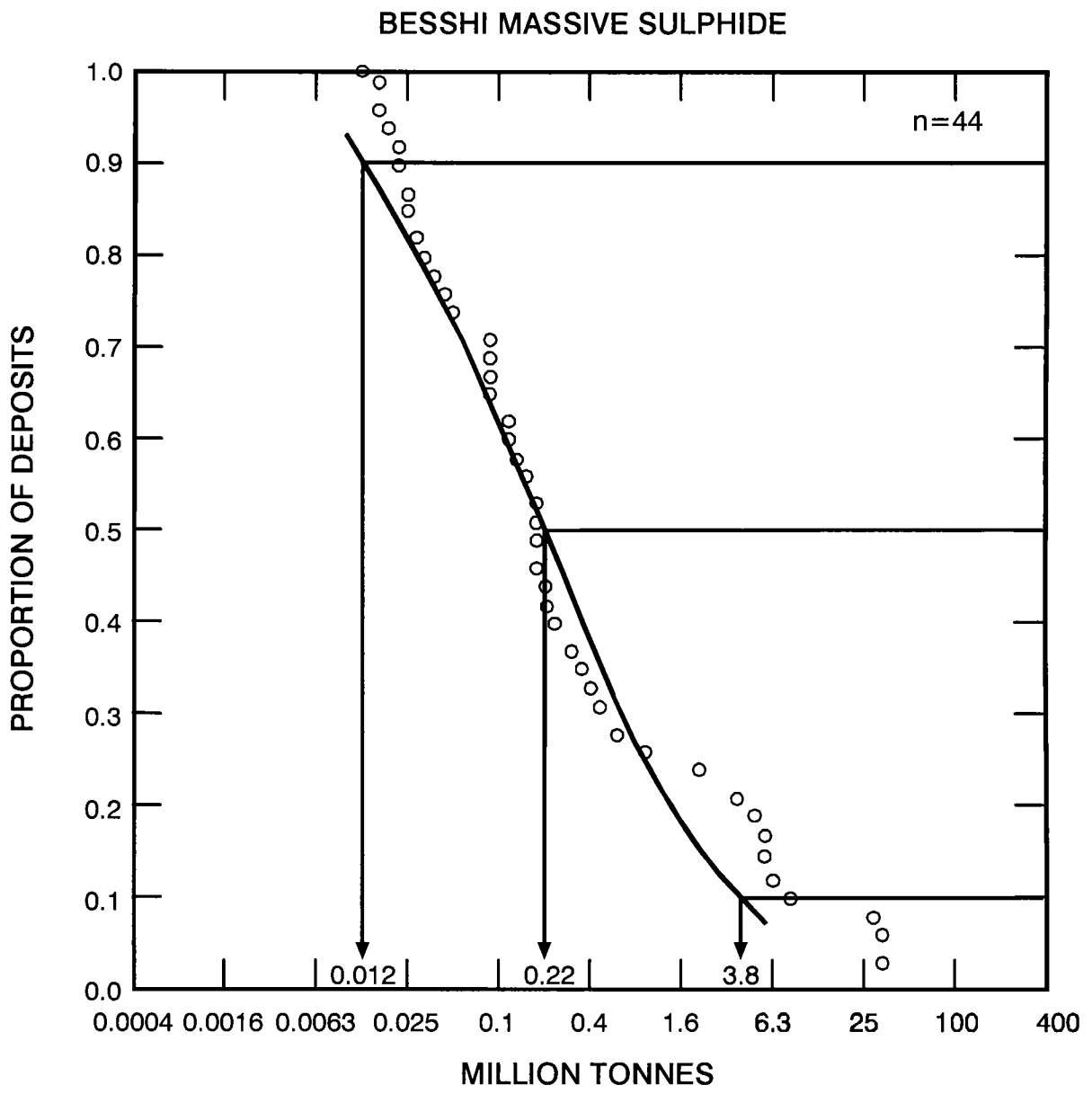
Molybdenum grades of porphyry Cu-Mo deposits



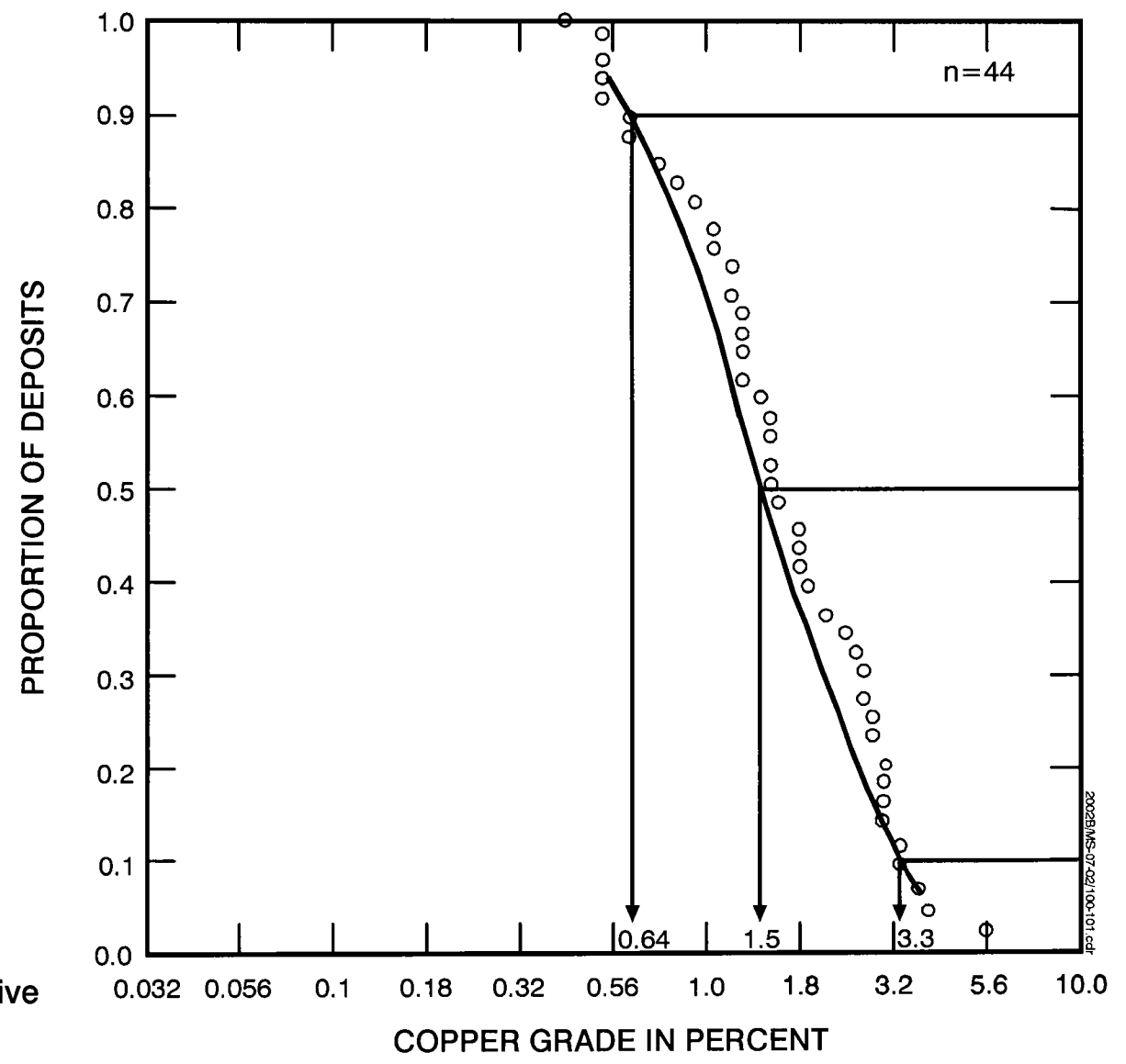
Gold grades of porphyry Cu-Mo deposits



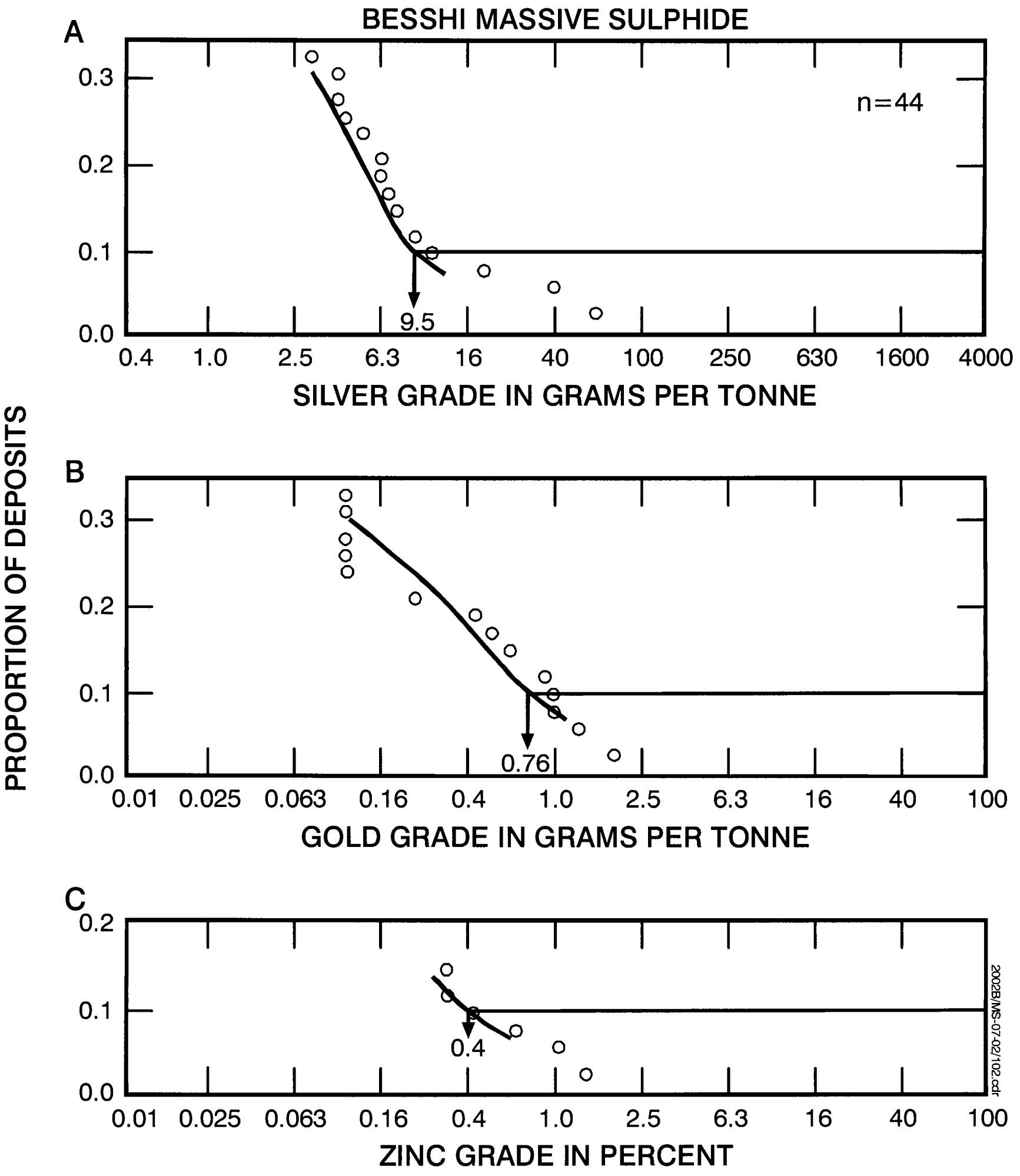
Silver grades of porphyry Cu-Mo deposits



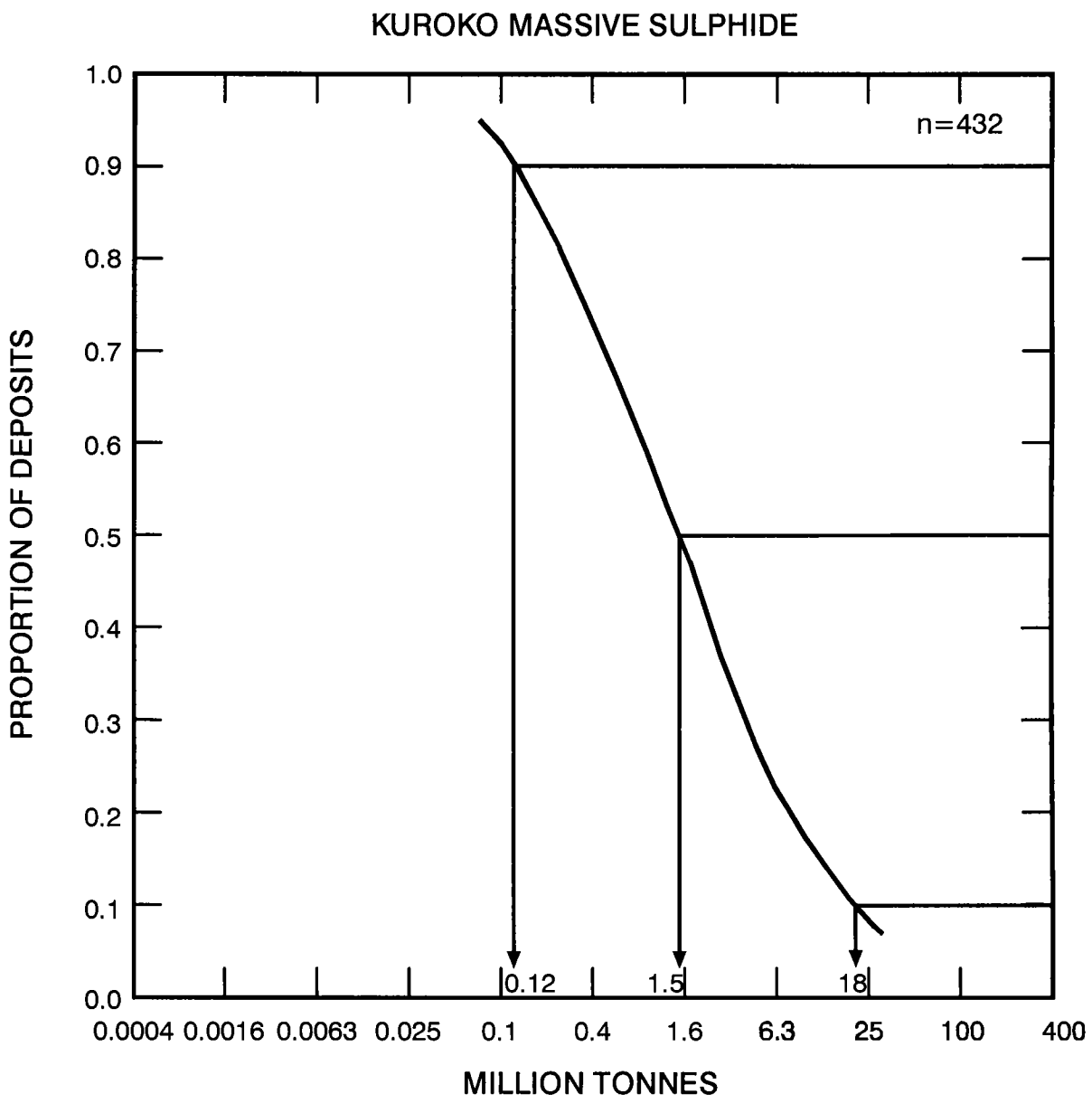
Tonnages of Besshi massive sulphide deposits



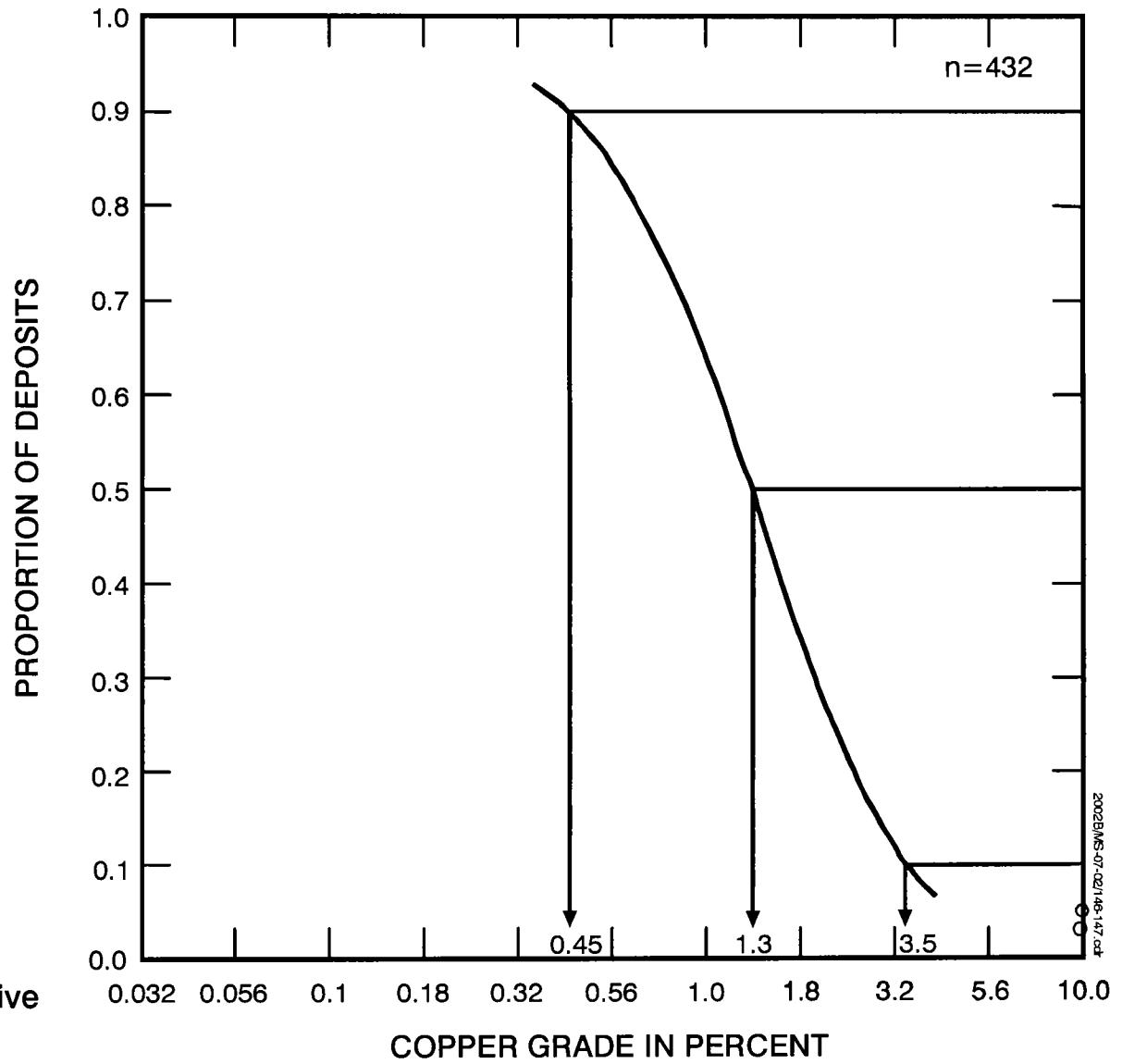
Copper grades of Besshi massive sulphide deposits



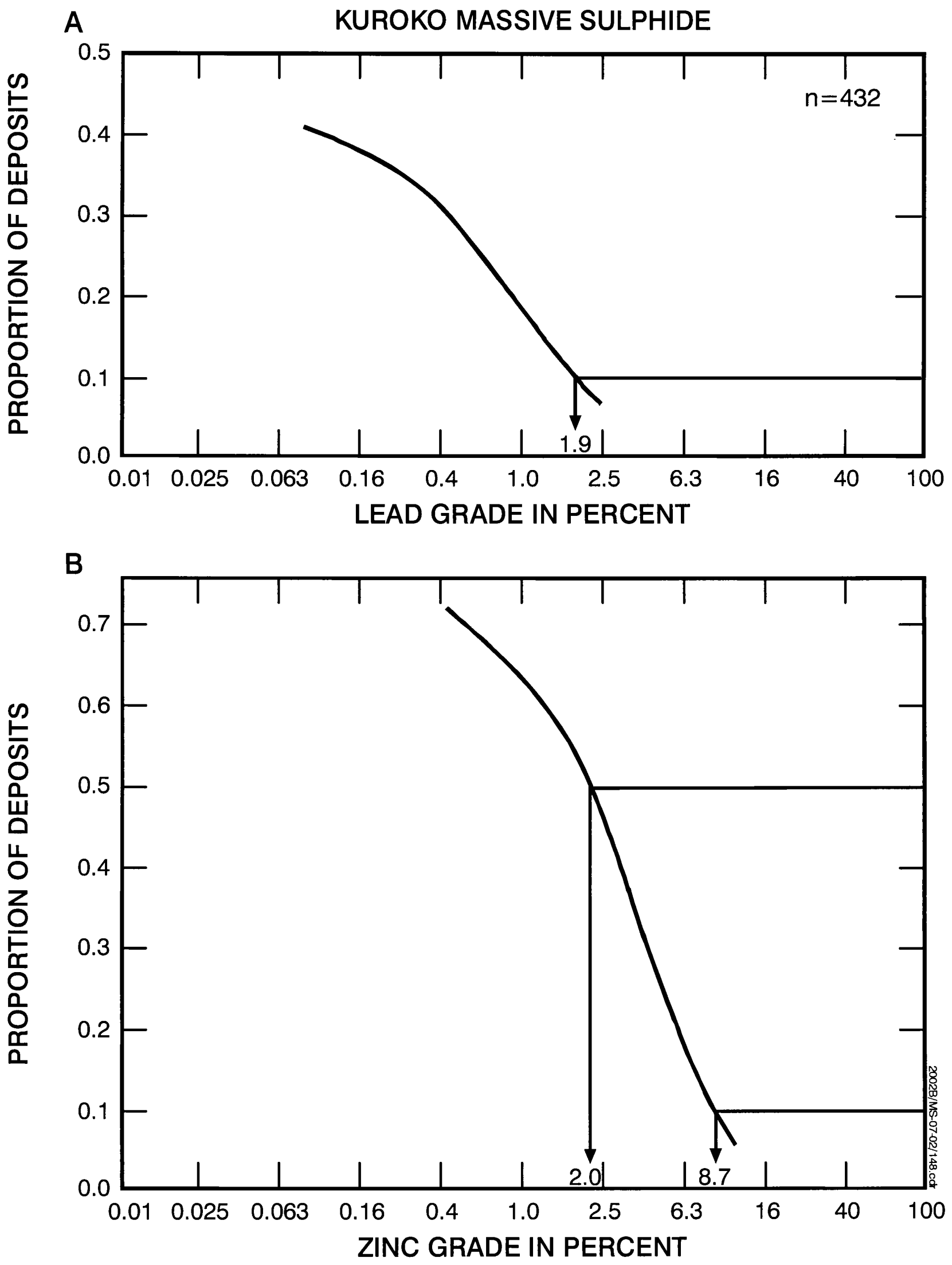
By-product grades of Besshi massive sulphide deposits
A, Silver; B, Gold; C, Zinc



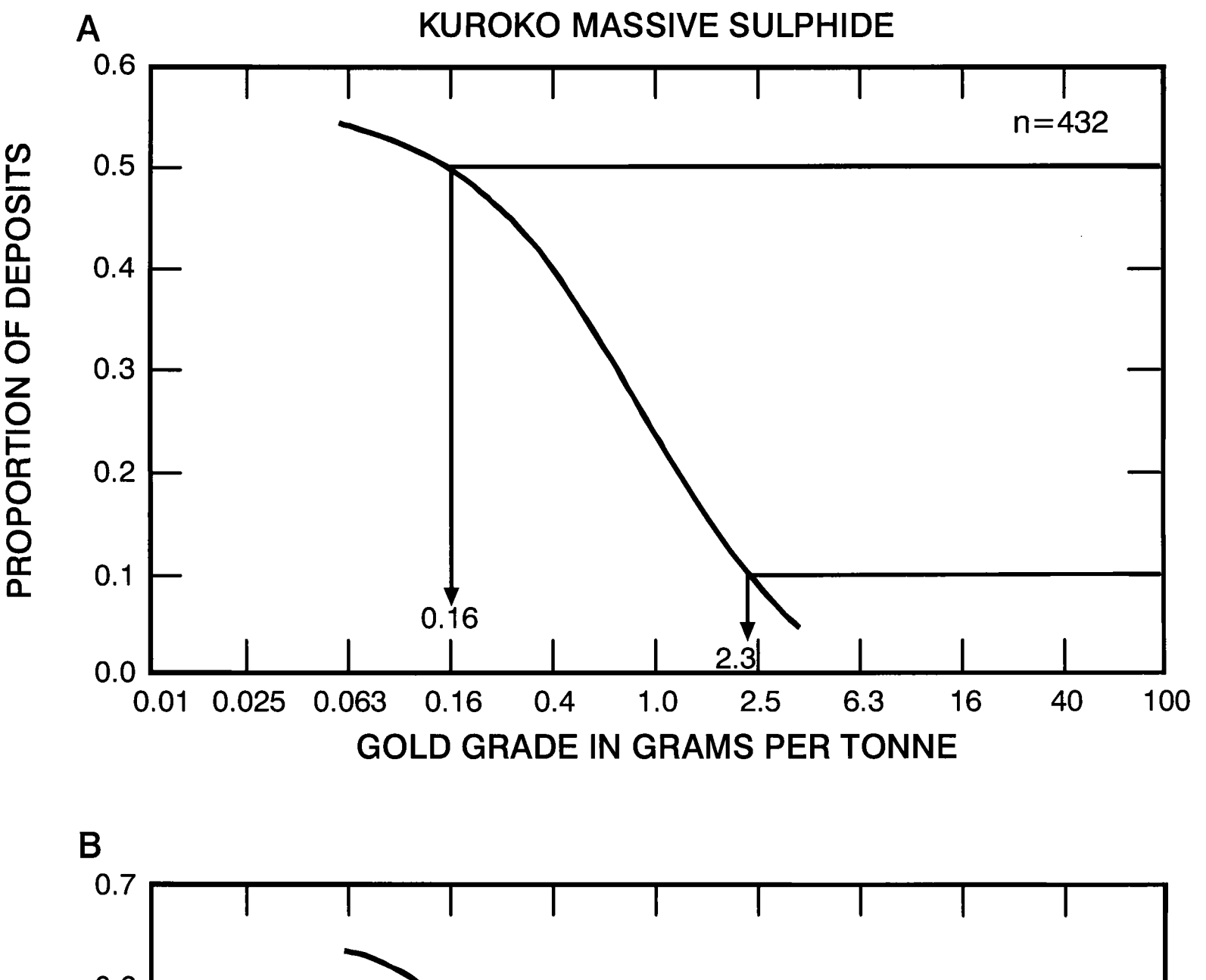
Tonnages of Kuroko massive sulphide deposits



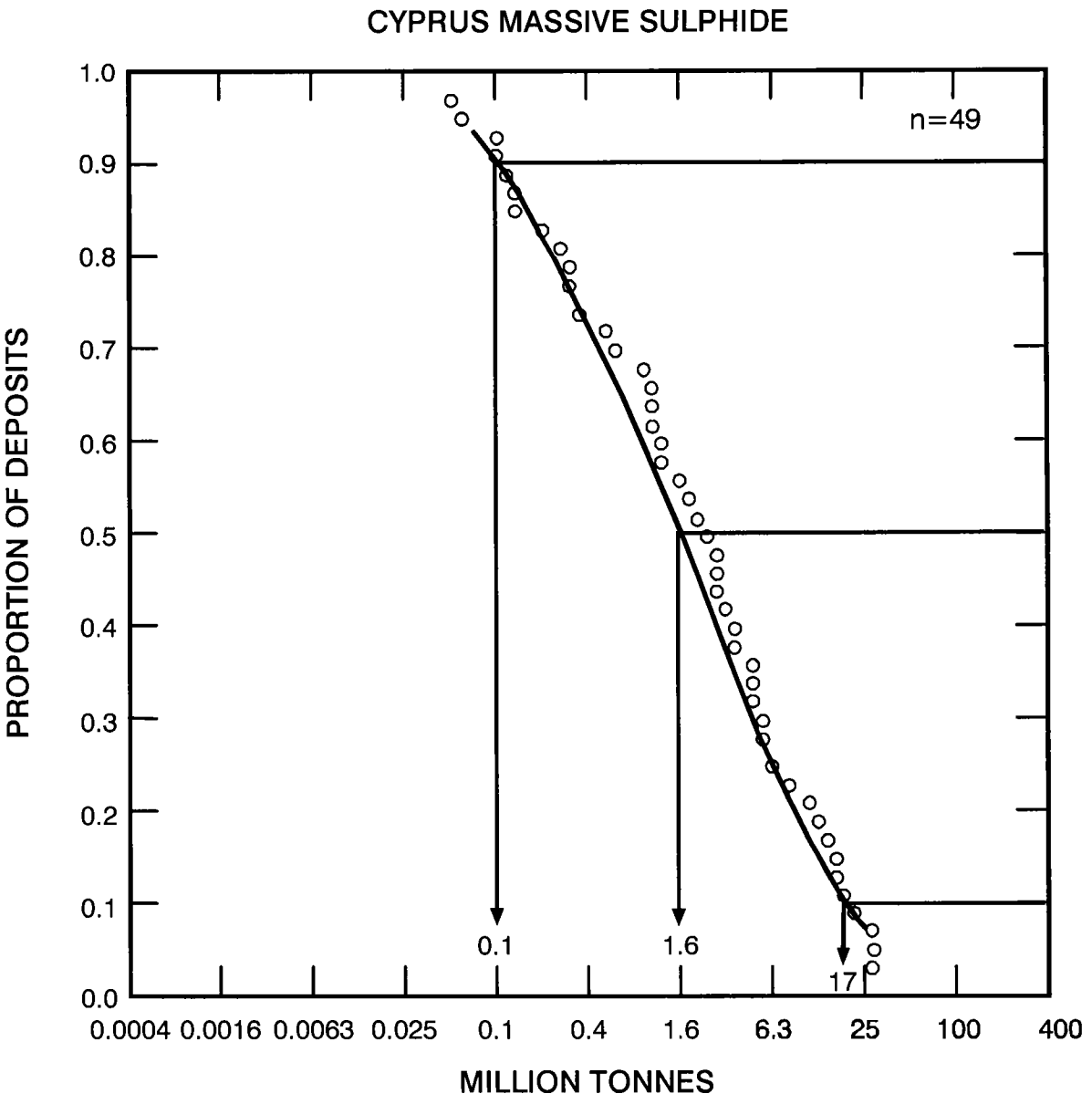
Copper grades of Kuroko massive sulphide deposits



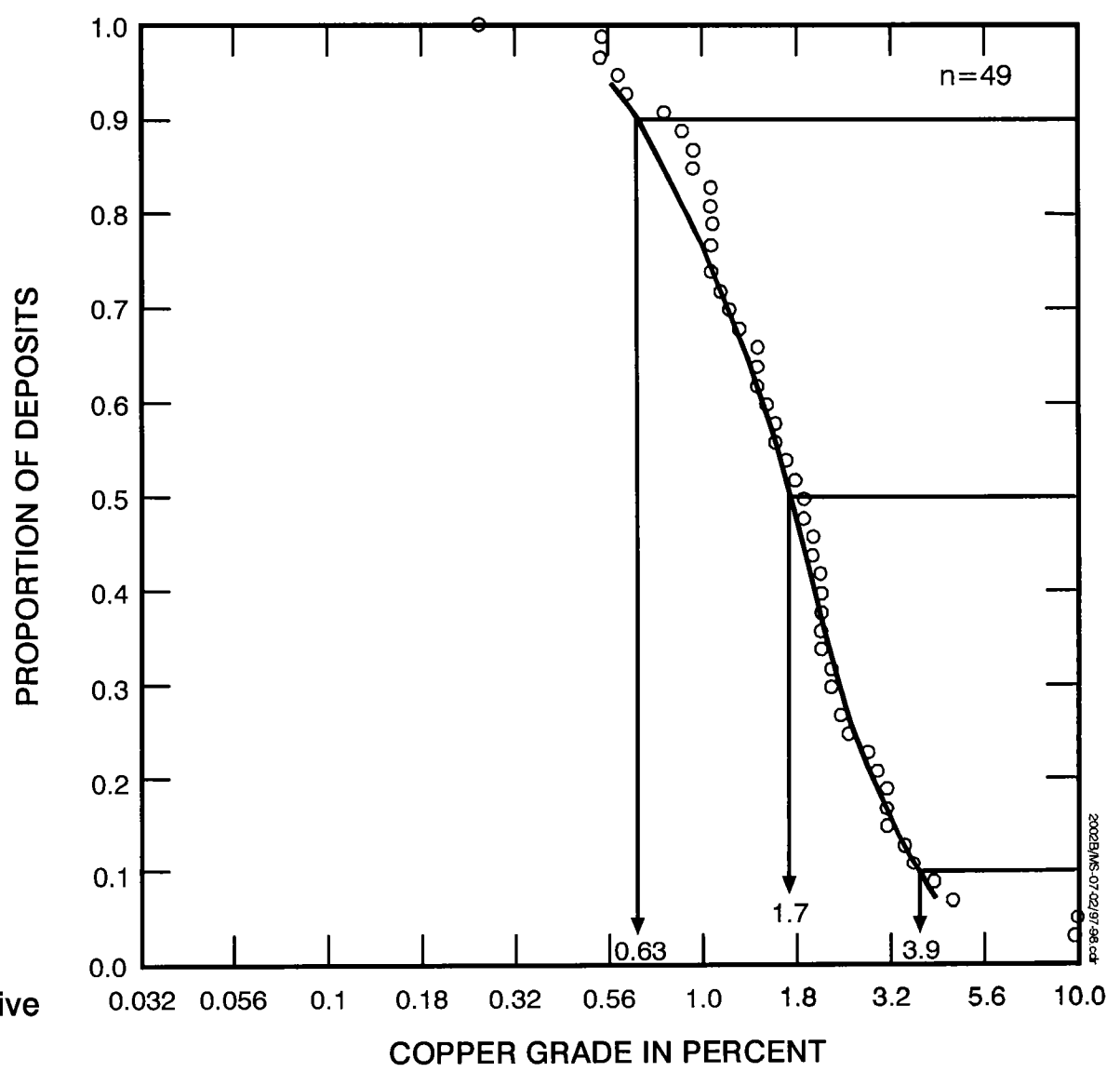
Lead-zinc grades of Kuroko massive sulphide deposits
A, Lead; B, Zinc



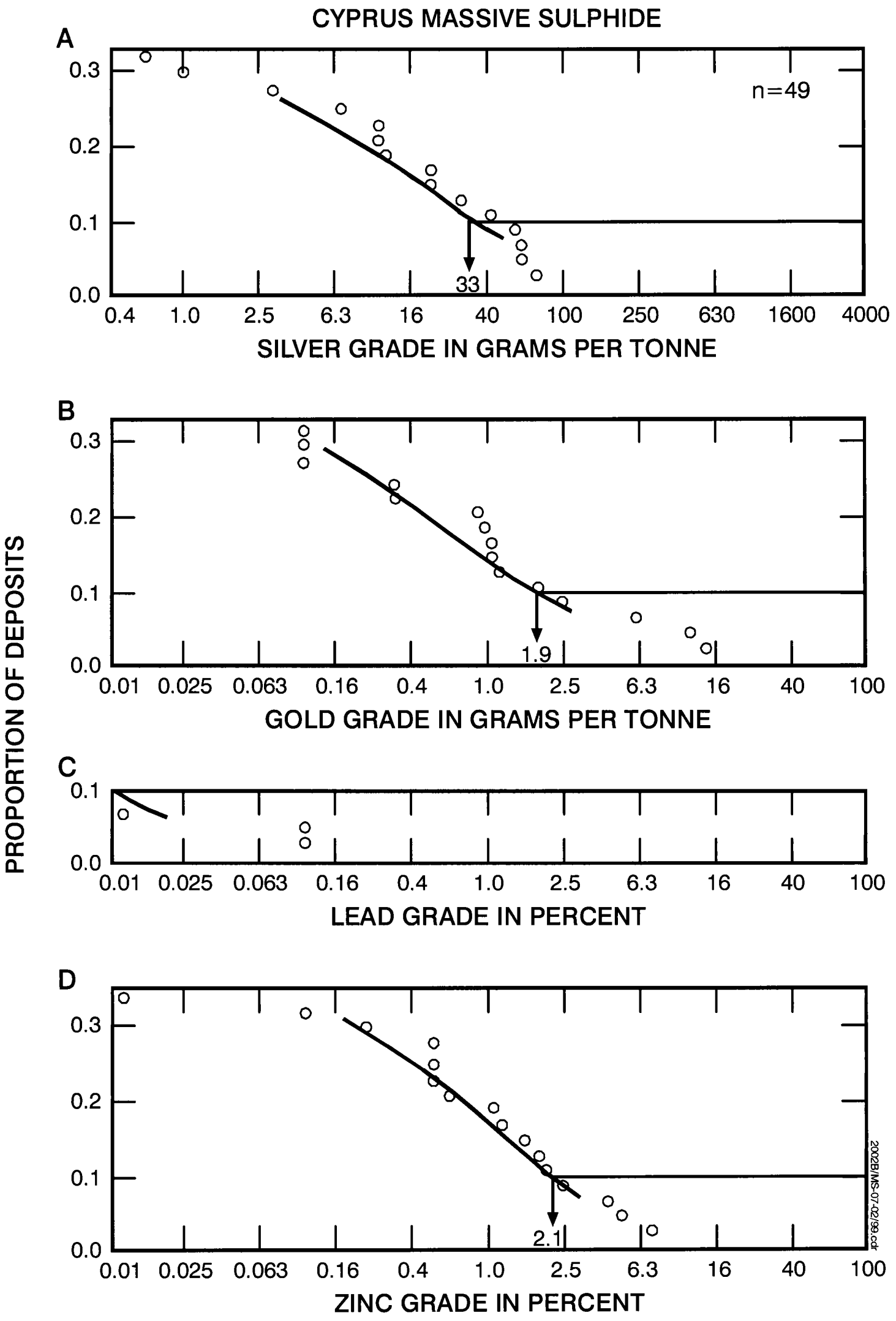
Precious metal grades of Kuroko massive sulphide deposits
A, Gold; B, Silver



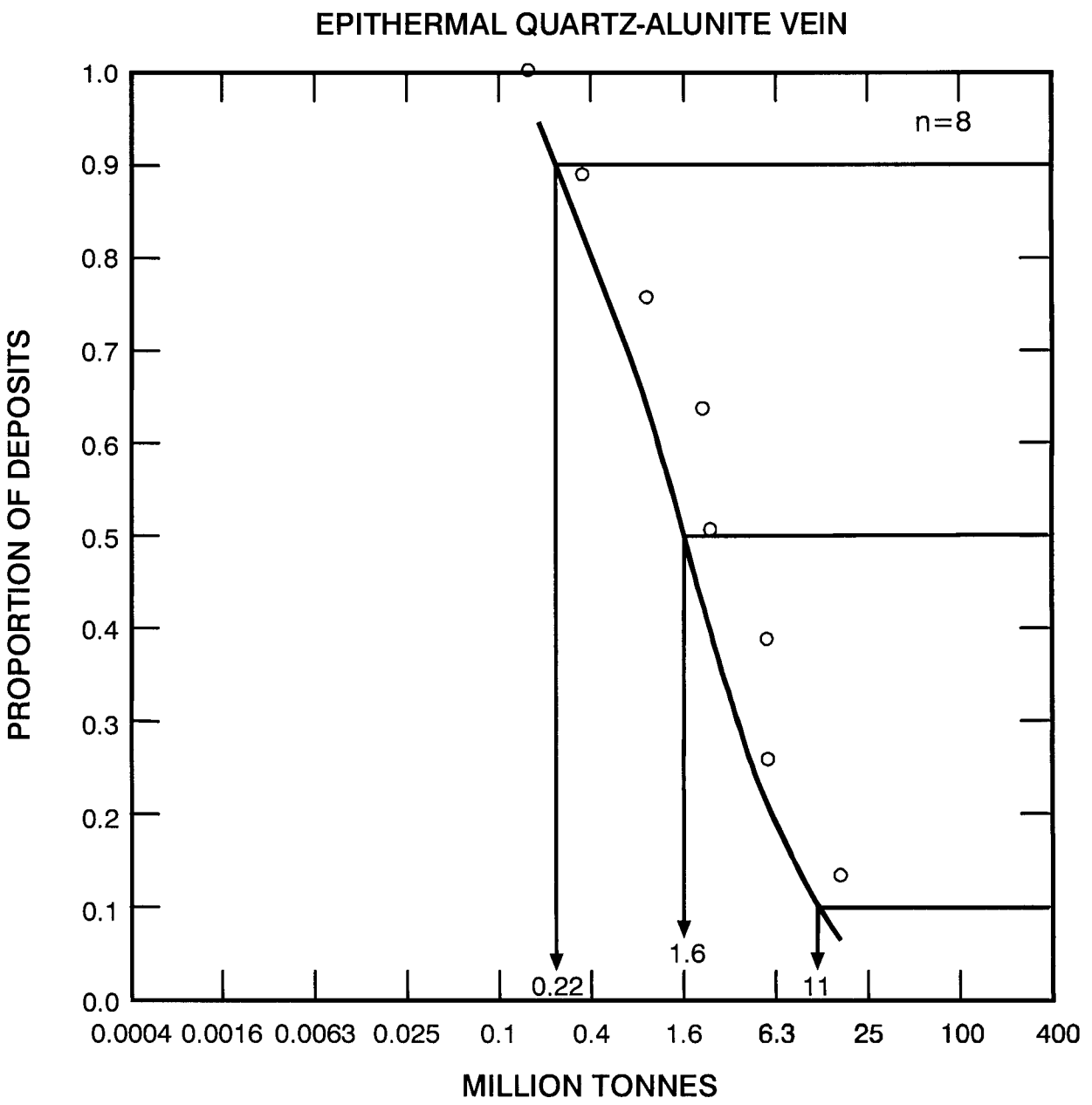
Tonnages of Cyprus massive sulphide deposits



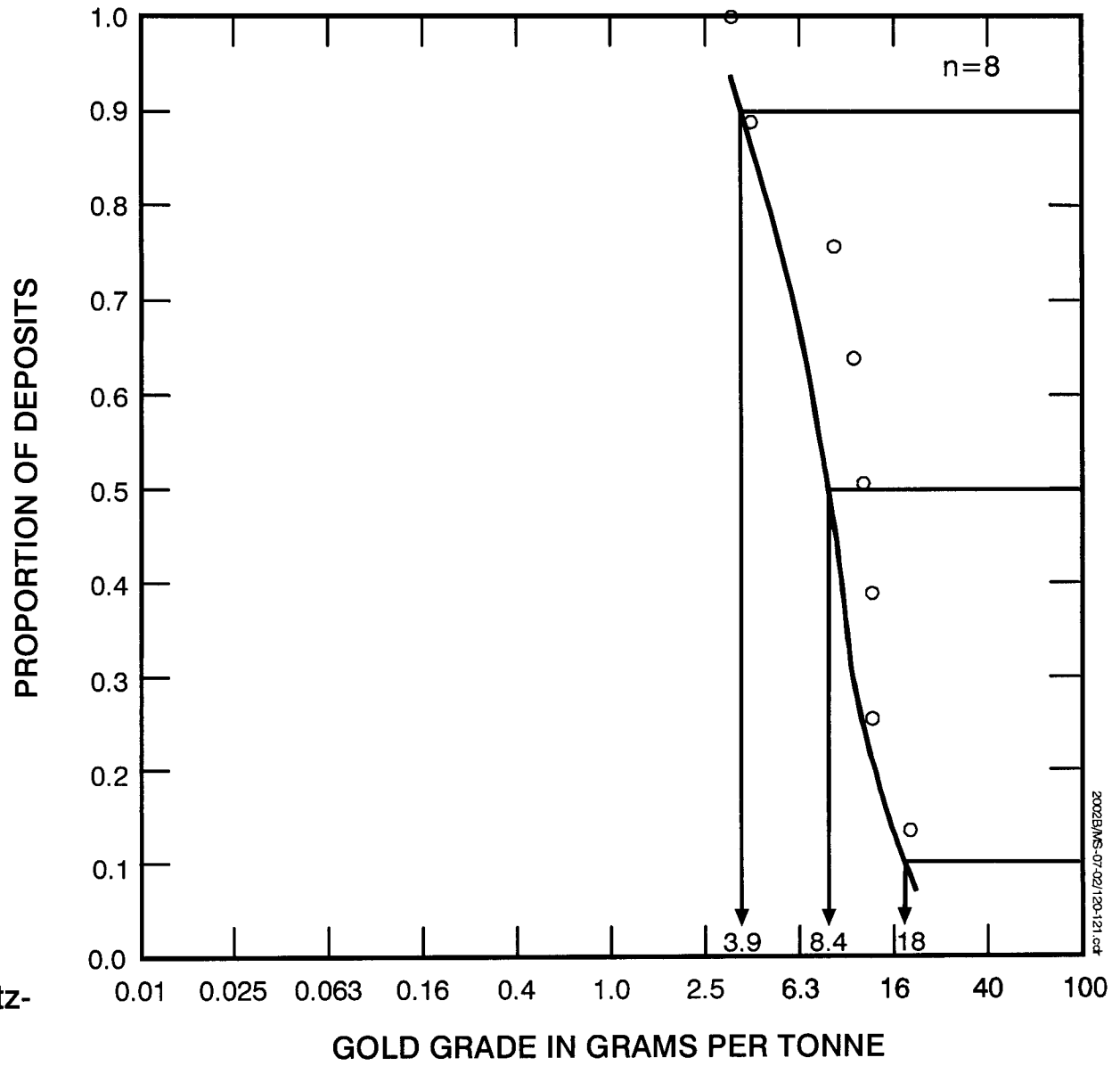
Copper grades of Cyprus massive sulphide deposits



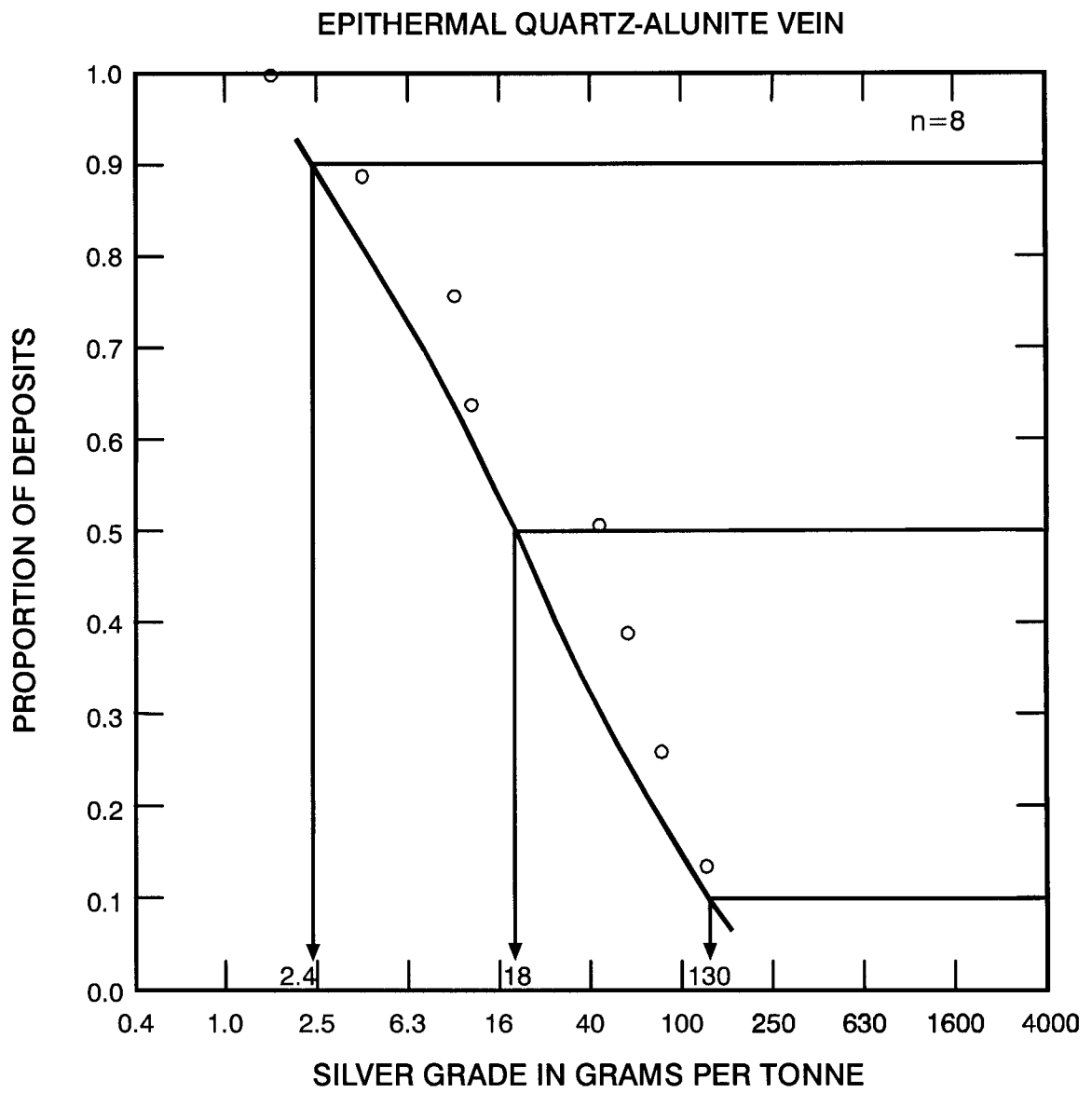
By-product grades of Cyprus massive sulphide deposits
A, Silver; B, Gold; C, Lead; D, Zinc



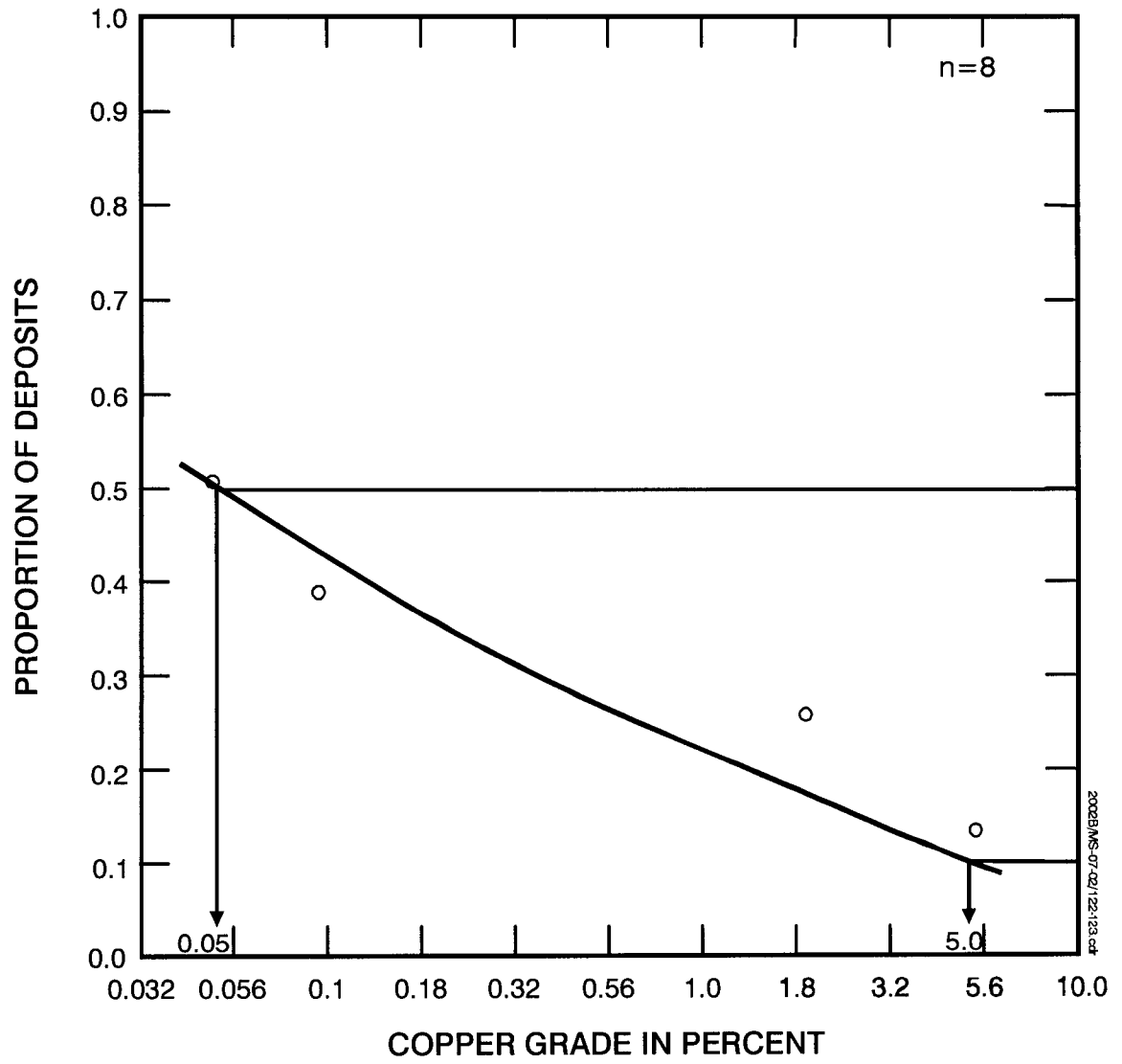
Tonnages of epithermal quartz-alunite vein deposits



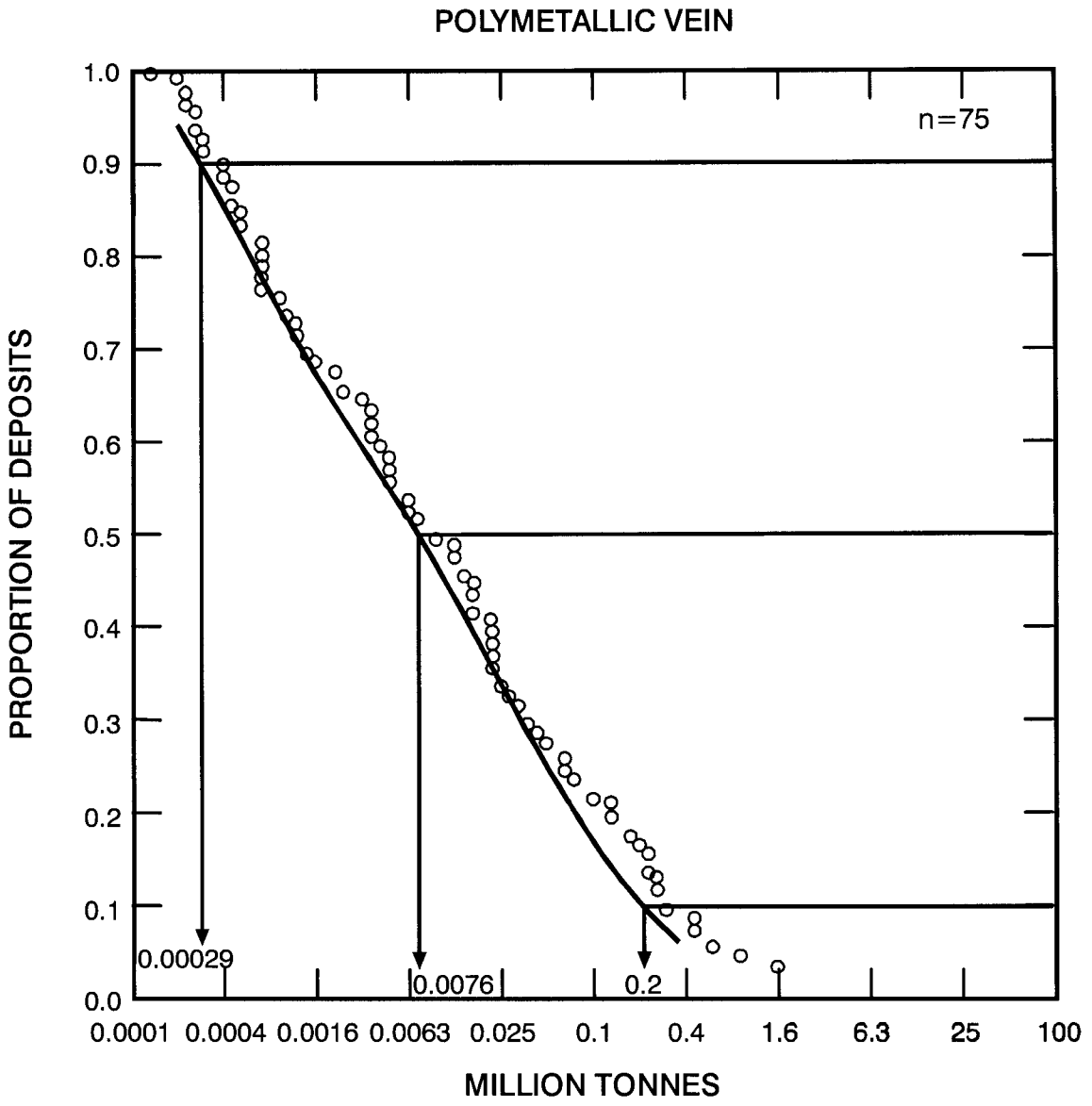
Gold grades of epithermal quartz-alunite vein deposits



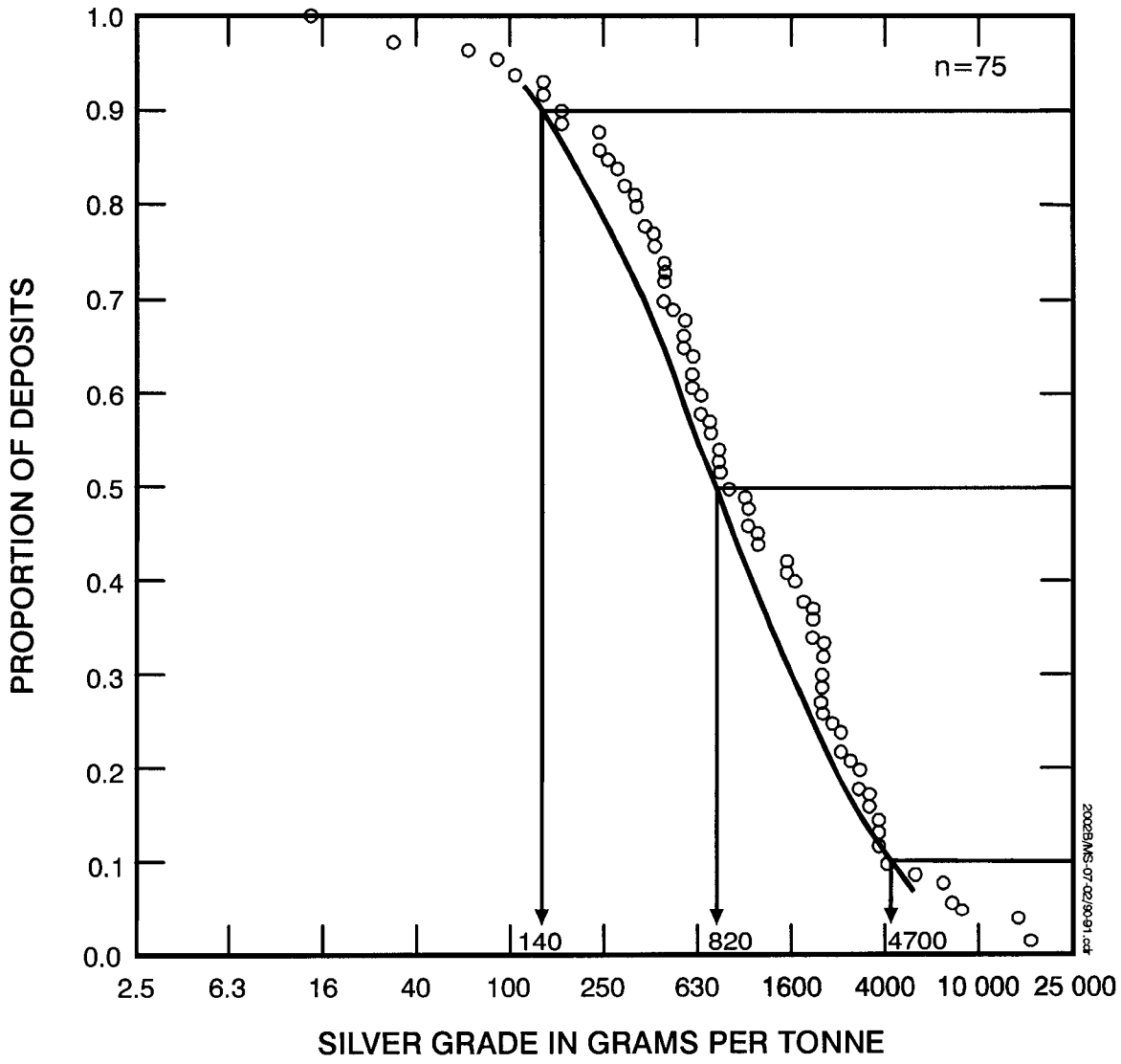
Silver grades of epithermal quartz-alunite vein deposits



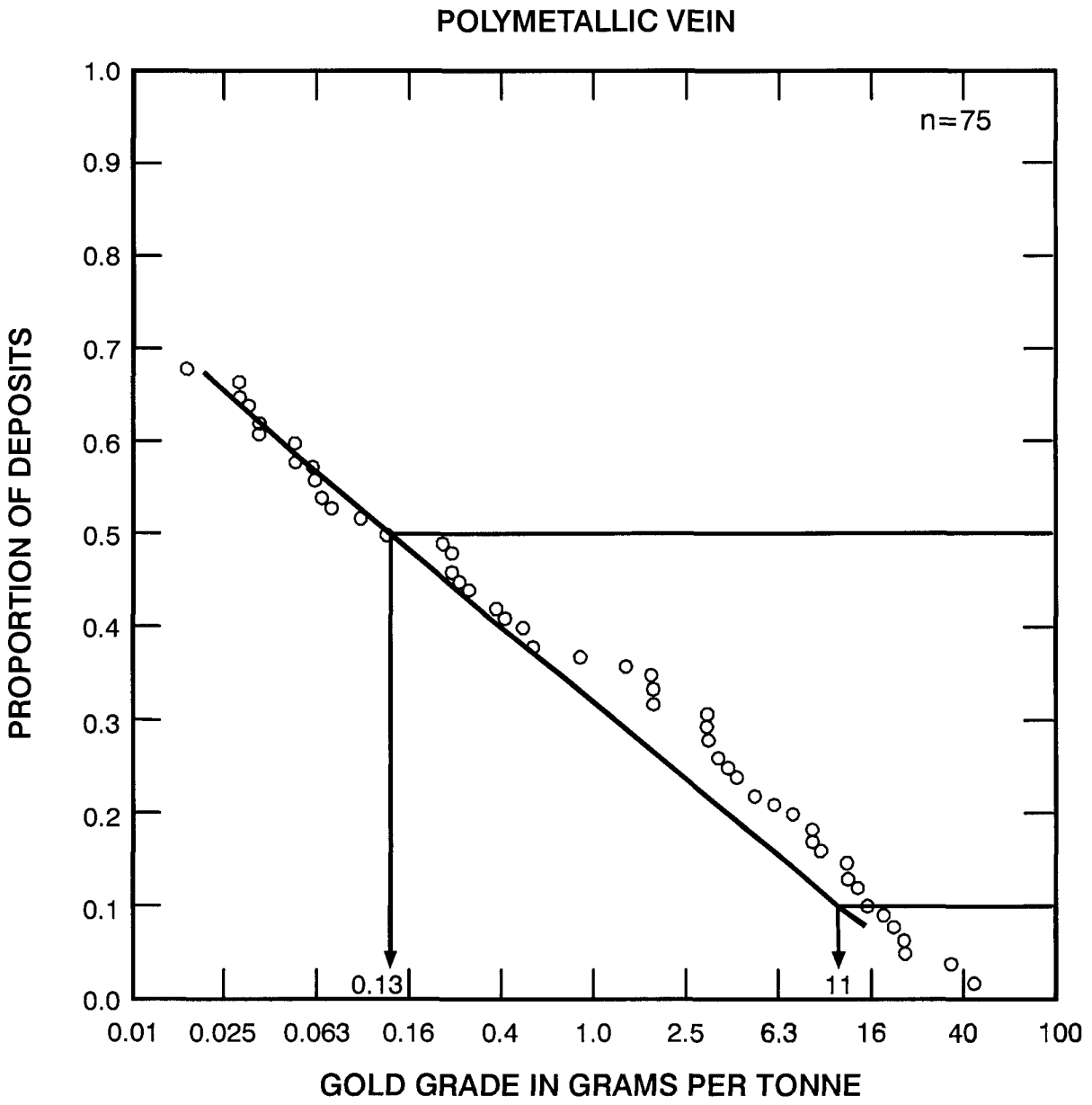
Copper grades of epithermal quartz-alunite vein deposits



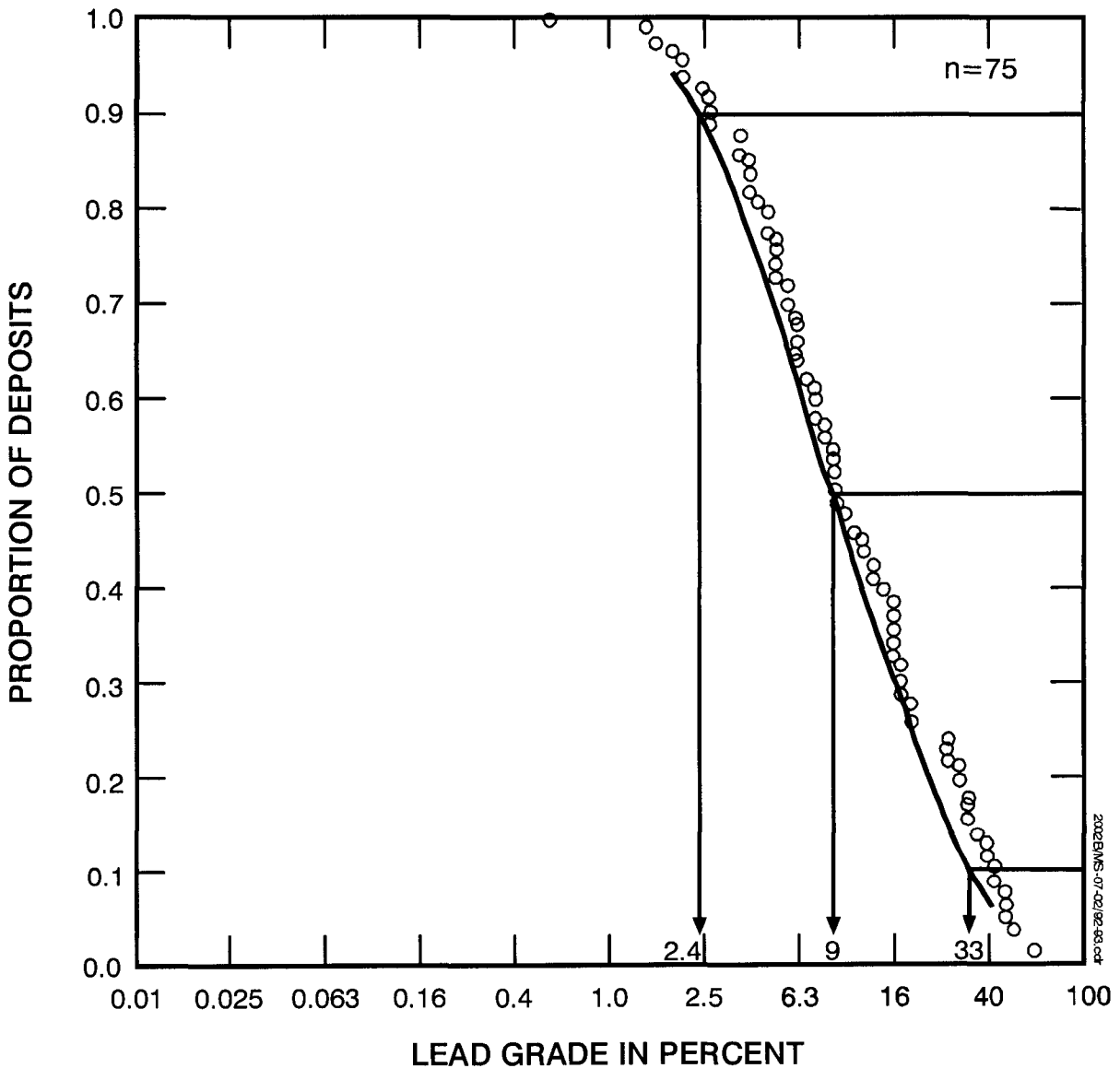
Tonnages of polymetallic vein deposits



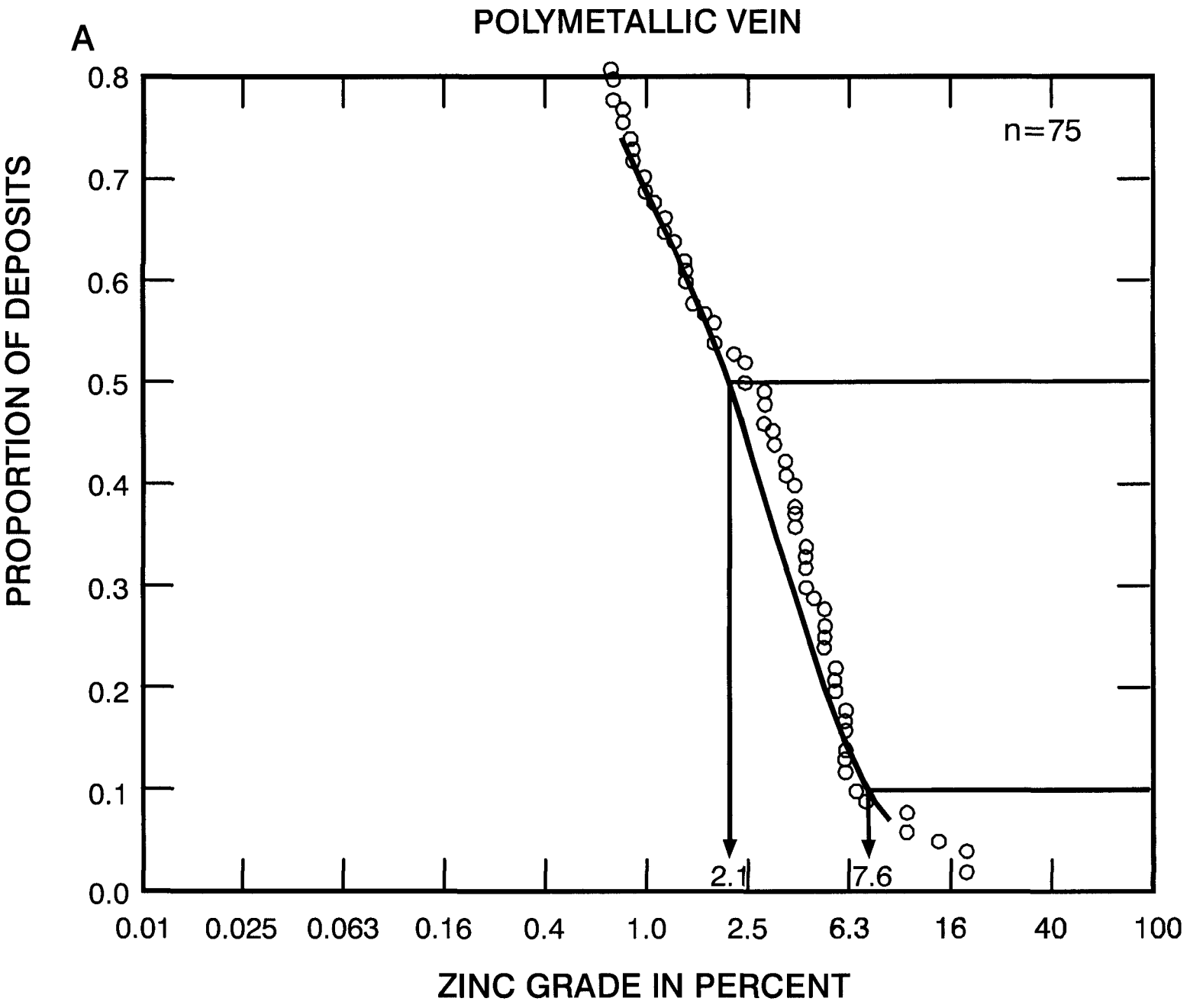
Silver grades of polymetallic vein deposits

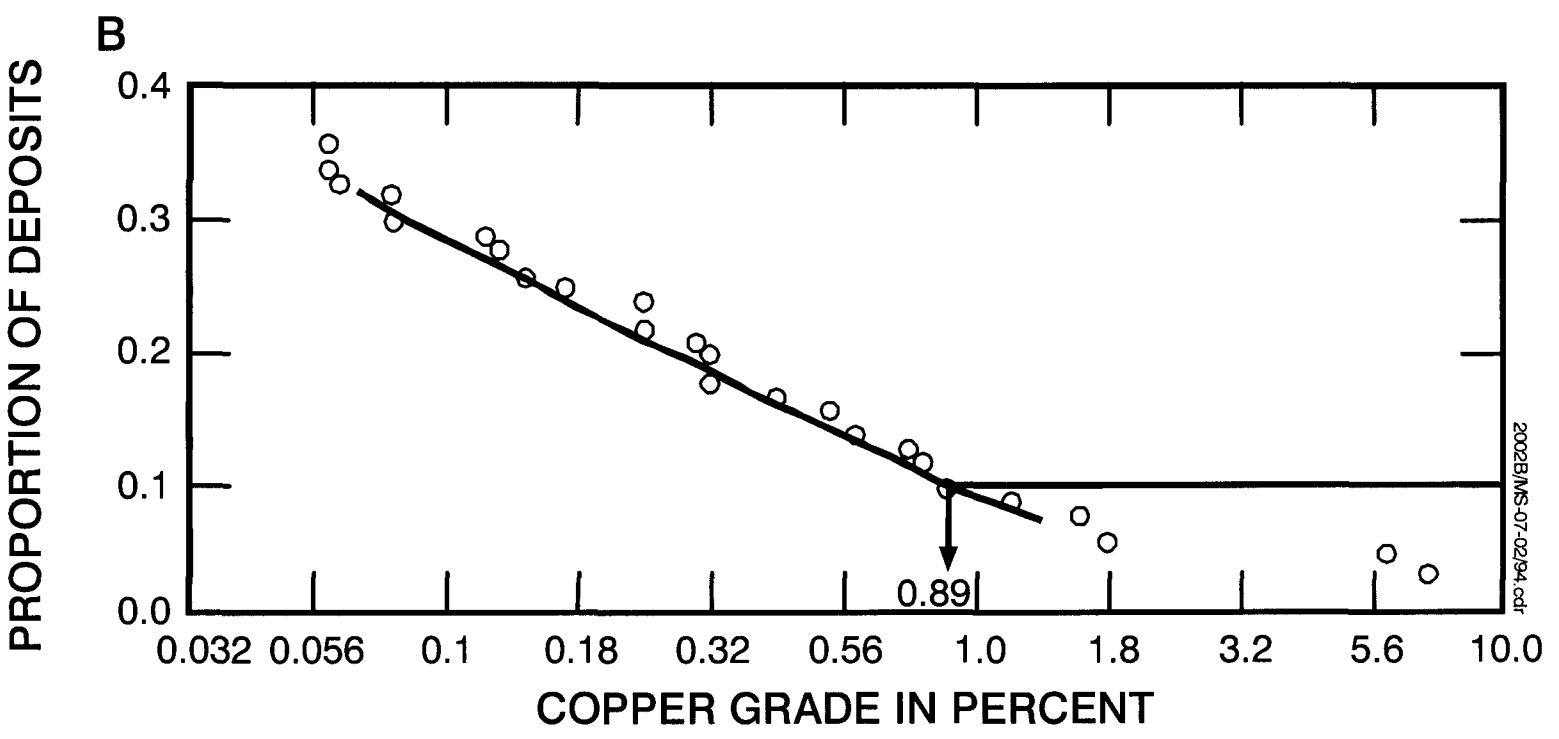


Gold grades of polymetallic vein deposits



Lead grades of polymetallic vein deposits





Zinc and copper grades of polymetallic vein deposits
A, Zinc; B, Copper