MRPA01

TASMANIA

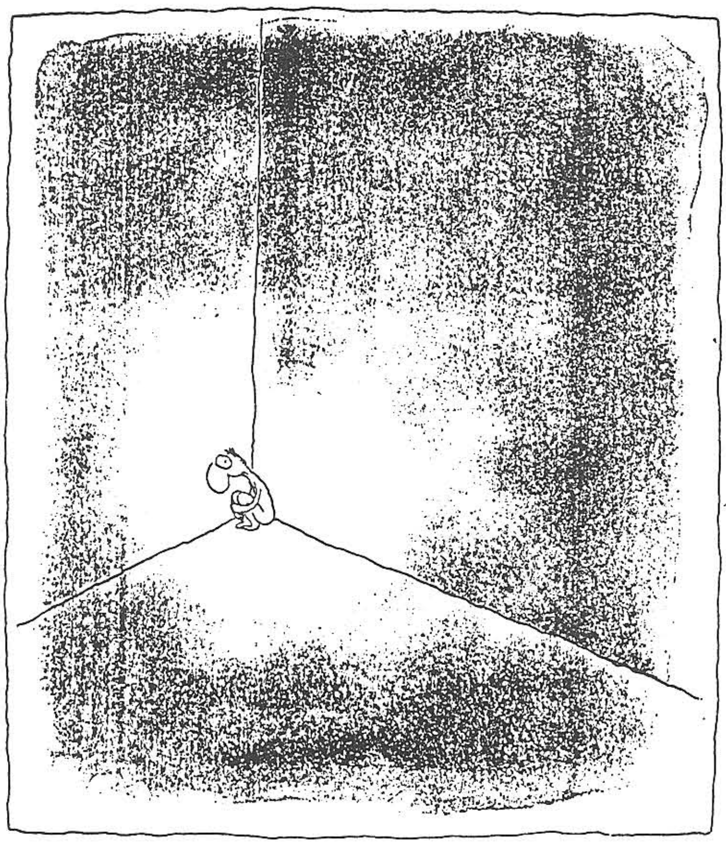
Contrasting Approaches to the Assessment of Mineral Resource Potential

DEPARTMENT OF RESOURCES AND ENERGY

DIVISION OF MINES AND MINERAL RESOURCES

CONTRASTING APPROACHES TO ASSESSMENT OF MINERAL RESOURCES POTENTIAL

DIVISION OF MINES POSITION



CONTENTS

FIGURES

TABLES

1. SUMMARY

As directed, the Division of Mines and Mineral Resources has completed a preliminary review of the literature available on mineral resource potential and potential prospectivity assessments throughout the State.

Specifically, the Division has evaluated the submissions tabled by the Combined Environmental Groups and the Tasmanian Chamber of Mines.

The two submissions provide diametrically opposed points of view on the probity of prospectivity assessments using current knowledge.

The C.E.G. submission infers that the current level of geoscientific knowledge is adequate for an informed judgement of prospectivity, and attempts to offer an empirical approach to its assessment.

The Tasmanian Chamber of Mines position paper, in contrast, indicates the uncertainty in the knowledge of the State's geology and mineral resources. No preferred method of mineral resource potential assessment is put forward but the need for repetitive assessments is advocated.

The Division of Mines & Mineral Resources cannot agree with either of these positions.

It is not agreed that the current state of geoscientific knowledge is adequate for an informed definitive judgement of prospectivity, nor is knowledge of some newly discovered mineral deposits adequate for the application of models to other areas of the State.

On the other hand, the division does not believe that the state of geoscientific knowledge is so lacking that no preliminary assessments can be made. The Department accepts that recent advances in the knowledge of the style of deformation of Tasmanian Palaeozoic and Precambrian rocks does introduce considerable uncertainty in the extrapolation of the mapped geology to depths currently accessible to mineral exploration and development. Further, it is accepted that these new advances in the geological knowledge lead to new opportunities for mineral exploration.

It is concluded that mineral resource potential assessments in the current content cannot rely on empiricism alone, must take into account long term fluctuations in commodity prices and new advances in knowledge and must address potential changes in commodities needed for humanity.

Further, it is concluded that a preliminary assessment must consider the following:

(i) past history of Exploration Licence tenure,
(ii) the extent of the current geoscientific data base,
(iii) the adequacy of this data base,
(iv) known mineralisation,
(v) the scope and thoroughness of past mineral exploration,
(vi) currently, established mineral deposit models: genetic, descriptive and grade tonneage, and
(vii) the degree of confidence that can be placed in these models.

Finally, definitions of high, medium, low and unknown mineral resource potential are presented. It is proposed that these be applied to the areas nominated for protection by the Combined Environment Groups.

However, it is not justifiable in terms of past history or of the best current geoscientific opinion, that preliminary prospectivity or mineral resource potential, assessments be applied to decisions that could lead to permanent alienation of land from mineral exploration and mining development, but that such assessments should be re-appraised from time to time in the light of advances in geoscientific knowledge and future trends in the values and types of commodities needed by mankind.

2. INTRODUCTION

Two very contrasting approaches to mineral resource assessment have been offered by the Combined Environmental Groups (Herrmann, 1990a, b) and the Tasmanian Chamber of Mines Ltd (Newnham, Leaman and Uttley, 1990).

2.1 COMBINED ENVIRONMENTAL GROUPS APPROACH

Herrmann (1990a) stresses the need for an empirical approach taking into account the geological and genetic factors of economically significant Tasmanian mineral deposits and foreign deposits where relevant. He favours the adoption of the BMR classification of high, medium and low prospectivity of Higgins et al. (1988) taking into account the "parameters of geological probability, findability and likely economic significance of known and potential deposits". In his assessment of the economic mineral potential of the areas under consideration (Herrmann, 1990b) clarifies some of the statement quoted above. He states that:

"... any future deposits, to be of economic significance, will need to be of large tonnage, fairly high grade and with an in ground value of 0.6 billion dollars. Empirically, this narrows the exploration field to two principal target types: polymetallic VMS deposits and metasomatic tin deposits", although he admits to some uncertainty with respect to the "Henty Fault style of gold mineralisation".

He further states that the results of the assessment be presented in clear terms understandable to the layman, in a quantitative manner or "to assign a quantitative confidence index where subjective or qualitative terms are used".

However, Herrmann clearly states that "prospectivity" assessments can be conducted at any one of three confidence levels:

1. **Preliminary**: involving a rapid scan of empirical geological data and comparison with established geological models.

2. **Comprehensive:** involving detailed literature review of published geological information, relevant descriptions and genetic models of mineral deposits, compilation of production and reserves data from Tasmanian deposits and conversion to dollar values using present data metal prices, projection of economic trends over the short term ("foreseeable future"), results of previous exploration programmes and production of maps indicating distribution, extent etc. of past exploration programmes.

3. **Exhaustive:** modelled on the U.S. Wilderness Act. Involves an exhaustive mineral assessment programme centred on the generation of new data, in contrast to the more cursory depths of evaluation listed above which only entail review of existing data. Such activities as geological mapping, geophysical surveys, geochemical sampling, detailed study of known mineral deposits, drilling and research.

2.2. TASMANIAN CHAMBER OF MINES APPROACH

The Tasmanian Chamber of Mines did not specifically outline a preferred method of "mineral resource potential assessment", but stressed the need for "dynamic or recurring assessments" as promoted, among others, by Higgins et al. (1988).

Newnham, Leaman and Uttley (1990) clearly reject the concept of empiricism favoured by Herrmann and stress the need to incorporate new geological models which are continually emerging and some of which are yet to be applied to exploration in Tasmania.

They advocate repetitive mineral resource potential estimates by the Division of Mines and Mineral Resources over the whole of Tasmania, including National Parks.

Although not defining a mechanism of resource potential assessment, the Chamber's paper endorsed the approach adopted by the Canadian Department of Energy, Mines and Resources (Hutchison, 1986).

Hutchison reviewed the Canadian experience with mineral resource assessment programmes over 140 years, and in the period between 1958 and 1982 in particular. This paper promoted a similar philosophy to that of Higgins et al. (1988):

"... We are dealing in large part with intangibles in the form of undiscovered resources. As such, the 'inventory' process is difficult and commonly subjective and yields no final, absolute answers".

"Policies and mechanisms for determining the most effective use of lands require mineral and fuel resource estimates for assigning 'future values' for lands".

As stated by Newnham, Leaman and Uttley (1990), the trend of the resource estimates in Canada has been one of early quantitative assessments which expressed results in numerical terms - "numbers of deposits expected, grades and tonnages" which reached a peak in 1972 to expressing results in qualitative, non-numerical terms (Hutchison, 1986). This was because it was realised that "the existing information base and methodologies were inadequate to support rigorous analyses".

Hutchison further states in the current assessments an attempt is made to build the assessment process in a number of steps:

"1. Acquiring the best relevant new data.

2. Using skilled expertise to create a "portrait" that emphasises the character of the fuel or mineral deposits being sought and its local geological environment.

3. Unravelling the processes of formation and historical evolution of the resource deposit to derive a deposit model.

4. Applying the deposit model in a predictive manner to target environments for new deposits or possible extensions to existing deposits."

This process is outlined in Fig. 1. It is important to note that "hindsight studies" that is, later review, are considered an integral part of the process.

The deposit models are derived from a process involving observations on both the individual deposit scale and the regional geological setting and involve the use of interpretative and conceptual data (Fig. 2).

It is important to recognise the importance of the conceptual component and the ephemeral nature of the models - they constantly undergo re-assessment and refinement. Thus a model is only valid "for the time being" (Hutchison, 1986).

This point is underscored from an explorationist's point of view by Woodall (1983) who states that there are two stages of mineral exploration: an early generative stage and a subsequent exploration stage. During the generative stage both field based and literature reconnaissance is carried out, the commodities to be searched for and the search area are decided and a budget is set. This is heavily dependent on the application of "empirical and/or theoretical conceptual models...".

"The development of and application of an empirical model involves:

(i) the observation of geological features commonly associated with mineral deposits;

(ii) a judgement of the likely relevance of the observed associations; and

(iii) the assessment of the mineral potential of some unexplored region in the light of this knowledge.

Because judgement of relevance is an essential stage in the development of an empirical model, empirical models cannot be developed independent of scientific understanding".

1. BEST AVAILABLE <u>RELEVANT</u> NEW DATA
- Regional & local geology
- Tectonic history
- Geophysics, geochemistry
- etc.

2. "PORTRAITS" OF DEPOSITS
- Physical & chemical characteristics
- Depositional environments
- Signatures (geochemical, geophysical)
- Isotopes & geochronology
- etc.

3. PROCESSES OF FORMATION
- PT conditions
- Fluid regimes
- Alteration processes
- etc.

4. APPLICATION OF <u>PREDICTIVE</u> MODELS
- Qualitative & quantitative assessments

5. HINDSIGHT STUDIES

WHERE DID WE GO WRONG ?

Figure 1: Key elements in a modern sequential approach to resource assessment. (After Hutchison, 1986).

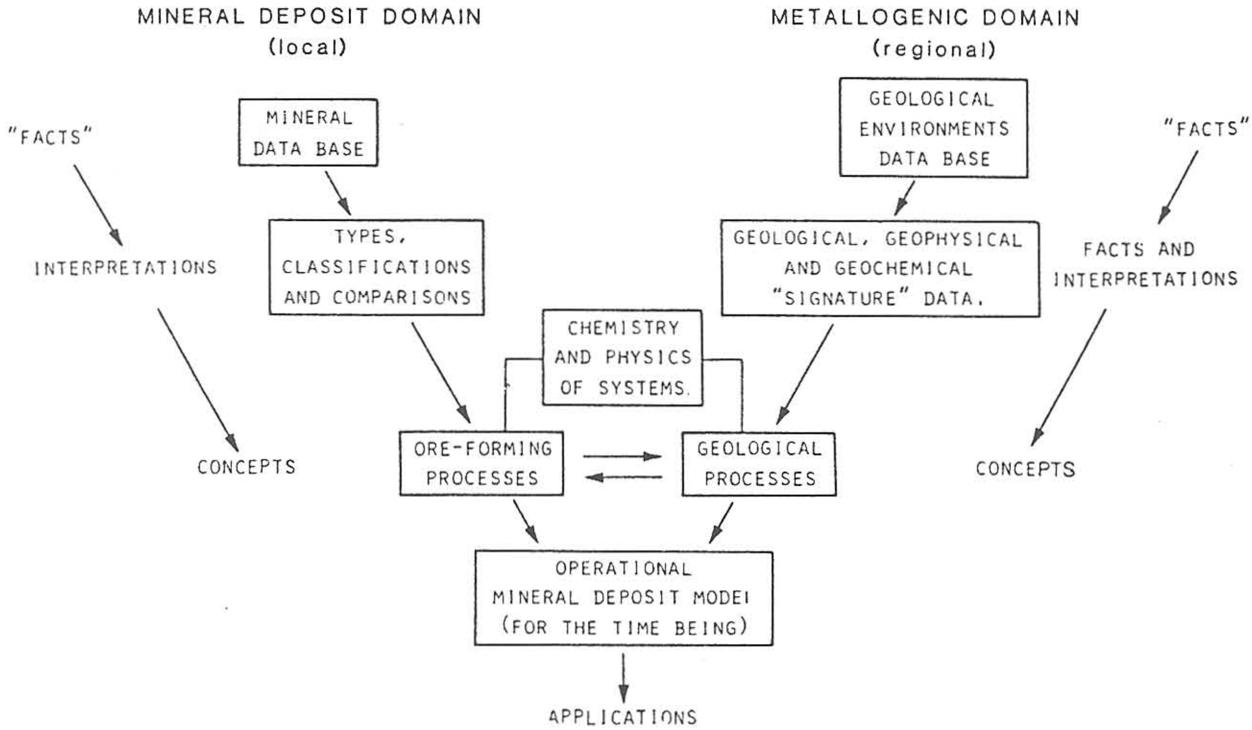


Figure 2: Development of operational deposit model from local deposit and regional metallogenic data. (After Hutchison, 1986).

..."One serious limitation of empirical models is that they cannot predict new deposit types". Woodall cites the discovery of the Kambalda nickel deposit in 1964 as an example of a major deposit style not then adequately covered by an empirical model.

Mineral discoveries can thus eventuate by the development of new ideas on the factors responsible for ore or petroleum accumulation prior to the existence of any knowledge of that particular style of mineralisation and/or in areas previously believed to be barren.

Theoretical and laboratory studies of "the source of the mineral or metal, the media of its transport, the cause of its movement from source to site of accumulation and factors which result in precipitation, enrichment or trapping can lead to the discovery of mineral deposits". Woodall cites the Yeelirrie uranium deposit in Western Australia and the Olympic Dam copper deposit, discovered under 300 metres of barren rock as examples of finds largely related to the development of new conceptual models.

Woodall then states:

"Our ability to conceive useful conceptual models during the generative stage of exploration is limited only by the density of available, reliable geological, geochemical and geophysical data and our understanding of the physics and chemistry of earth processes".

Earlier he said:

"Much of the data assessed at this stage is part of the valuable national, geoscience data base assembled by Government geological surveys and universities".

Woodall goes on to assess the factors which constitute successful exploration. Briefly, he considers three factors are essential:

(i) confidence
(ii) money
(iii) time

The effectiveness of exploration is governed by three factors:

" (i) the extent to which the search area has been reduced to manageable dimensions during the generative stage;

(ii) the effectiveness of the available exploration methods; and

(iii) the quality, skill and motivation of the scientists and the technicians entrusted with the search".

In short the process of resource potential assessment is very similar to that of an exploration company assessing the prospectivity of an area. Both require vision and scope of knowledge and cannot rely on empiricism alone. They are both limited by the quality of the available data and are subject to sudden and major changes caused by the advance in scientific knowledge. Metallic mineral exploration current involves search several hundred metres to over a kilometre below the surface; oil exploration on land has involved drilling to depths of 9 kilometres. Therefore any mineral resource potential assessment must take into account our knowledge of the geology at depth when assigning a confidence level to the assessment. This means that such an assessment can never be completely unequivocal or final.

2.3 DEVELOPING A METHOD OF MINERAL RESOURCE POTENTIAL ASSESSMENT FOR TASMANIA

Development of a method of resource assessment appropriate for Tasmania involves consideration of past international experience, previous resource estimates carried out in Tasmania and must also involve analyses of, and comment on, the very different approaches outlined by the Combined Environmental Groups and the Tasmanian Chamber of Mines.

The next sections of the paper provide a critique of the two papers as a means to establishing the Department's method of resource assessments for the areas nominated by the Combined Environmental Groups for incorporation in National Parks or World Heritage areas.

3. CRITIQUE OF THE COMBINED ENVIRONMENTAL GROUPS PAPER "MINERAL RESOURCE ASSESSMENT METHODS" by W. HERRMANN

Herrmann (1990a) provides a reasonable summary of the resource potential assessment methods circulated at the meeting of the Working Group, but intersperses this with a large number of subjective comments, many of which are arguable or incorrect.

3.1 QUALITY OF DATA BASE

The geological data base in western Tasmania has been considered to be adequate to enable estimates of mineral potential to be made (Solomon, 1990). This statement is only true of certain areas and much of the information is severely dated. The largest scale and year of publication of geological maps in Tasmania is shown in Figure 3. Areas covered by 1:250 000 scale mapping are in fact compilations of existing data available in 1973. Some of this information may be in the nature of geological interpretation from aerial photographs. Much of the older information (15 years +) is inadequate for resource estimates. The substantial changes to parts of the St. Valentines 1:50 000 sheet published in 1987 by the 1:25 000 mapping of the Mount Read Volcanics project is a recent example of this.

In general: "The usefulness and longevity of a geological map are greatly influenced by the state of geological knowledge at the time when that map is made the scale at which mapping is done, and the time available to do the mapping." (U.S. Geological Circular 1020, 1987).

In particular, the current recognition of major large scale thrusts in the Precambrian and Early Palaeozoic rocks of Tasmania (Carey and Berry, 1988; Leaman and Richardson, 1989; McClenaghan and Findlay, 1989; Berry and Crawford, 1989) make any depth extrapolation of geology mapped at the surface hazardous.

Figure 3A: Year of publication and largest scale of Government geological maps covering the C.E.G. nominated areas.

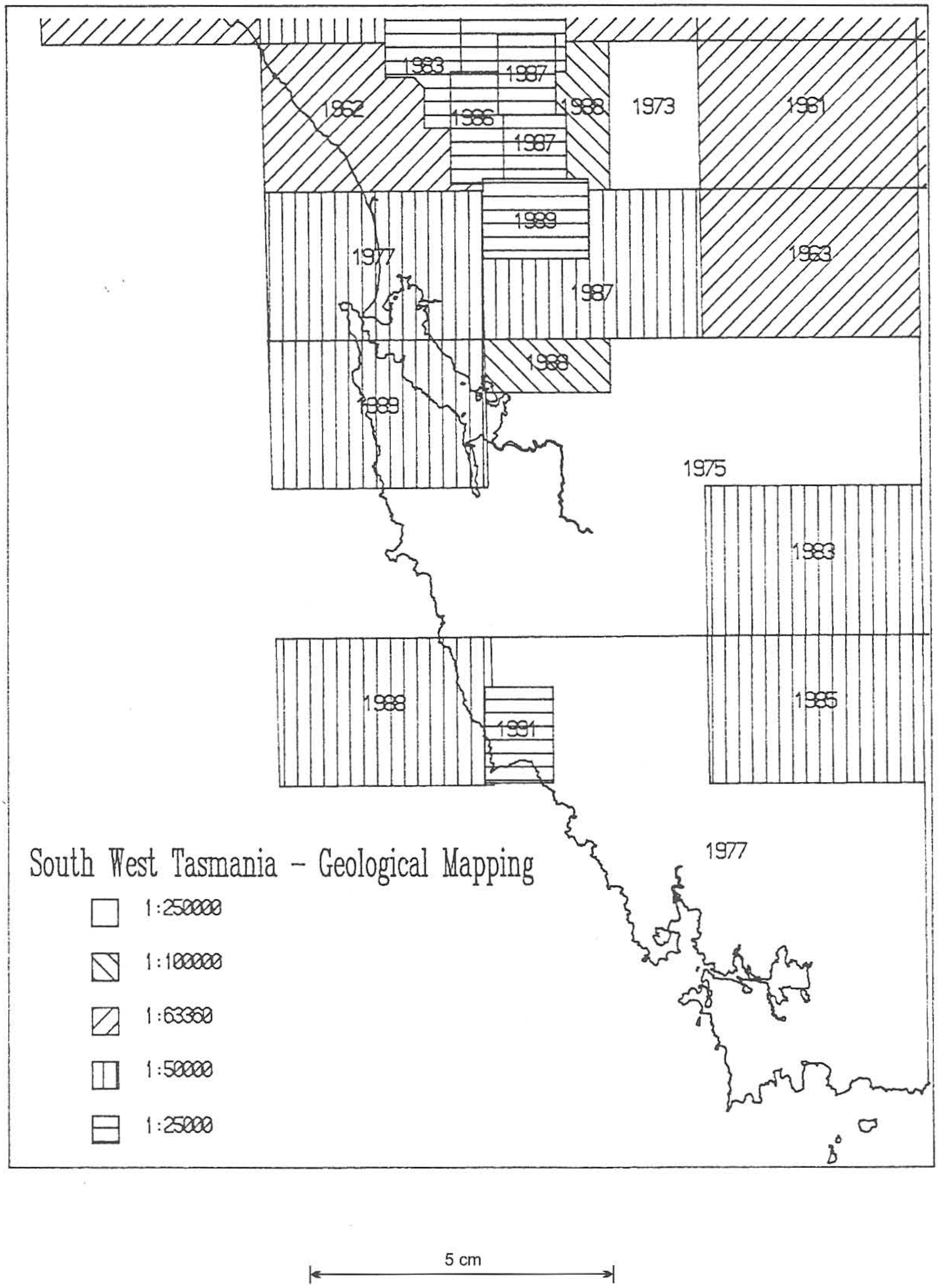


Figure 3B: Year of publication and largest scale of Government geological maps covering the C.E.G. nominated areas.

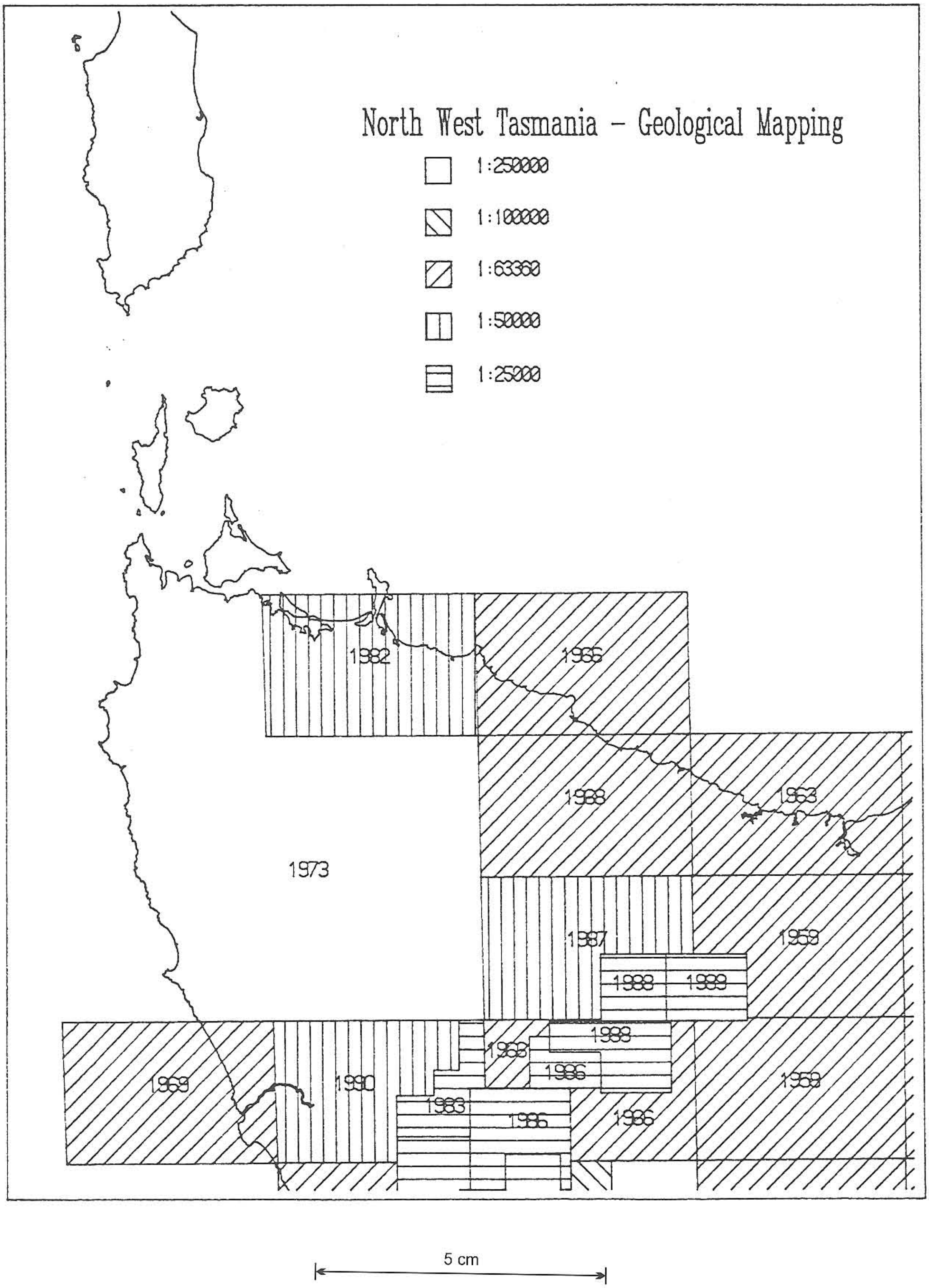


Figure 3C: Year of publication and largest scale of Government geological maps covering the C.E.G. nominated areas.

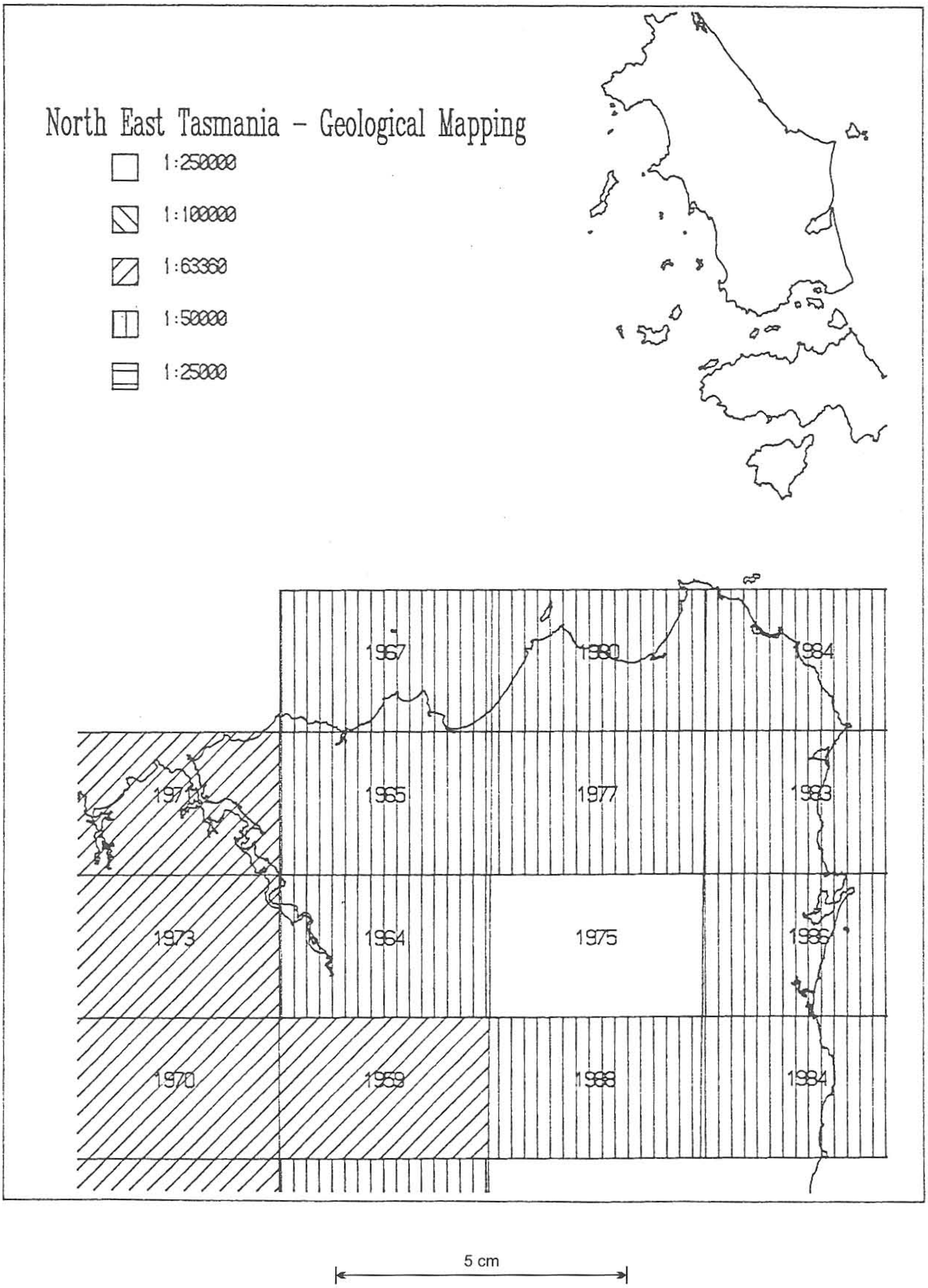
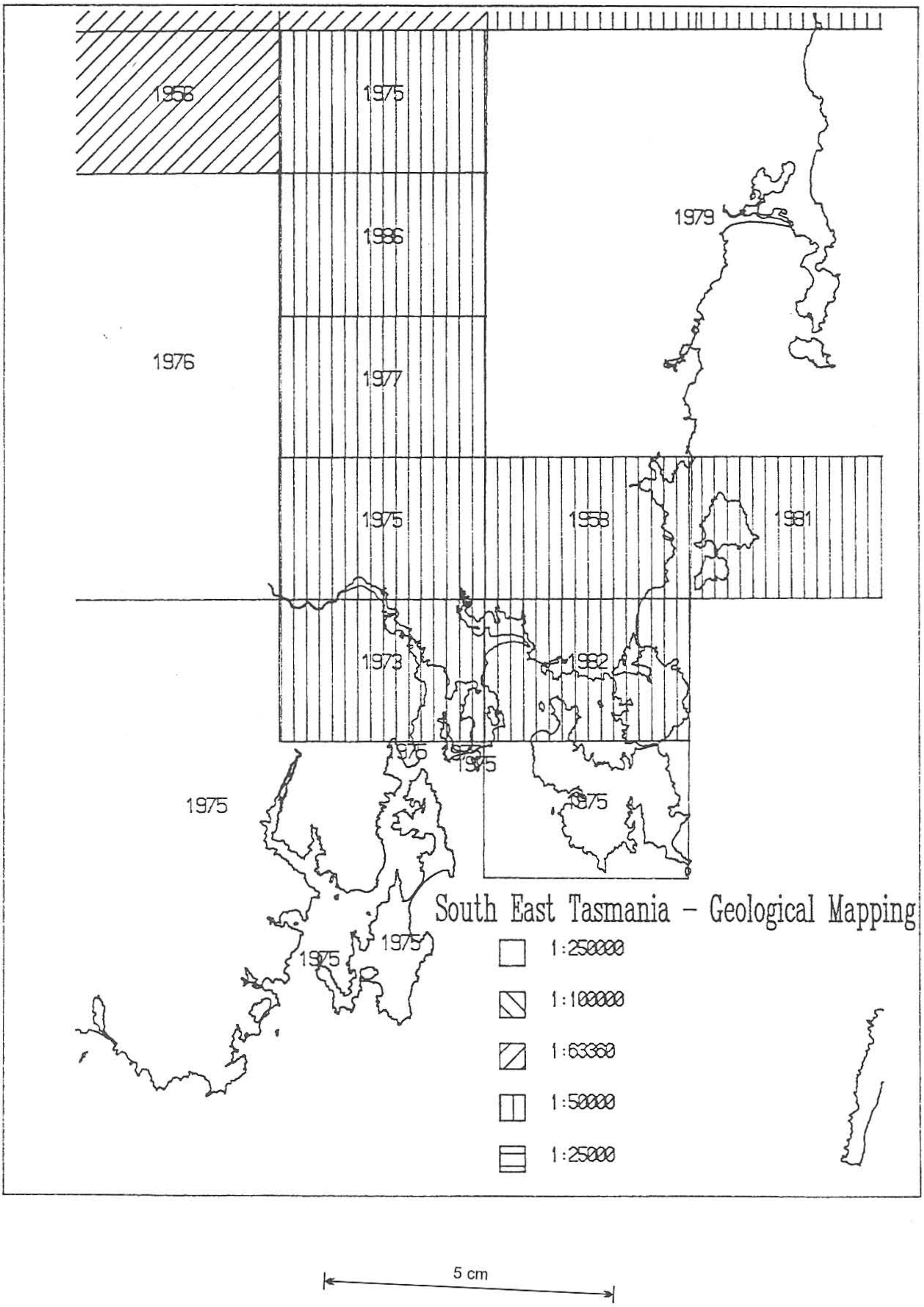


Figure 3D: Year of publication and largest scale of Government geological maps covering the C.E.G. nominated areas.



3.2 DEFINITION OF ECONOMICALLY VIABLE DEPOSITS

Herrmann (1990b, and 1989) considered the lower limit of economic viability of a mineral deposit to be 0.6 billion dollars of in situ value of fairly high (but undefined) grade. This definition fails to take account of accessibility, marketability, base of beneficiation and environmental factors all of which are vital inputs into the decision whether or not a body of rock is worth mining for a specific commodity.

Moreover, it fails to acknowledge the considerable metallurgical infrastructure currently available in western Tasmania and the potential for ore from suitable small deposits to be transported to, and treated at, established mills using spare plant capacity or by upgrading or adapting existing capacity, or by substitution of ore feed.

Herrmann's definition is at variance with his stated empiricism: the facts are that two of the three new mines to open in the last five years: the Amatek silica deposit at Corinna and the Anchor tin mine in the Blue Tier both fail to meet Herrmann's definitions of style of mineralisation or in-situ value. Clearly the narrow confines of Herrmann's definitions of worthwhile economic targets are not consistent with present commercial reality. The single deposit which has been recently developed which falls within Herrmann's guidelines is Hellyer which ranks in the top order of World wide ore discoveries in the last decade.

Further, such a definition of worthwhile economic targets, would restrict potential mines to large deposits requiring the major capital input usually associated with multinational corporations. Again, MK Silica and Spectrum Resources represent developments initiated by small concerns. With respect to the silica deposit, such a development falls within the context of small Tasmanian industries supplying high quality products to world markets.

A third category of deposit which slips through Herrmann's net of commercial attractiveness is the polymetallic Devonian vein deposit of the Mt Farrell, Zeehan or Magnet type (Herrmann, 1990a, p. 4). Again this restriction is at variance with fact: in 1976 the then Electrolytic Zinc Company successfully transported mine wastes from Magnet to Rosebery for zinc extraction. Today the Magnet Mine which produced 633,006 tonnes at a grade of 7.3% lead, 7.3% zinc and 147 g/tonne of silver would realise some $155 per tonne (G. Iliff, personal communication).

Fourthly, Herrmann (1990a, p. 4) suggests that the very small lode type deposits of the Curtin Davis area "never were, are not now and are not foreseeably likely to be economically significant". Some of these deposits, such as Rich P.A., probably did in fact return short term profits, but it is admitted that their present day value probably does not lie in the intrinsic value of their ore. Rather, it is the unusual mineralogy particularly in the abundance of sulphosalt minerals such as jamesonite and bournonite that might signify a worthwhile prize at depth. As can be seen by an examination of Both and Williams (1968) classic study of the zonation of sulphide minerals in the Zeehan area such assemblages cluster around the significant tin deposit of Queen Hill.

Finally, Herrmann's evaluation is strictly tied to present day metal prices and is severely constrained by the commodities considered to be of economic worth. It fails to consider the long term volatility in price of some of Tasmania's traditional mineral products such as tin and tungsten and does not adequately evaluate, or dismisses pre-emptively, some commodities that offer promise for the future such as ochre, clay, silica and magnesite.

The following main conclusions emerge from Herrmann's definitions of prospectivity and their application to western Tasmania (Herrmann, 1989).

1. His criterion of <u>present day</u> economically viable mineral deposits is too narrow and is at variance with present Tasmanian experience. In short, it is <u>not</u> empirical.

2. His considerations of worthwhile commodities and deposit grades does not address future trends and commodity prices and is therefore entirely inappropriate for long term land use planning.

3. He has downplayed the potential of some areas - particularly the Mt Read Volcanics - to lower levels of prospectivity than are considered appropriate. These issues will be addressed in detail when the area is assessed in detail.

4. The paper on the economic geology of western Tasmania is narrow in scope, pessimistic in judgement, and a remarkable case of limited vision.

5. Herrmann's (1990a) classes of prospectivity assessments are too generous in their definition. Compared to other studies in the field, his preliminary stage would equate to a cursory examination, and his comprehensive category is of the standard of the preliminary assessment of Higgins et al. (1988). Given the philosophy of Hutchison (1986) and Woodall (1983), and the case studies cited in the latter paper, we do not consider the term "exhaustive" appropriate to an assessment of the type carried out by the U.S. Geological Survey in wilderness areas. We prefer the term "intensive" for this type of data generative assessment.

4. CRITIQUE OF THE TASMANIAN CHAMBER OF MINES POSITION PAPER 'KEEPING OUR OPTIONS OPEN' BY L.A. NEWNHAM, D.E. LEAMAN AND P. UTTLEY

The Chamber of Mines position paper does not offer any clearly stated mechanism of mineral resource assessment potential, but effectively negates the feasibility of offering any present solution to long term exclusive land preservation policy through Clause 5 of its Executive Summary.

'It is scientifically impossible to identify areas not required by the future Mining Industry because of the continually and rapidly changing nature of the geological sciences, exploration methologies and the mineral requirements of mankind'.

This single statement lies in the crux of the current argument. Evaluation of this clause, together with the other points of the Executive Summary, defines the likelihood of compromise between the stated positions of the Combined Environment Groups and the Chamber of Mines.

Clause 1 of the Executive Summary addresses the Chamber of Mines viewpoint of the significance of the Mining Industry. This statement is assessable in the light of currently available statistical information:

'A strong responsible Mining Industry is vitally important to the social and economic well being of all Tasmanians. The Government must encourage such an industry and support its long term viability. This can be achieved only by the discovery of new resources - which requires repeated exploration access to large areas of land'.

In 1986-87 metallic mineral production (f.o.b.) value from Tasmanian ores constituted 4.33% of Australian production from 0.88% of its area.

TASMANIA PRODUCES FIVE TIMES THE NATIONAL AVERAGE OF METALLIC MINERAL PRODUCTION PER SQUARE KILOMETRE

The value from production of Tasmanian minerals in 1988-89 was $588 million.

The demographic characteristics of western Tasmania have been summarised by Lee (1977) based on the census of 1971. His conclusions were that the economy of western Tasmania was sustained by mining. By the courtesy of Mr B.D. Hall, (Australian Bureau of Statistics), we have been able to demonstrate that the same situation applied 15 years later in 1986, after the discovery of Hellyer, but prior to the development of that major orebody.

Between 1971 and 1986 the population of western Tasmania (defined as the population of the then extant municipalities of Queenstown, Gormanston, Strahan, Zeehan and Waratah) declined from 12,368 to 11,132. During that time there had been a dramatic decrease in the work force at Mt Lyell, which was in part offset by the increase in the HEC work force related to the construction of the Pieman, Henty-Anthony and King hydro-electric developments. (In the interim the Gordon-below-Franklin scheme was under development, but was quashed by the decision of the High Court of Australia in 1983). However, the increased tourism generated by the Franklin River debate did not compensate for jobs lost in the mining industry and the proportion of people employed in the mining industry did not decline significantly over the 15 years between 1971 and 1986.

TABLE 1: COMPARATIVE STATISTICS OF PEOPLE EMPLOYED IN THE MINING INDUSTRY IN WESTERN TASMANIA 1971-1986

	% of work force engaged in		
MUNICIPALITY	mining 1971 (Lee, 1977)	mining 1986	electricity/construction 1986
Queenstown	57.0	28.3	22.0
Gormanston	55.2	2.9	77.5
Strahan	22.7	4.8	13.4
Zeehan	60.1	45.4	29.1
Waratah	71.7	64.1	3.6

According to Lee (1977) the economy of a region is dominated by mining if 15% of the workforce is employed in the industry. Taking the west coast region as a whole, the proportion of the workforce employed in the mining industry declined from 56.3% to 39.3% between 1971 and 1986. However, if the electricity and construction sectors are discounted the proportion of the workforce employed in the mining industry in 1986 increases to 51.4%. The inescapable conclusion is that the west coast remains dependent on the mining industry and to remain a viable community will continue to do so for the foreseeable future.

There are a number of points made in the Chamber of Mines position paper that require clarification. In particular it is important to see the degree of fit between existing geophysical data and the speculative and interpretive geological cross sections in Figures 9, 10 and 11 of their paper.

However, there has been considerable recent support for major shallowly dipping thrust faulting involving the early Palaeozoic and Precambrian rocks of western Tasmania. McClenaghan and Findlay (1989) have mapped thrust contacts between metamorphosed Precambrian orthoquartzite and Cambrian dolomite, mudstone and lithicwacke. Independent geophysical interpretations of gravity and aeromagnetic data by Leaman and Richardson (1989) have indicated that these thrust faults are major structures on a regional scale.

Carey and Berry (1988) have shown that there is major thrust stacking of rocks varying in age from Cambrian to Devonian at Point Hibbs and Berry et al. (1990) have suggested that the Rosebery and Henty Faults are joined at depth by a major flat lying fault. Berry and Crawford (1988) have proposed that the ultramafic-mafic complexes of western Tasmania and the Adamsfield and Beaconsfield areas, the source of the eluvial and alluvial platinoid and chromite deposits, were emplaced westwards for distances of several tens of kilometres about 540 million years ago, and that this thrust faulting also involved the Precambrian basement in places. Clearly, although some of the cross sections shown in Newnham, Leaman and Uttley (1990) are speculative, there are mounting scientific data to indicate that there has been more than one event of major thrust faulting, one of Cambrian age and another of Devonian age or younger.

> THIS SUGGESTS THAT LARGE AREAS OF PRECAMBRIAN METAMORPHIC ROCKS, COMMONLY REGARDED AS RELATIVELY UNPROSPECTIVE IN THE PAST FOR BASE METAL DEPOSITS MIGHT OVERLIE YOUNGER MINERALISED ROCKS OR HORIZONS PROSPECTIVE FOR PETROLEUM.

5. CONCLUSIONS FROM THE CRITIQUES

The balance of opinion provided by the papers distributed by the Department of Resources and Energy to the Working Group on prospectivity and other sources quoted here emphasise that repetitive assessments are necessary (Brobst and Goudarzi, 1984; Taylor and Steven, 1983; Woodall, 1983; Hutchison 1986; Higgins et al., 1988).

Solomon (1990) states that 'mineral resource estimates' provide important input into land use decisions and that 'estimates of mineral potential in western Tasmania have been possible because of the relatively detailed geological knowledge available'.

Herrmann (1990a) states that, in the time available, an assessment of areas not required by the mining industry can only be superficial. This is clearly an inadequate basis on which to make an informed judgement on a matter of vital long term importance to the Tasmanian economy because:

1. there have been major advances in the geological knowledge of the State in the last three years which casts serious doubt on previous interpretations of the structural geology;

2. the existing geological mapping data base largely pre-dates these advances and much of it is of an inadequate scale, or of inadequate detail, on which to make a reasoned judgement of mineral potential;

3. new classes of deposits have been discovered recently whose genesis is unknown and therefore any extrapolation based on inadequately determined models would be extremely dubious, or totally incorrect; and

4. such an assessment could not take into account future developments of the mineral requirements of humanity. That is, such a premature judgement would jeopardise the sustainability of Tasmania's mineral industry.

Already industry concern with Tasmanian land use policies has resulted in a decline in exploration expenditure in Tasmania. The current shift in exploration emphasis from a gold to base metal exploration (Mining Journal, June 15, 1990) and buoyancy in zinc and lead prices (Mining journal, May 4, July 6, 1990) would generally be expected to lead to an increase in exploration expenditure in the State. However, concern over future land use decisions had resulted in a stagnation in exploration activity in this State (Australian Minerals Industry Council, 1990).

Therefore, the current exploration licence tenure position cannot be taken as either a measure of prospectivity or of long term mineral resource potential of the C.E.G. nominated areas.

It is argued that allowing sufficient time to make a reasoned preliminary judgement of mineral resource potential poses no threat to the environment. Mineral exploration in Tasmania is currently examined closely with respect to its environmental impact and exploration programmes in conservation areas require approval by a committee comprising representatives from the Departments of Parks, Wildlife and Heritage; Environment and Planning; and Resources and Energy as well as the Forestry Commission.

6. A METHOD OF MINERAL RESOURCE POTENTIAL ASSESSMENT

6A FACTORS WHICH NEED TO BE CONSIDERED

It is considered that the following factors need to be taken into account in any assessment of mineral resource potential of the C.E.G. nominated areas:

(i) the geology, distribution of mineralisation and the adequacy of that information;

(ii) current descriptive, grade-tonneage (Cox and Singer, 1986) and genetic (Barton, 1986) models of mineral deposit types, as well as relevant conceptual information (cf. Woodall, 1983);

(iii) the long term tenure of areas covered by exploration licences;

(iv) commodities sought, and quality of, past exploration programmes;

(v) possible future trends in commodity prices; and

(vi) possible future shifts in commodities required for humanity

6B COMMENT ON THE RELEVANCE OF THE FACTORS REQUIRING ASSESSMENT

(i) In terms of geology, the degree of confidence in the surface mapping data (rock distribution, structure, detail of subdivision) and its extrapolation to depth;

(ii) Current exploration models provide an index of commodities and styles of mineralisation expected in a given area. If a class of mineral deposit, currently well understood, has been discovered in an area, then the area must be considered prospective for that deposit type. It is somewhat irrelevant to consider the size of known deposits; rather grade-tonneage models of the type developed by the U.S. Geological Survey (Cox and Singer, 1986) should also be taken into account. Three types of models will be considered:

(a) empirical or descriptive;
(b) genetic; and
(c) grade-tonneage.

(iii) The spread of exploration licences in the past provides a historical perspective on areas considered prospective for certain commodities.

(iv) Past exploration history rarely provides information on the full range of potential commodities in an area. Some programmes have been highly specific in terms of minerals sought. An example is Base Resources' tenure of Exploration Licence 29/83 in the Campbell River area, which was directed towards diamonds. Such projects may enable a start-of-the art exploration focus for a given commodity for a given period, but also result in a stagnation in the application of advances in knowledge in the distribution of other minerals.

(v) Possible changes in commodity prices require the skills of a fortune teller and are not readily addressable in this report. Nor can long term mineral resource potential be considered from the narrow viewpoint of present prices. Other factors, such as the presence of valuable co-products also must be considered.

(vi) This partly overlaps question (v), but also addresses new commodities required for the future. High purity silica deposits for lens glass and ochre deposits for use as pigments are two recent examples of new developments and potential developments being the result of changes in the exploration focus for minerals sought. Again, it would require a soothsayer to predict future directions accurately.

For the reason that the Combined Environmental Groups suggest that the results of any mineral resource potential assessments should be an input into decisions relating to permanent land use classification and because of the importance of the mining industry to the economy of Tasmania in general and the viability of the western Tasmanian community in particular, a narrow focus based on an empirical evaluation of present day prospectivity must be rejected. Rather, the assessment will be based on conceptual as well as empirical grounds and will also take into account the quality of the geoscientific data base and the degree of understanding in the mineral deposit models. For example, Barton (1986) relates the available models to a spectrum of understanding ranging from the empirical (e.g. gold vein deposits) to the "almost entirely genetic models" (e.g. potassium in evaporites, gold placer deposits).

Barton further states that:

"THE GENETIC MODELS ARE FAR MORE POWERFUL BECAUSE THEY ARE MUCH MORE FLEXIBLE".

Barton ranks the level of genetic understanding of several classes of mineral deposits (Fig. 4). Placer gold excepted the most completely understood class of metallic mineral deposit in Tasmania is the volcanogenic massive sulphide class with a level of understanding estimated by Barton at 70%.

Several recently discovered deposits in western Tasmania (Henty gold, Corinna silica, Savage River ochre) have not been studied, or the studies into their genesis are in their infancy. Consequently, exploration for these classes of deposits at this stage is based almost entirely on empiricism. This results in major uncertainty in exploration.

If the search area is selected on empirical features in the geology which match the setting of the deposit type sought and these matched features are accidental rather than being related to the factors which formed the deposit, then the chances of discovery are minimises. Woodall (1983) pointed this out when he stated that in selected an area for exploration, a ranking was given to the empirical features; that is, conceptual thinking was involved.

THE MORE THE PROCESSES OF FORMATION OF MINERAL DEPOSITS ARE UNDERSTOOD, THE BETTER THE CHANCES OF EXPLORATION SUCCESS.

6C CLASSES OF MINERAL RESOURCE POTENTIAL PREFERRED BY THE TASMANIAN DEPARTMENT OF RESOURCES AND ENERGY

The classes of mineral potential are based on those pioneered by the United States and Canadian Geological Surveys. Of the definitions presented by a variety of investigators, the Department prefers a definition based on, but slightly modified from, Taylor and Steven (1983).

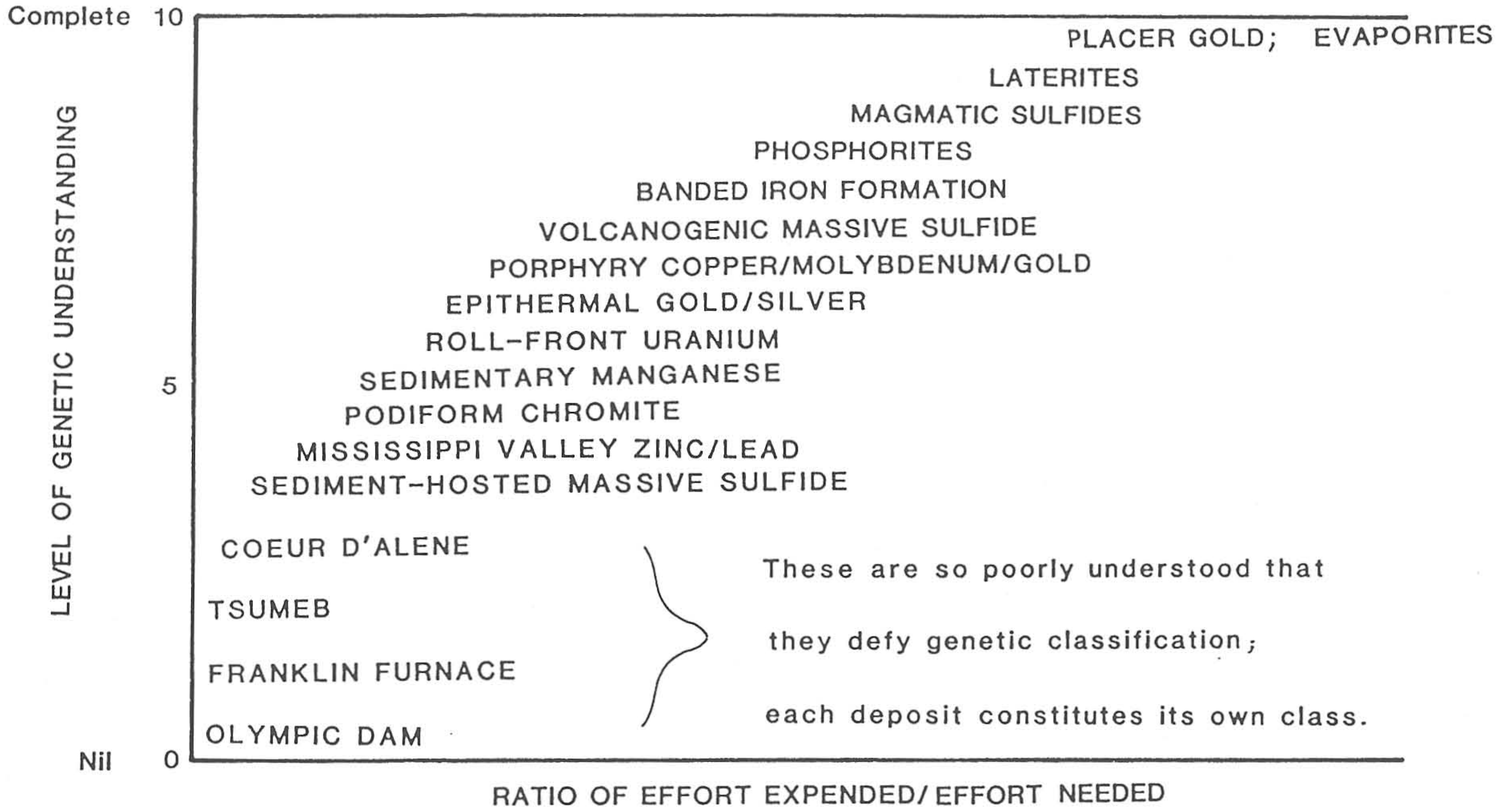


Figure 4: Schematic growth patterns for the understanding of some typical genetic models. The level of genetic understanding ranged from 0 (nil) to 10 (complete). (After Barton, 1986).

A HIGH MINERAL RESOURCE POTENTIAL exists where the geological characteristics favourable for resource accumulation of the are known to be present, or where enough of these features are present to support the relevant genetic model and where there is evidence that mineralisation, not necessarily of economic size or grade, has taken place.

A MODERATE MINERAL RESOURCE POTENTIAL exists where the geological data suggest that the factors favourable for formation of a class of deposit are present or can be reasonably inferred, or where the geological features of the area show a reasonable degree of fit with those of the deposit class considered. There need not be evidence of mineralisation in the area.

A LOW MINERAL RESOURCE POTENTIAL exists where evidence suggests that the geological conditions suggest that mineral concentrations are unlikely and that the relevant genetic model cannot be supported. As noted by Taylor and Steven (1983), this requires an element of positive knowledge.

A category of UNKNOWN MINERAL RESOURCE POTENTIAL is used in situations where <u>either</u> the geoscientific data base is inadequate to assess the likelihood of the resource accumulation, <u>or</u> the relevant deposit models are so poorly understood that a reasonable assessment cannot be made. This definition is not to be equated with low mineral resource potential, but takes into account a high degree of uncertainty or incompleteness in the available information.

7. CONCLUDING COMMENTS

It is also advisable to take note of Taylor and Steven's view that no area can be classed as having no mineral resource potential. Obviously areas can have no mineral potential for a specific type of mineralisation.

The Department of Resources and Energy deplores the fact that mineral resource potential assessments might be used as a basis for decisions that might lead to permanent reservation of areas for exclusive nature preservation without the opportunity for future resource potential evaluation using contemporary geoscientific ideas or exploration technology. In 1982, scientists from the then Economic Geology Section of the Department of Mines expressed that view to the Senate Select Committee on South West Tasmania:

"No area should be declared a National Park or be inundated without being subjected to detailed geological, geophysical, geochemical and mineral resource investigations of at least the standard carried out in United States Wilderness areas by the U.S. Geological Survey and the U.S. Bureau of Mines" (Green et al., 1982).

Note that permanent alienation of land for any purpose, not only wilderness preservation, is implied by that statement. The current explosion in knowledge of Tasmania's geology and broadening commodity base together with major advances in ideas of the three dimensional distribution of rock types have provided many new avenues for future exploration and geological research. These developments need further evaluation. Thus, the statement of Green et al. (1982) is as valid today as it was eight years ago.

8. REFERENCES

Australian Mining Industry Council, 1990. Shrinking Australia. Australia's economic future: access to land.

Barton, P.B. Jr., 1986. User-friendly mineral deposit models. U.S. Geol. Survey Circular 980, 94-110.

Berry, R.F. and Crawford, A.J., 1988. The tectonic significance of Cambrian Allochthonous mafic-ultramafic complexes in Tasmania. Aust.J. Earth Sci. 35, 523-533.

Berry, R.F., Elliott, C.G. and Grey, D.R., 1990. Structure and tectonics of western and northern Tasmania. 10th Australian Geological Convention, Excursion Guide E3.

Brobst, D.A. and Goudarzi, G.H., 1984. Introduction. U.S. Geol. Surv. Prof. Paper 1300, 1-10.

Carey, S.P. and Berry, R.F., 1988. Thrust sheets at Point Hibbs, Tasmania: Palaeontology, sedimentology and structure. Aust.J. Earth Sci., 35, 169-180.

Cox, D.P. and Singer, D.A., eds., 1986. Mineral deposit models. U.S. Geol. Surv. Bull. 1693.

Herrmann, W., 1989. Economic geology and the National Estate of western Tasmania. Unpublished report.

Herrmann, W., 1990a. Mineral resource assessment methods. Unpublished report.

Herrmann, W., 1990b. Preliminary assessment of the economic mineral potential of areas proposed for National Parks in the draft forest and forest industry strategy. Unpublished report.

Higgins, N.C., McNaught, I.S., Miezities, Y. and Solomon M., 1988. An assessment of the mineral potential of the Helsham Inquiry area and the adjoining areas containing the 'Hole in the Doughnut' area, Central Plateau Conservation Area and Walls of Jerusalem National Park. B.M.R. Record 1988/52.

Hutchison, W.W., 1986. National geoscience programs: a base for resource assessments of Canadian lands. U.S. Geol. Survey Circular 980, 1-18.

Leaman, D.E. and Richardson, R.G., 1989. The granites of west and north-west Tasmania - a geophysical interpretation. Bull. Geol. Surv. Tasm. 66.

Lee, T.R., 1977. The social and demographic structure of Tasmania's west coast. Pp 101-111, in Banks, M.R. and Kirkpatrick, J.B., eds. Landscape and Man. Royal Society of Tasmania.

McClenaghan, M.P. and Findlay, R.F., 1989.1 Macquarie Harbour. Geological Atlas 1:50 000 series - sheet 7913S. Dept. Mines Tasm.

Newnham, L.A., Leaman, D.E. and Uttley, P., 1990. Keeping our minds open: Long term exploration opportunities in Tasmania. Summary position paper. Tasmanian Chamber of Mines Ltd.

Taylor, R.B. and Steven, T.A., 1983. definition of mineral resource potential. Econ. Geol. 78, 1268-1270.

Woodall, R., 1983. Success in mineral exploration: A matter of confidence. Geoscience Canada, 11, 41-46.