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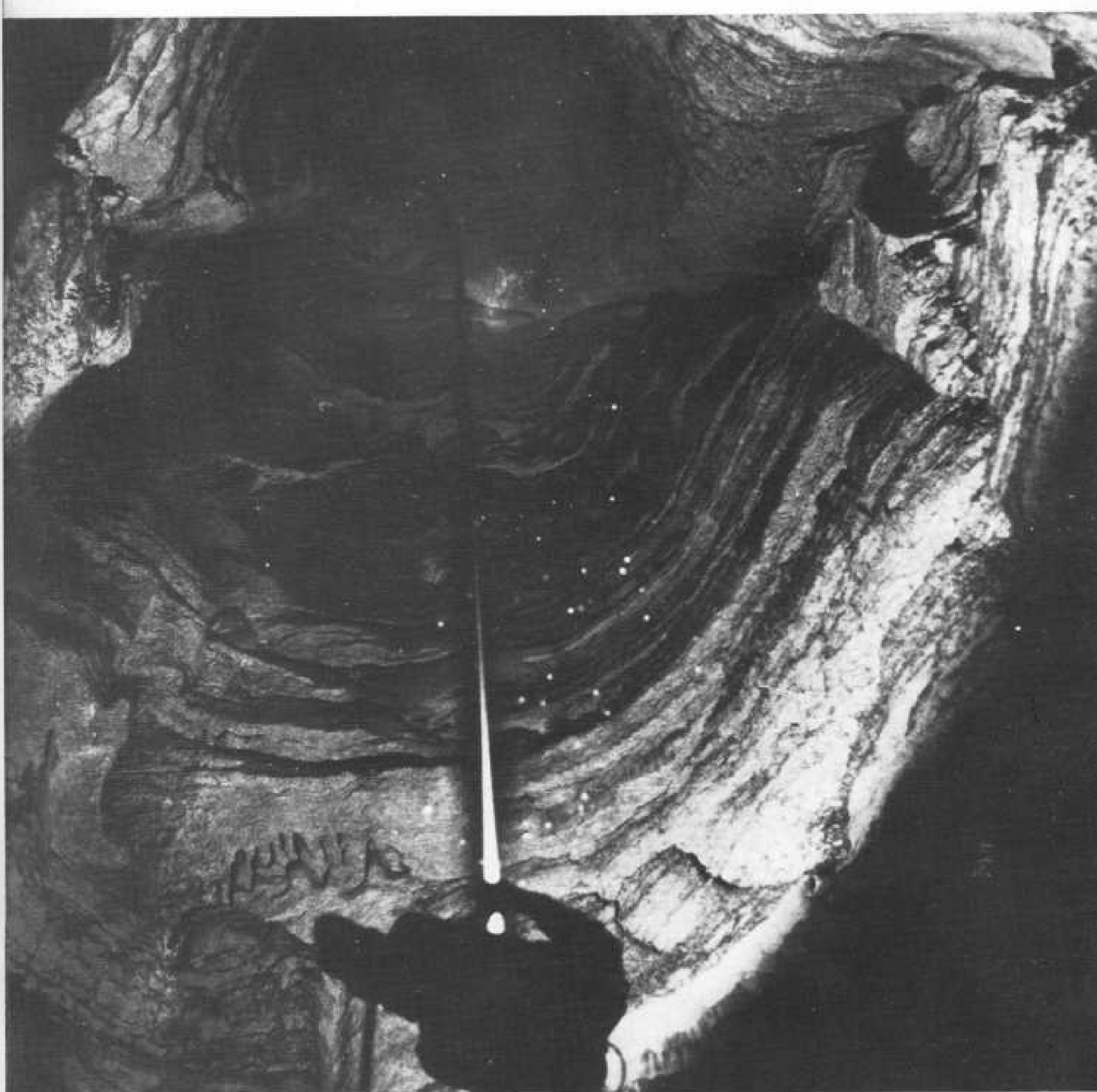
Helictite

JOURNAL OF AUSTRALASIAN CAVE RESEARCH



Looking up the vertical shaft of Midnight Hole, Ida Bay, Tas.
Photograph by R.K. Frank

HELICTITE

Helictite was founded by Edward A. Lane and Aola M. Richards in 1962.

This Journal was (and is) intended to be wide ranging in scope from the scientific study of caves and their contents, to the history of caves and cave areas and the technical aspects of cave study and exploration. The territory covered is Australasia in the truest sense – Australia, New Zealand, the near Pacific Islands, New Guinea and surrounding areas, Indonesia and Borneo.

In 1974 the Speleological Research Council Limited agreed to support the Journal with financial assistance and in 1976 took over full responsibility for its production.

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To explore and chart and organize and promote the exploration and charting of caves and cave systems.

To promote, support and assist in the scientific evaluation and investigation of caves and to foster speleology as a science and a sport.

To promote and to assist in the promotion of speleology and speleological Societies and to assist such Societies with grants of money and otherwise.

Other publications by SRC Ltd:

CAVES OF THE NULLARBOR, T.M.L. Wigley and J.R. Dunkley 1968.
- a review of Speleological Investigations in the Nullarbor Plain.

THE EXPLORATION AND SPELEOGEOGRAPHY OF MAMMOTH CAVE, JENOLAN. J.R. Dunkley 1972. - a detailed history and description.

CAVES THROUGH THE AGES. G. Hangay, J.M. James & M. Dorrell 1974.
- a colouring book for children.

PAPUA NEW GUINEA SPELEOLOGICAL EXPEDITION NSRE 1973. J.M. James 1974.
- the report of the 1973 Niugini Speleological Research Expedition to the Muller Range.

A BIBLIOGRAPHY OF THE JENOLAN CAVES. PART ONE: SPELEOLOGICAL LITERATURE. J.R. Dunkley 1976. - a detailed reference list.

THE CAVES OF JENOLAN, 2: THE NORTHERN LIMESTONE. B.R. Welch (ed) 1976.

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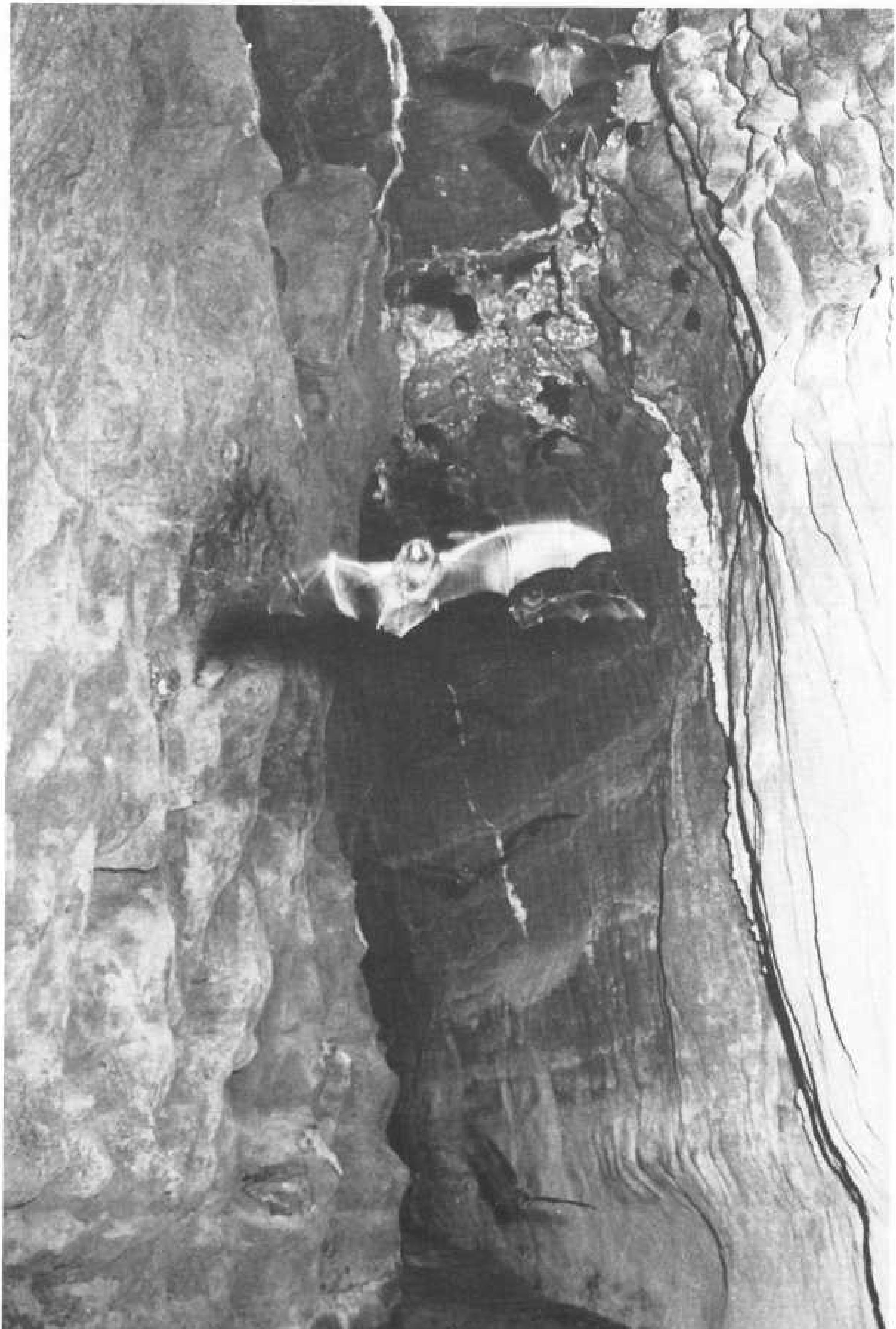

Plate 1. The common bent-wing bat *Miniopterus schreibersii* Kuhl in NG-2 cave, New Guinea, Snowy River, Vic. (Photo: R.K. Frank)

EVALUATION CRITERIA FOR THE CAVE AND KARST HERITAGE OF AUSTRALIA

Report of the
Australian Speleological Federation
National Heritage Assessment Study

Edited by A.G. Davey

Abstract

Protection and management of natural heritage features such as karst landforms requires considered evaluation of the relative significance of individual features. The grounds for significance depend on the perspectives taken. Aesthetic, educational, scientific and recreational values are all relevant and must each be given explicit recognition. Karst landforms are often considered primarily from a scientific perspective. The criteria used for evaluation of such natural heritage features for conservation and management purposes need to reflect this full range of values. This means that karst sites may have significance from any one or more of these perspectives, as examples of natural features or landscapes, as examples of the operation of natural processes , as examples of cultural features or landscapes or as the site of recreation opportunities. Some such sites will be identified as significant because they are representative of their class (irrespective of the relative importance of classes); others will be judged as significant because they are outstanding places of general interest.

Background to the study

When the concept of a Register of the National Estate was introduced under the *Australian Heritage Commission Act, 1975,* the Australian Speleological Federation (ASF) recognised that explicit guidelines were needed if consistent identification of the significance of cave and karst features in the national estate was to be achieved.

After consultations with the then Interim Committee on the National Estate, the Federation received a grant under the 1975/76 national estate program to study the problem. The project was managed by a steering committee consisting of A.G. Davey (then convenor of the ASF Commission on Conservation, and chairman of the committee until early 1977), N.J. White (the then ASF President, and chairman from 1977), P.G. Matthews (ASF Handbook Commission), R.K. Frank (Victorian Speleological Association) and D.C. Mercer (Department of Geography, Monash University), together with E. Hamilton-Smith (ASF Commission on Cave Tourism & Management), who as Honorary Study Director was responsible for management and co-ordination of the project.

The bulk of the study program, details of which are outlined in the section on study methods was completed by 1978. When the report had not appeared by 1982, A.G. Davey offered to complete it for publication. The delay and change of editorship have necessitated some significant cuts in the intended scope and detail of the report. As well, the report is now unavoidably out-of-date in some respects. For instance, some highly significant caves such as those on the Franklin River in Tasmania have come to light since this survey was completed. Similarly, many important contributions in recent literature are not referred to here.

Despite any difficulties caused by delay, the report nevertheless should provide useful background for consistent evaluation of natural heritage features such as caves and karst. The principles outlined in the report will also have application in numerous other areas. Some of the ideas developed during the project are already in use elsewhere. An example is the plan of management for Kosciusko National Park (NSW, NPWS 1982), for which A.G. Davey was a consultant. Some elements of the logic and structure of that plan are based on ideas explored during this earlier national estate program project. Other examples which include application of this work include Davey (1980) and Worboys et al. (1982).

The report integrates material from contributions by M. Brooks, A.G. Davey, K.G. Grimes, E. Hamilton-Smith, D.C. Mercer and G. Pure, together with material drawn from many of the discussion papers contributed during the study (see Appendix 1 and the section on study methods). It has been improved by

constructive criticism of many other persons, as noted in the Acknowledgements. While every effort has been made to achieve consensus and accommodate the at-times disparate views of all the persons who participated in the project, the project steering committee accepts responsibility for the statements made herein; the report does not necessarily represent the opinion of the Australian Speleological Federation.

INTRODUCTION

In 1973 the Australian Government commissioned an inquiry to examine and report on the 'national estate' and ways in which its conservation, presentation and management might be fostered. The report of that inquiry (Australia. Committee of Inquiry into the National Estate 1974) prompted new legislation (the *Australian Heritage Commission Act,1975,* amended in 1976) which established a permanent Australian Heritage Commission.

The national estate is a concept relating to components of the cultural and natural environment which are:

a) of such outstanding world significance that they need to be conserved, managed and presented as part of the heritage of the world;

b) of such outstanding national value that they need to be conserved, managed and presented as part of the heritage of the nation as a whole; and

c) of such aesthetic, historical, scientific, social, cultural, ecological or other special value to the nation or any part of it, including a region or locality, that they should be conserved, managed and presented for the benefit of the community as a whole *(ibid)*.

The *Australian Heritage Commission Act, 1975* further defines the national estate as consisting of 'those places, being components of the natural environment of Australia or the cultural environment of Australia, that have aesthetic, historic, scientific or social significance or other special value for future generations as well as for the present community'.

The Australian Heritage Commission, as it is now constituted, has two main roles: to provide policy advice to the Australian Government and to maintain a Register of the National Estate. This report is a contribution by the Australian Speleological Federation to assist in defining clear grounds for identifying those elements of the total stock of caves and karst in Australia which should be listed in the Register as 'significant'.

THE NATURE OF CAVES AND KARST

A simple definition of a cave is 'a natural underground cavity penetrable by human beings'. The largest and most widespread caves are generally karst caves which have formed as a result of solution by water of a relatively soluble rock. Limestone is the most common rock involved. 'Karst' is a generic term used for the characteristic terrain produced by such solution. It includes surface landforms such as small-scale solutional channels and sculpturing (collectively referred to as 'minor solution sculpture'), blind valleys, closed depressions (dolines) and springs, together with subsurface features (i.e. caves). More complete descriptions of the wide variety of features encompassed in the phrase 'caves and karst' are to be found in standard reference works on karst geomorphology (e.g. Jennings 1971a, Sweeting 1973) and speleology (e.g. Ford & Cullingford 1976, Moore & Sullivan 1978).

It is not possible to study a cave in all its aspects without also looking at the related surface features. Throughout this report, both surface and subsurface karst features, together with their related biota, will be considered as equally relevant. The central concept of karst is essentially an ecological one - karst features are component parts of a highly interactive system. Caves are just one component. The physical features are also integral parts of relatively unusual biological systems. The focus of this report, therefore, is on caves, simply because they are fascinating natural landforms; but it necessarily involves just as careful a consideration of a wide variety of other landforms and biological features which are all important related elements of the same basic resource.

Some caves and some surface landforms similar to those of karst areas can be formed by processes other than solution. Collectively, such phenomena are referred to as 'pseudokarst' (Grimes 1975, Quinlan 1968) and though less common are often of considerable interest because of their relatively unusual origins and because of the ways in which they parallel or contrast with corresponding karst features. The most common pseudokarst caves are lava tubes.

CAVES AND KARST IN AUSTRALIA

Caves are scarce in Australia relative to other continents (Jennings 1975). Figure 1 gives some indication of the distribution of caves in Australia, each dot representing a locality where one or more caves have been reported. For comparison, Figure 2 gives a similar indication for the conterminous United States of America, a continental area of comparable size to Australia. In both cases, some qualification is necessary. For instance, large areas with relatively scattered caves (e.g. the Nullarbor Plain, S.A. & W.A.) show up as many dots whereas other areas with many caves concentrated into a small area (e.g. Jenolan, N.S.W.) are shown only as a single dot. Further explanation of these maps is given by Jennings (1983).

The figures do not attempt to show the full extent of karst terrain, as distinct from caves. Neither do they necessarily include reported karst features other than caves, except generally for dolines and a few other categories such as springs. The potential for karst development (i.e. the disposition of rocks of suitable solubility) can be assessed by reference to geological maps. In large measure, the contrast between Figure 1 (Australia) and Figure 2 (U.S.A.) arises because of a smaller total area in Australia of suitable soluble rocks. However, climatic and a number of other factors are also important in determining the extent to which karst processes operate in any particular area. For instance, the Nullarbor karst (if defined as extending to the onshore limits of carbonate rocks in the Eucla Basin) is one of the world's largest single karst areas, but its aridity and semi-aridity has precluded development of recognised caves and other major karst features in numbers even nearly proportionate to its size (Lowry & Jennings 1974).

Pseudokarst features are liable to occur in a wider variety of geological contexts, even though they are rarer in total. The extent to which surrounding terrain has to be considered as functionally related to them varies considerably.

Despite the relative scarcity of caves in Australia, there is a considerable diversity of karst and pseudokarst features because of a wide variety of geological and geographical settings. Further comment on the relative significance of the caves and karst areas scattered around Australia follows in the section on criteria of significance. Nevertheless, it should be understood that this report is not an attempt to indicate the significance of particular caves or karst features in Australia. That is the next step.

STUDY METHODS

Caves and karst features represent such a diverse resource that they cannot be assessed on any single scale of significance. Numerous factors need to be assessed, and the level of significance of different attributes of even one feature can vary enormously. The problem is by no means confined to caves, but virtually all other examinations of the problem have concentrated exclusively on relatively large areas as distinct from sites and have usually considered living resources rather than landforms (Dasmann 1975, Margules & Usher 1981, New Carolina ... Office of State Planning 1974, Stanton & Morgan 1977, Task Force ... 1974 and U.S. ... Bureau of Land Management 1980). The purpose of this project was to develop a clear picture of the various factors to be considered in the context of caves and the grounds that might justify any statement that some particular cave or karst feature was significant.

The steering committee felt at the outset that it was essential to capitalise on the wide range of experience of caves and related features among Australian speleologists. The objective was to reach agreement, as far as possible, about what are essentially problems of judgement. The attitude of any individual to specific elements in the national estate is necessarily subjective. There is no such thing as a 'right' answer. Our purpose was to focus the full range of informed subjective views in such a way as to try to explain the basis for personal judgements and to develop an explicit framework for collective recognition of the most significant components of the environment.

The adopted strategy consisted of four main elements, each designed to ensure a wide participatory base:

* A survey of individual speleologists, to identify issues and personal attitudes.

* Circulation of discussion papers designed to promote individual participation in the study and informed discussion about a wide range of general and specific issues that needed resolution.

* Circulation of a wide range of personal statements on specific themes, for others to react to.

* Preparation of a draft report outline and conducting a series of local workshops in response to it.

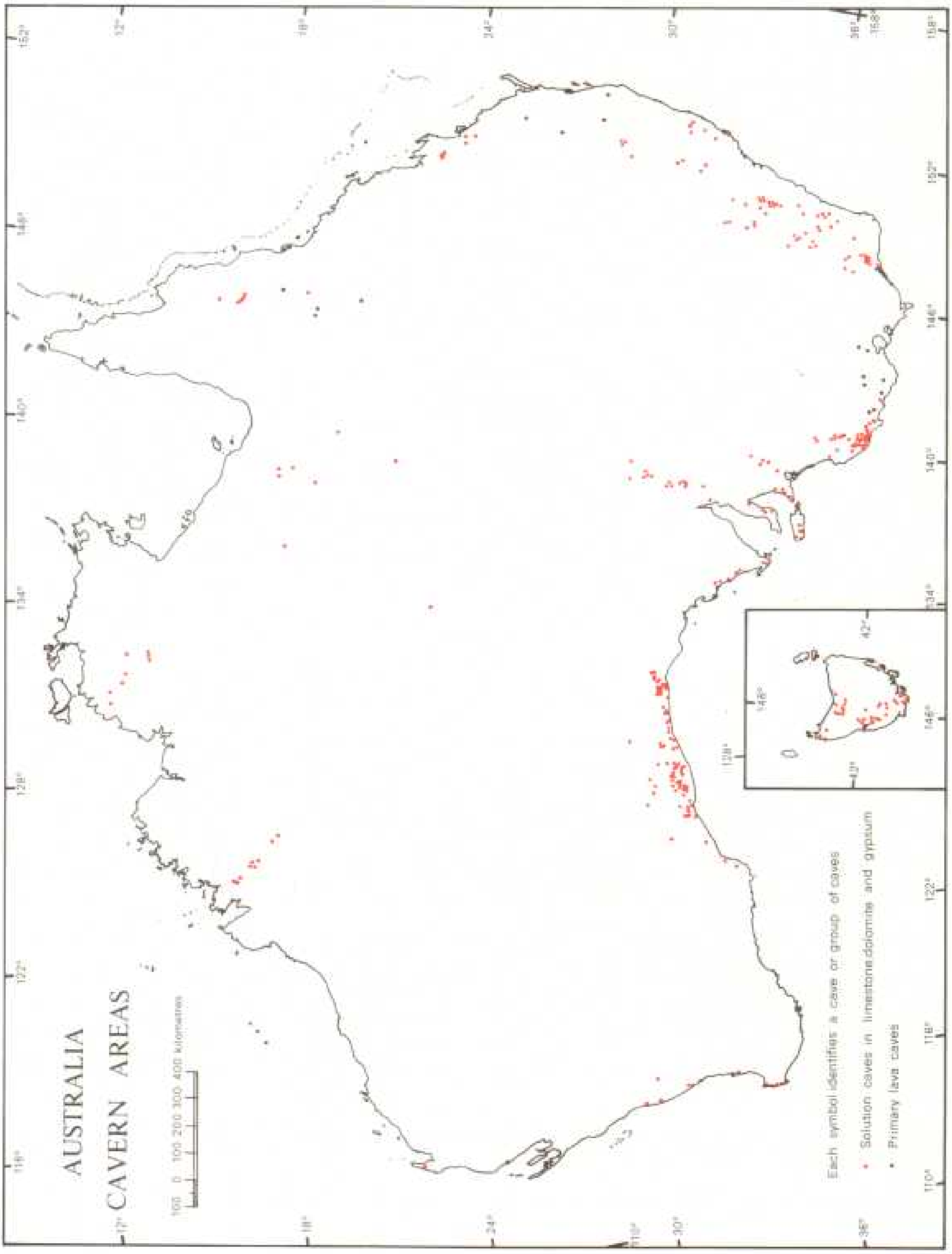
AUSTRALIA
CAVERN AREAS
100 0 100 200 300 400 kilometres
Each symbol identifies a cave or group of caves
Solution caves in limestone,dolomite and gypsum
Primary lava caves

Figure 1.

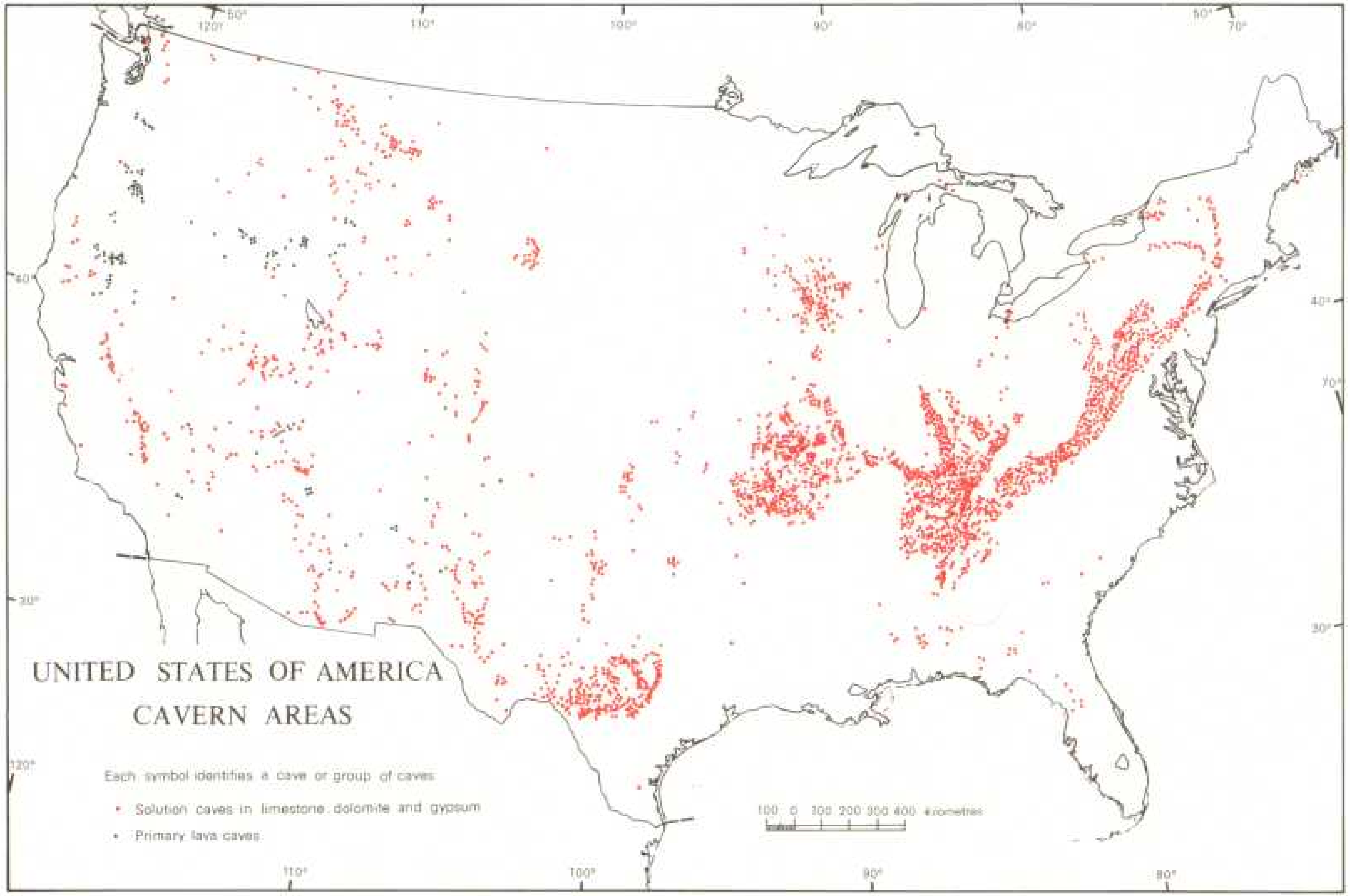

Figure 2. (Redrawn from the National Atlas of the U.S.A. 1970)

A major difficulty in building consensus in this kind of study is the geographic dispersal of the participants. Much effort went towards overcoming, as far as possible, the fact that individual speleologists are scattered all over Australia and ought all to be involved. One of the discussion papers (all of which are listed in Appendix I) concentrated on this particular problem. The mailing list for the study consisted not only of the constituent societies of the Australian Speleological Federation but also a continually growing number of individuals who registered their interest. Several papers were published, explaining what was happening and promoting the active involvement of societies and individuals (Hamilton-Smith 1976, 1977; White & Hamilton-Smith 1977).

A questionnaire (Appendix II) was distributed throughout Australia to gauge opinions about ways in which significance should be assessed, and how opinion related to the experience, interests or demography of the respondent. Meanwhile, several focal discussion papers were commissioned (Appendix I: A). Because landscape evaluation seemed the closest parallel in which there were at least a few published results, one of the papers examined the various techniques already tested in that field for possible application to our problem. Another paper concentrated on the concept of 'place', as used in the legislation, since it seemed one of the more difficult issues to be clarified.

As well as these relatively abstract contributions, individual speleologists throughout Australia were invited to provide brief notes on specific matters they considered to be relevant to judging the significance of caves. The result was a series of stimulating contributions on various aspects of the earth and biological sciences, history and archaeology, and tourism and recreation (Appendix I: B).

All of these various papers were progressively distributed via the mailing list. Many individuals read them and some started discussions among their fellows. Numerous individuals and some groups sent in written comments which helped to clarify many important issues (Appendix I: C).

The ideas contributed during circulation of the discussion papers and the results of the survey were used to draft a report outline which in turn was distributed to the mailing list for further comment. Then followed a series of local workshops in virtually every state capital and a number of regional centres at which members of the steering committee sought feedback on the draft from member societies and individual speleologists. The response to this phase of the study was one of considerable enthusiasm and involved several hundred people in more than a dozen widely dispersed workshop discussions. As a consequence, this report embraces ideas and attitudes expressed during the study by a large number of interested people.

SURVEY RESULTS

The questionnaire (Appendix II) was distributed to all subscribers of ASF Newsletter No.71 in August 1976, and to any other person who expressed an interest. Between three and four hundred were distributed and 215 responses were received. The survey sample is not necessarily random even among speleologists and, for obvious reasons, it was virtually confined to that sub-set of the general population which already has some experience of or interest in caves.

The profile of respondents indicates that the majority had taken up their interest in caves relatively recently. 42% of respondents had caving experience of less than five years, while only 28% had caving experience of ten years or more (Question 6, Appendix II). Almost half (44%) came from members of speleological societies in New South Wales, followed by Queensland (15%) and Victoria (13%), with other states and the A.C.T. (but not including the Northern Territory where there are no societies) each little more than 5% (Question 7, Appendix II). Only 3% of responses were from persons not affiliated to a speleological society.

As expected, most people had the greatest experience in their home state (counting the A.C.T. as part of N.S.W.), although only those persons with very short caving experience (generally less than two years) demonstrated any significant lack of awareness of the general characteristics of cave and karst areas throughout Australia (Questions 7 & 8, Appendix II).

The first of the questions sought an indication of the factors which most influenced personal involvement in caving. The numerous different descriptions (from 'getting away from it all' through a wide array of comments to 'doing something useful') were categorised and the relative frequency of occurrence in the arbitrary categories is shown in Table I. The preponderance of stated interest in 'exploration' is hardly surprising, considering that the sample was drawn primarily from speleological societies, but its emphasis over aesthetic values is nevertheless revealing. The relatively low score for 'scientific interest' possibly reveals a truer picture of personal attitudes than if we had asked 'why are caves important (to society)?' because it reflects the fact that persons with clearly scientific interests in caves make up a relatively small proportion of the membership of speleological groups.

CATEGORY	% OF ALL RESPONSES
Exploration	39
Aesthetic values	21
Sport	16
Personal satisfaction	15
Scientific interest	8

TABLE I: Categorised response to the question 'what do you most like about caving' (Question 1 of the questionnaire).

Exploration, in the sense of the feeling or perception of discovery and as quite evidently distinct from the physical skills and exertion involved ('sport'), is a rather more important motivation for interest in caves than is often admitted.

The questionnaire then turned to identifying the different aspects of caves which most impressed people, making a distinction between a personal view on the one hand and on the other that person's idea of what a national view might be. Question 2 called for seven descriptive statements (Table II) to be ranked in order of importance. Many respondents objected, pointing to numerous difficulties. Despite numerous qualifications which are needed to take account of these difficulties, the results still appear to be useful. There were no significant differences between personal and national assessments. The aggregate of both is shown in Table II. If the apparent differences in the table are significant (and those between Items 2, 3 and 4, and 5, 6 and 7, respectively, are not) they suggest that speleologists regard a cave which is both large and very beautiful as relatively important. Despite the earlier conclusion about 'exploration' being favoured over 'aesthetics', the result here suggests that speleologists' grounds for personal involvement are a little different from their grounds for assessing the importance of specific caves, and that in this latter context the contemplative or reflective aesthetic value is perhaps the most important. However, we cannot be sure about this, for we neglected to include a statement such as 'an unexplored cave' to test this response.

The failure of surface features (Item 7 in Table II) to excite much interest reflects bias which perhaps is only to be expected when one talks to people who are primarily interested in caves!

DESCRIPTION	AGGREGATE SCORE*	SEQUENCE OF APPEARANCE IN QUESTIONNAIRE
A large roomy cave with easy access and extensive decoration which is massive in size and very beautiful	1200	1
A cave of great beauty, but very narrow and difficult of access	1500	4
A small cave of no great beauty but containing fossils or other features of interest to scientists	1600	3
An extensive cave with many crawls, climbs, ladder pitches, river passage, mud & rockfall	1600	2
Australia's longest known cave	1900	6
Australia's deepest known cave	2000	5
A spectacular mass of exposed limestone on the surface, sculptured into bizzare shapes by natural weathering	2000	7

TABLE II: Ranking of a series of places in order of their importance as expressed by different people.

* lowest score = the most important; figures are rounded to the nearest hundred.

A similar analysis to that of Table II was undertaken, based solely on those respondents with caving experience of fifteen years or more (15% of all respondents). The major difference is a greater emphasis on scientific values, in that the third- and seventh- ranked statements in Table II move up in relative importance to second and fifth ranking respectively, without otherwise disturbing the order of the others. This indicates a trend of increasing interest in the wider complexity of things with experience.

Concerning the weight that state boundaries should be given in assessing the significance of features (i.e. a state level of significance rather than or as well as a national one; Question 3), respondents were decisively (83%) in favour of state boundaries being taken into consideration. But on the question of whether accessibility of sites was an important consideration, respondents were more ambivalent (41% for, 59% against; Question 3B).

When asked which was more important, being outstanding or being representative, a majority (73%) favoured a representative approach (Question 3C). However, the group with 15 years experience or more gave stronger support (43%) for the outstanding approach. As explained below, we interpret this to mean *as well as* representative, rather than *instead* of it.

Questions four and five each asked respondents to nominate up to five specific places, in order of importance, which they considered worthy of listing in the Register of the National Estate. The first was restricted to sites known to the respondent personally, whereas the second covered sites throughout Australia whether or not the respondent had visited them. Most of the responses were at a fairly general level (a region, an area or a cave), without identifying specific elements that were of significance and without implying boundaries. In discussing these results, specific caves have been aggregated with their surrounding area. The responses to Question 4 (sites known to respondents personally) reflected the concentration of speleologists in Sydney in fortuitous proximity to a wide number of cave areas. The three areas which were the most frequently nominated (either as areas or as specific caves within that area) were all in New South Wales (Bungonia, Jenolan and Yarrangobilly). By contrast, the three areas most frequently cited (on the basis of the reputation of caves Australia-wide; Question 5) were the Nullarbor Plain (S.A. & W.A.), Mole Creek (Tasmania) and Ida Bay (Tasmania) (see Table III). The contrast is not so evident on the basis of first preferences only, with the three most frequently cited areas on personal experience being Mole Creek, Yarrangobilly and Jenolan, and Australia-wide by repute being Mole Creek, the Nullarbor Plain and Jenolan.

If the group with fifteen years experience or more is analysed for comparison, the three places most frequently nominated are the same. Further down the frequency list, the effect is primarily to emphasise such places as Augusta - Margaret River (south-west W.A.; fourth-ranked instead of 9th), Naracoorte (South Australia; seventh instead of thirteenth) and Buchan (Victoria; eighth instead of eleventh) at the expense of places in New South Wales. This probably reflects an increase in breadth of experience with time, with visits to caves further from centres of population.

Of the individual caves cited (rather than areas), those with by far the greatest number of respondents listing them were Exit Cave (Ida Bay, Tasmania), Kubla Khan Cave (Mole Creek, Tasmania) and Mullamullang Cave (Nullarbor Plain, W.A.). All three of these are extremely large and very beautiful, although only Kubla Khan can be described as having decoration which is massive in size (see the comments relating to Question 2 above). The first and last are also the longest two caves in the country. Table III gives the lie to the earlier supposition that characters such as longest or deepest are relatively unimportant. Extent or size are stated as grounds of importance in no less than seven of the places listed in the table! In the case of the Nullarbor Plain, beauty does not rate a mention. However, the results do suggest that scientific values are given rather more prominence than was concluded earlier. 'Uniqueness' appears in a way which suggests that it is widely understood as 'distinctive' or 'very different' rather than 'strictly unique' (which of course applies to every thing to the point of absurdity). The label is applied to only a limited number of cases in this list (the Nullarbor semi-arid karst, the Chillagoe - Mungana seasonally humid tropical towerkarst, and Bungonia - probably in reference to the Bungonia Gorge as much as to the caves). This suggests that places which in some way distinguish Australia or are peculiar to it, or at least relatively unusual examples within Australia, are regarded as important. Interestingly, the stated grounds for many of the less frequently cited places (not listed in Table III) more often emphasised scientific values, often as the sole grounds, than was the case of places listed in Table III. 'Bats', 'scientific values' and 'fossils' were recurrent themes.

The actual places which emerged from this analysis are not important, although their prominence certainly makes them essential candidates for later consideration as items for listing. What is far more interesting to us in this context is what these suggestions reveal of the attitudes of our respondents. There are many apparent contradictions, but in our later discussions we have accommodated as much as possible of this input in building up a framework for assessing such features on a consistent basis.

PLACE	STATED GROUNDS FOR IMPORTANCE	NUMBER OF CITATIONS	TOTAL
Nullarbor Plain (S.A. & W.A.)	* extent, size	36	
	* scientific value	26	
	* uniqueness	21	
	* karst type	9	
	* other	5	97
Mole Creek (Tasmania)	* beauty, decoration	56	
	* size, extent	19	
	* scientific value	9	
	* tourism	4	
	* sport	3	
	* under threat	2	
	* other	1	94
Ida Bay (Tasmania)	* length, size	38	
	* beauty	6	
	* recreation	5	
	* tourism	2	
	* other	6	61
Mt. Etna - Limestone Ridge (Queensland)	* bats	26	
	* Queensland rarity of caves	8	
	* conservation necessary	8	
	* remoteness	4	
	* accessible to population	4	
	* other	5	55
Chillagoe - Mungana (Queensland)	* uniqueness	16	
	* decoration, beauty, features	12	
	* size, extent	9	
	* scientific interest	5	
	* isolation	4	
	* other	8	54
Jenolan (N.S.W.)	* beauty	16	
	* tourism	12	
	* recreation, accessible to population	10	
	* scientific value	6	
	* extensive	2	
	* other	4	50
Yarrangobilly (N.S.W.)	* beauty, decoration	14	
	* scientific value	11	
	* extent, depth	5	
	* sport, tourism	4	
	* other	5	39
Bungonia (N.S.W.)	* recreation value	11	
	* scientific value	9	
	* threat	5	
	* gorge	4	
	* uniqueness	4	
	* other	2	35
Augusta - Margaret River (south-west W.A.)	* decoration, beauty	19	
	* scientific interest	8	
	* decoration	4	
	* other	1	33
Junee - Florentine (Tasmania)	* depth	11	
	* exploration	8	
	* sport	5	
	* scientific	3	
	* other	2	30
Buchan (Victoria)	* sport, tourism	8	
	* in Victoria (!)	5	
	* decoration	5	
	* variety	5	
	* other	1	29
Naracoorte (S.A.)	* fossils, scientific value	22	
	* beauty, decoration	4	
	* sport	2	
	* other	2	27
Cliefden (N.S.W.)	* beauty	14	
	* under threat	3	
	* tourism potential, access	5	
	* scientific interest	2	27

TABLE III: Places nominated on their repute (rather than just personal knowledge), ranked in order of the frequency of their nomination, together with the cited grounds for their importance. Only those places listed by twenty or more respondents are shown here.

AN ECOLOGICAL DEFINITION OF 'PLACE'

For the purposes of the *Australian Heritage Commission Act, 1975*, 'place' includes '... a site or region ... and, in relation to the conservation or improvement of a place, includes the immediate surroundings of the place' (section 3 (1)). The question to be addressed in this report revolves around whether the item or place to be listed in the Register should, in a particular case, be a chamber or a particularly fine part of a cave system, an entire cave, a group of adjacent or related caves (or the land containing them), a cave area or an entire cavernous region.

A cave (or any other karst feature) is only one component of a wider system which might be defined in geomorphological or hydrological terms. Similarly, the contents of any cave relate to wider systems:

- the cave environment is determined by hydrological and meteorological systems of which it is part;
- biological elements are part of a wider system upon which cave-dwelling plants and animals depend for energy inputs; and
- floor deposits and speleothems may provide a geological record of climatic change.

The integrity of any one cave or feature may well be threatened by a change in any of the systems to which the feature belongs. Thus the environment of a cave may be damaged by logging or road-making within the watershed draining to the cave (e.g. Waitomo, New Zealand - Hawke 1977). Similarly, a change in one aspect of a cave may adversely affect other aspects. For instance, opening of a new entrance may change the cave climate, which in turn may destroy some animal populations or cause deterioration in the aesthetic quality of the cave as a result of the drying out of speleothem decoration.

The relationships between the various systems involved introduces a further complication. For example, the groundwater system is inter-related with surface vegetation, the fauna of the cave is in turn inter-related with the groundwater, and so on. Thus there is little point in protecting a single feature unless the other elements of the total system are also protected from interference.

Insofar as listing of elements of the national estate in the Register is intended to recognise those elements for the purposes of protecting and presenting them, listing of places in the Register needs to take account of the complete system of which any specific feature is a part. In considering protection of any one site, we should determine not only the nature and boundaries of each of the systems to which that site belongs, but also the extent to which the character or integrity of the site is liable to be affected by alterations in any other part of these systems.

A major constraint upon this approach is our lack of knowledge. For instance, we know that the beauty of such caves in the south-west of Western Australia as Jewel Cave and Easter Cave depends on the stability of the groundwater system. However, we do not have any adequate information about the structure, dynamics and spatial extent of that system and we certainly do not know the effects upon it of various land use practices (e.g. logging or vegetation clearance for grazing).

A further constraint is the sheer size and complexity of some systems. Bat maternity sites provide an interesting example. The survival of a bat population is dependent upon the preservation of its maternity site. The bat population is, however, likely to be adversely affected not only by disturbance of the maternity site, but also by disturbance at other caves which may be used by the same bat population for hibernation or acclimatisation, or by the use of chemical pesticides anywhere within the living range of the bats, which may well encompass an area of 400 km radius (Dwyer & Harris 1972; Hamilton-Smith 1965, 1972a, 1974). This poses some major questions about the practicability of 'protecting' the total system of which the maternity site is just one element. It also raises the problem of the lack of inter-relationship between the protection of places (or real estate) on the one hand, and the protection of living resources on the other.

From an ecological point of view then, it is highly desirable that boundaries of places for the purpose of the Register should be natural ones relating to total ecosystems, rather than arbitrary, historical or administratively expedient ones. In many cases this will also mean the incorporation of a buffer area which protects the particular system of interest. Obviously this can pose considerable practical problems. In the example of Jewel and Easter caves discussed above, or virtually any bat maternity cave, we do not know the boundaries of the systems which are involved. In other cases, it may be difficult to justify registration of the huge area involved. For instance, the watershed which influences the Buchan-Murrindal karst in eastern Victoria is the total catchment of two large rivers, encompassing many thousands of square kilometres.

A further practical question is the extent to which a place as defined for purposes of registration provides a viable land unit for resource management purposes. It is obviously desirable that any registered place be amenable to management in sympathy with the aims of registration, and to facilitate this it is desirable that the ownership and management of the place be integrated rather than fragmented. In practice, this will not often be possible but it is clearly an important factor to be considered.

Finally, there is an argument for registration of relatively large areas rather than single features to off-set at least one of the potential disadvantages of registration, namely, the extent to which visitor pressure may increase. Thus, if Kubla Khan Cave at Mole Creek in Tasmania were registered as a single cave it is very likely that visitor pressure would increase, with a consequent increase in management problems. If a larger area, or all of the Mole Creek limestone, were registered instead, it is less likely that visitor pressure would be concentrated on Kubla Khan Cave as a direct consequence. There are two important objections to this. Firstly, if Kubla Khan Cave is truly important, then this wider definition, without drawing attention to the cave, would fail to achieve the objectives of the legislation, in that the specific values of that particular place within the total area would not be made explicit. Secondly, any strategy which is reliant on secrecy, or the notion that very important sites should not be given explicit recognition, is no substitute for responsible resource management of that site. If any place is sufficiently important to warrant recognition as a significant element in the national estate, then it is essential that it also be given management of an intensity and a kind commensurate with its importance. This is a serious limitation of the legislation, since there is no direct link between the Register of the National Estate and management of the resources involved. Under the Australian federal system, this particular problem is very difficult to overcome.

We conclude that there are two overriding factors in defining 'places', of the kind which are of interest here, for the purposes of the Register:

* A place should be defined as extending to the limits of the systems of which the particular sites of interest are part, as far as practicable.

* The specific values which are the basis of significance for the purposes of the Register must be made explicit for the component parts as well as for the entire defined place.

APPROACHES TO DETERMINING SIGNIFICANCE

The key issue in determining whether or not any place might be registered lies in deciding whether any given place has *'aesthetic, historic, scientific or social significance or other special value'* (*Australian Heritage Commission Act, 1975*). General usage of the term 'significance' implies a perception of the relative values of places and a judgement as to the noteworthiness of the place concerned; it also conveys a notion of that significant place being 'outstanding' in some way.

Many of the discussion papers associated with this study explored issues related to the question of significance and, among other things, suggested that the basis for asserting that a site was 'significant' would inevitably vary from one place to another (and from region to region). The key considerations in any individual case might be quite general, or alternatively might be one of a whole range of quite technical considerations. And the same feature might well have several different kinds of significance: as a beautiful feature, as an example of natural phenomena for scientific study, or education, as the site of recreation opportunities, and so on.

In addition, it is suggested that 'significance' has functional connotations - 'significance for what?'. The purposes to which registration may contribute is not yet clearly defined but it should be recognised that the approach to assessing and determining the significance of a site must vary according to the intended function of the place. Taking into account the range and complexity of potential functions of sites on the register, it is clear that cave or karst features will be selected for registration using a variety of criteria. Comparison of the *relative* importance or 'significance' of sites selected for different reasons is extremely difficult.

The purposes of identifying appropriate significance are fairly tightly constrained. There are important limitations on the scope and purpose of making decisions about 'significance'. We must be aware that the capacity of national estate registration to achieve anything other than the objectives explicitly provided for in the legislation is strictly limited. There will usually be little point in attempting to exploit for other purposes a structure which is really only appropriate for determining 'significance' for the rather special purposes of the Australian Heritage Commission Act.

A further issue which needs to be considered is the extent to which all elements of 'the natural environment of Australia' should be represented within the national estate concept. The original *Report of the National Estate* certainly implied that at least some attention needs to be given to recognition of the range of environmental features, and the need to ensure preservation of a sample of all significant elements. The concept of representation implies the inclusion of at least a sample of each kind of place. In turn, this means having some classification system which tells us what kinds of places exist in Australia and which is sufficiently detailed to ensure that nothing of significance is likely to be missed.

The two possible approaches are contrasted in Table IV. In real life, one cannot simply argue whether one or the other should be adopted. Inevitably, it is the 'outstanding' approach that will be adopted, and the realistic question is whether it should be deliberately supported and complemented by the 'representative' approach. We argue that it should be. The 'representative' perspective makes a serious attempt to:-

a) meet the interests and judgements of future generations;

b) ensure that all classes of place are fully and systematically considered; and

c) establish a viable relationship between the protection of 'places' and the protection of the flora and fauna dependent on those places; i.e. it better accommodates an ecological approach to definition of 'place', and to conservation of *habitat* as integral to the conservation of *species*.

At the same time, the extent to which the 'representative' perspective succeeds in achieving this will be constrained by inevitable limitations on our current knowledge. Constant updating is essential.

OUTSTANDING	REPRESENTATIVE
Apparently closer to the intent of the legislation than the 'representative' approach.	With this approach, place X might be of 'other special value' only because it represents a class of places not otherwise included.
Official support for nominations is more easily obtainable.	This approach has less popular appeal.
Extremely subjective in application - places judged 'significant' at this time may be considered irrelevant in the 21st century; even worse, places judged irrelevant now may be considered of utmost importance in the 21st century (by which time it may well be too late to protect them).	Less subjective in application, and likely to be less prone to bias. More likely to ensure that the 20th century decisions are relevant in the 21st century or later.
Major operational problem lies in achieving consensus between varying and often conflicting personal judgements.	Major operational problem lies in achieving consensus on the nature and extent of a classification system. However, there is still a problem in deciding which place or places should be representative of any one class.

TABLE IV: A comparison between the 'outstanding' and 'representative' approaches to determination of significance.

Pragmatically, this suggests that in the case of caves and karst features, ASF should give particular attention to ensuring the overall representativeness of the caves and karst features nominated for inclusion in the Register of the National Estate. Other organisations (scientific groups, land management authorities, landowners and local organisations) are all likely to nominate some caves and karst features, but ASF is probably unique in its capacity for a national overview. This is because of the Federation's national documentation system which provides comparable information on caves and karst features throughout the country.

In contrast with the 'representative' approach, the 'outstanding' perspective leads us to ask such questions as:-

* Which caves or karst features are the most beautiful or spectacular?

* Which caves or karst features have the greatest recreational value?

* Which caves or karst features provide the finest examples of geomorphic features?

The 'representative' approach can only operate if there is some kind of classification system for caves and karst features, or at least a schedule of characteristics which are held to be relevant and which should be represented in some way. This will then lead to such questions as:-

* How truly representative is this cave or karst feature of the class or classes to which it belongs?

* How adequately is each class of karst feature represented in the Register of the National Estate?

* Which caves or features are the most appropriate ones to represent a specific class?

* How many representatives are justified for any class?

The Australian Heritage Commission is also concerned with the geographic level at which each place is considered 'significant'; e.g. local, state, national, or world. This again raises the issue of 'outstanding' vis-a-vis 'representative'. Let us take two examples:-

a) Kubla Khan (Mole Creek, Tasmania) is a cave of remarkable beauty and majesty, well-known to speleologists if not to the general public, and is probably one of the most beautiful caves of Australia. If we adopt the 'outstanding' approach, it certainly justifies national significance, and may be (but probably only just) a contender for world listing. On the 'representative' approach it is a very pretty example of a relatively numerous class of caves, and may justify selection at state or national level, but certainly would not be a world contender.

b) By contrast, Labertouche Cave (a complex weathering cave in granite, east of Melbourne) is relatively small, with limited aesthetic quality. It is commonly used for recreational purposes by Scouts, rarely by speleologists, is probably unknown to most people. However, it is a most unusual and particularly interesting cave from a geomorphological viewpoint; this is probably unknown to most people who have seen it, let alone the general community. If one adopts the 'outstanding' approach, only a few geomorphologists would support its significance at any level. Yet, if we were to whole-heartedly adopt the 'representative' approach, this little cave is possibly one of Australia's stronger contenders for world listing.

Another way of referring to the significance of Labertouche Cave might have been to have suggested that it is 'probably almost unique'. This kind of implication raises a further set of questions. The concept of something being 'unique' is always determined by the scale at which one views it and should probably be qualified by any person making such a statement saying 'unique to my knowledge'. More importantly, does the fact that something is 'unique', with no further attribute of importance, make it 'significance'? Nature is essentially a matter of continuous variation, rather than of discrete classes, so we think that the word 'unique' is probably of limited usefulness in this entire exercise. 'Distinctive' is perhaps better.

Finally, this raises another aspect of boundary determination. From an ecological viewpoint, and from, say, local or state considerations, one might recognise a relatively large area or functional complex as a 'place'. However, within such an area, specific features may justify recognition at national or world level. For example, Hamilton-Smith and Champion (1975) argue for protection of a quite large area of the karst at Mount Etna, near Rockhampton in north Queensland. (Note, however, that protection is not synonymous with registration, as we stress elsewhere.) This total area is certainly of local and state significance. However, a number of features *within* this larger area are probably of national significance, e.g.:-

* the terraced pools;

* the caves used by the bat *Macroderma gigas*;

* the karst terrain on exposed limestone outcrops;

* Johannsen Cave;

* Bat Cleft; and

* two very unusual caves (Lost Paradise and Ballroom) formed by erosion in a sill.

This will probably mean that areas of this kind will require several nominations with overlapping areas and boundaries, but each defining a different level of significance. It is not yet obvious to what extent the Commission has come to terms with this necessity.

The significance of places to be identified in the Register of the National Estate is expressed in the legislation in terms of aesthetic, historic, scientific or social significance. These factors in the assessment of overall significance of resources come down to identifying the *values* of specific places, e.g.

. for aesthetic appreciation;
. for education (in all of its forms);
. for scientific enquiry; and/or
. as the site of recreation opportunities.

In other words, specific environments or sites might be regarded as significant (either as *outstanding* examples of their kind or as *complementing* or *balancing* the range of features represented elsewhere in the system) on any one or (usually) more of the following grounds:

* As examples of *natural features or landscapes* -

  . for aesthetic appreciation,
  . for education and presentation, and/or
  . for scientific inquiry;

* As examples of the operation of *natural processes* -

  . for aesthetic appreciation,
  . for education and presentation, and/or
  . for scientific inquiry;

* As examples of *cultural features or landscapes* -

  . for aesthetic appreciation,
  . for education and presentation, and/or
  . for prehistorical, historical or social inquiry;

* As the site of *recreation opportunities* -

  . for aesthetic appreciation,
  . for participation,
  . for education and presentation, and/or
  . for social inquiry.

CRITERIA OF SIGNIFICANCE

In seeking to supplement the 'outstanding' approach with a 'representative' one, there is a need for a reasonably comprehensive classification of caves and karst which can be used to test the completeness, or otherwise, of the Register. The continuous variation of nature is not readily categorised and many features quite properly belong in several categories. Nevertheless, it is useful to classify caves and associated features into general genetic classes, as we have done in Table V. This table provides an indication of the range of rock types and geomorphic processes (and the most significant combinations of the two) which characterise Australian caves. This kind of classification has some significant limitations. The complex of processes involved in the formation of any particular feature is usually quite difficult to identify, and our understanding of the nature of the elemental processes is in itself inadequate (Grimes 1975; Jennings 1971a, 1975; Quinlan 1968, 1972). The classification presented here is an attempt to acknowledge these difficulties, while still providing a systematic basis for evaluation of our caves and related features; it provides a flexible framework for the description and analysis of the resources currently known to us.

It is not sufficient, however, to categorise caves or related features by process of formation, or rock type, alone. There is a series of highly relevant characters within any given category in Table V which are still deserving of attention and recognition in the Register. Just as the broad classification of Table V is one way of assessing the representativeness of the Register, so Table VI provides another basis for such assessment. It emphasises the character, morphology and variety of the features themselves, regardless of the mode of their formation.

1. KARST *(solution of unaltered rock is the dominant landform process)*

1.1 Carbonates (limestone, dolomite)

The most common type of caves in Australia and elsewhere (e.g. Jennings 1967e, 1968a, 1969, 1971a; Jennings & Sweeting 1963a; Lowry & Jennings 1974; Marker 1975, 1976b; Sweeting 1960; Williams 1978)

1.2 Evaporites (halite, gypsum) - rare in Australia

1.3 Siliceous rocks

Examples involving solution as the dominant process, rather than a combination of other weathering processes and solution, are relatively rare, but see Loffler 1978

2. PSEUDOKARST *(although solution may be a subsidiary process, one or more other processes dominate)*

2.1 Lava Caves

After limestone caves, the next most significant category of caves studied in Australia to date (e.g. Atkinson et al. 1975; Joyce 1976; Ollier 1963a, 1964a, 1967; Ollier & Brown 1965; Ollier & Joyce 1964, 1973)

2.2 Weathering

a) pseudokarren, gnammas, etc. (e.g. Dragovich 1968, Twidale & Corbin 1963, on granites)

b) tafoni, cavernous weathering, rock shelters (e.g. Dragovich 1969 in granite, Johnson 1974 in sandstone, Ollier & Tuddenham 1961 in sandstone)

c) boulder caves (e.g. Ollier 1965, Pound 1971 in granite)

2.3 Piping (alluvium, laterite, etc. - *weathering may be involved also*) e.g. (Gillieson 1971 in alluvium, Lefroy & Lake 1972 in laterite, Loffler 1974 in alluvium, Shannon 1975 in weathered duricrust and granite)

2.4 Wave Action - sea caves (e.g. Colhoun 1977, Middleton 1971)

2.5 Tectonic Movements (fault fissures, etc.) - unreported in Australia

2.6 Landslips - rare in Australia

2.7 Meltwater - glacier/snow thaw (e.g. Halbert & Halbert 1972)

2.8 Compound, indeterminate and special cases (e.g. Graham 1971 in basalt, Hale & Spry 1964 in dolerite)

TABLE V: Types of caves and related features.

It is important to appreciate that the two complementary classifications of Tables V and VI cannot be regarded as a complete and exhaustive taxonomy of caves or related features. Continuous variation is one reason for this. The complex compound nature of most natural features is another. However, the most important reason is that we inevitably only classify those characters which we judge to be significant at the time. Further research will always uncover new characters or combinations of characters which seem important and may also suggest that other characteristics which we previously thought were important are not perhaps so significant after all. Classification is simply a means of ensuring that we are as balanced, systematic and exhaustive as currently possible in our examination and description of these features and in our selecting of them for the Register.

In the following sub-sections we discuss some of the more important aspects of Australian caves and karst features as a way of expanding on these points, and to illustrate various key aspects referred to in Tables V and VI. These tentative classifications provide a systematic basis for the recognition of *all* kinds of caves and related features regardless of their relative abundance or their mode of origin or rock type. The two need to be used in conjunction; either one without the other would give an incomplete impression of the range of characters encompassed by caves and karst in Australia.

1. Rock type: age, stratigraphy/petrology, structure

e.g. aeolian calcarenites (dune limestones), various marine limestones bioherms, marbles, calcretes, dolomites, basalt, acid volcanics, granite, evaporites, sandstone, quartzite, laterite, alluvium, etc.

2. Regional context

a) climate, past and present
b) relationship of cave or karst/pseudokarst area to surrounding rocks: stratigraphic, tectonic, structural
c) the nature of the karst
   e.g. impounded/free, bare/covered (subsoil/mantled), subjacent, relict, buried/exhumed, syngenetic/postgenetic
d) topography, available relief
e) surface ecology: soils, vegetation associations, etc.

3. Surface features

a) landscape features (a few metres to several kilometres in scale)
   e.g. gorges, natural bridges & arches, dry valleys, semi-blind & blind valleys, steepheads, solution pipes, solution dolines, subsidence dolines, collapse dolines, cenotes, uvalas, poljes, streamsinks, springs, estavelles, tufa barriers & dams, hums, towerkarst, cockpit karst, conekarst, "tombstones", corridor karst; lava blisters, tumuli, barriers, lava canals, sinkholes, spatter cones, scoria cones, vents, etc.
b) small-scale features (millimetres to several metres)
   e.g. ripples, fluting, bevels, runnels, grikes, pavements, wells, solution pans, rockholes, blowholes, etc.

4. Types & stages of cave genesis and modification

e.g. vadose seepage, vadose flow, nothephreatic and dynamic phreatic; subsidence, collapse breakdown; various combinations of these

5. Controls on cave morphology

e.g. bedding, lithology, stylolites; jointing, faults; dykes; successive water table levels; successive lava flows, relationship to point of eruption; weathering

6. Present cave morphology

e.g. streams, lakes, gours, siphons/water traps, passages, domed chambers, rockfalls, flat roofs, potholes, blind shafts, fissures, flatteners, scallops, wall channel grooves, boxwork, spongework, anastamoses, deckenkarren, cave wall fluting, bellholes, wall pockets, mazes, rock pendants, volcanic vents, layered lava, lava stalactites and drips, lava level lines, ledges, benches

7. Hydrology, geochemistry and meteorology

physical and chemical state and dynamics of cave waters and atmosphere; e.g. crossing over of surface and underground drainage; differences between surface and underground catchments; breaching of surface divides by underground drainage; water chemistry: variation of streams/lakes and between streams, etc; air movements; CO_2 concentrations; variations in humidity and atmospheric condensation; tidal variations

8. Cave contents

a) clastic sediments
   e.g. entrance deposits; fluvial, lacustrine, cryogenic and exsudation deposits
b) biogenic deposits
   e.g. rockmilk, guano
c) speleothems
   e.g. columns, stalactites, stalagmites, helictites, flowstone, shawls, cave pearls, etc.
d) aragonite, gypsum, halite, guano minerals and other non-calcite mineral deposits
e) flora and micro-organisms
f) fauna (chiefly invertebrates and bats)
   e.g. trogloxene/troglophile/troglobite; species composition, abundance and life history; food chains; distribution; ecology

g) palaeontology
   - exposure of fossils in host rock
   - deposits of fossil & sub-fossil animal and plant remains

h) cave ice

i) prehistoric and historic relics

9. Human use of caves

a) art: prehistoric/historic/contemporary
b) occupation: prehistoric/historic/contemporary
c) recreation, including wilderness
d) tourism
e) education
f) research
g) other special uses; e.g. religious, ceremonial, defence
h) other factors of cultural, historical or social significance

10. Aesthetic attributes

a) of surface landscape and features
b) of cave: size, shapes, spaces, sounds, silence, colours, textures, contrasts
c) of speleothems and other features: size, shapes, forms, abundance, distribution, diversity, colours, contrasts

TABLE VI: Key characteristics of caves and karst.

Caves as aesthetic, educational and recreational resources

Because caves are so different from most of the environments with which people are familiar, and because many of the features in them are of considerable beauty and interest, caves have a wide range of aesthetic, educational, recreational and historical values.

The mineral decorations (speleothems) of caves are widely recognised for their beauty. This is not only due to their shape, size and colour, but also to their form, crystalline structures, delicacy, variety of form and size, contrast, rarity and juxtaposition with other features. Speleothems are far from the only beautiful sights within caves - many other features all add to the aesthetic experience: the shapes, colours, sizes, textures and reflections in passages, streams, lakes and on sculptured walls and ceilings, together with such things as shafts of sunlight coming in entrances, glowworm displays and fossil exposures.

Whereas visual aspects are important in the experience of the subterranean, many other perceptual factors involved in caves assume a much greater significance than they do in surface environments. Darkness itself has a very real aesthetic appeal to many people, just as it provides unusually strong contrast to the features within caves which are seen. There is a feeling of personal discovery in exploring the darkness of a cave with one's own light, and in appreciating the remoteness and solitude of cave conditions. The subterranean environment offers a special kind of wilderness experience. Deep silence and total peace is another stimulating and unusual attribute of many caves. Where there are sounds, they may have a special appeal of their own - the dripping of water into pools, the chattering of a colony of bats, or the constant sounds of air movement or running water.

Exploration of caves often involves a far closer association with the natural processes at work in the landscape than people normally experience - the roar and spray of a waterfall and plungepool underground is more impressive in the confined space and darkness of a cave than in a surface creek. The confined space of caves is in itself very impressive to most people; there is no horizon, and while walking or crawling around in tight passages or within a vast rockfall one can feel very much inside the earth. This feeling is an important component of the cave exploration experience, and it is as significant to the tourist in developed caves as it is to the explorer of 'wild' caves. To the caver, there are also unusual opportunities to indulge the primaeval sensations of wallowing in mud and water!

In addition to relatively passive aspects of the appreciation of caves and the perceptions made possible by the subterranean environment, there is a wide range of recreational values associated with caves. They offer many different physical challenges - vertical shafts, steep climbs, precarious traverses, rockpiles, long crawls, squeezes, rivers and streams, waterfalls, lakes and submerged passages. The contrasts between vertical and horizontal sections, dry dusty conditions and water and mud, and between rockpiles, mud, gravel, sand and smooth sculpted rock, are all important. So is the alternation from small confined spaces to large awesome chambers, or from deep potholes, tall blind shafts and narrow vertical canyons to broad flat rooms and passages, or from simple unbranching passages to complex three-dimensional mazes, or from straight passages to meandering, disorienting systems.

Flooded parts of caves offer diving challenges quite unlike the sea or rivers. The cenotes of south-eastern South Australia and the lakes in a few of the Nullarbor caves are of considerable international interest for cave divers. The very extensive Cocklebiddy Cave on the Nullarbor Plain in W.A. is almost all inaccessible except by diving, already requires the longest underwater journey of any cave in the world and is still incompletely explored.

The sheer size and complexity of some cave systems add another dimension to the recreational experience. Long trips into remote sections of complex arduous caves offer a completely different kind of experience from that of small simple systems. In a few caves, especially very large active systems or submerged passages, exploration is at the very limit of technology and human endurance. These challenges have a special attraction. There can be no doubt that the excitement of discovery and exploration is an important component of cave recreation; this need not apply solely to the discovery of new caves or sections of caves. People's perception of the very different environment of caves often means that the discovery of places new *to them* is as important as totally new cave exploration - so long as there is little or no perceptible sign of previous exploration.

Much of the aesthetic appeal of caves is due to the remarkable diversity of different types and to the variety of sights and sounds within them, but the surface environments of cave and karst areas are also an important component of the experience. A cave entrance provides a unique frame of reference on the outside world, and often the terrain and vegetation communities of karst areas are in themselves distinctive and interesting. Many of the geomorphological processes which contribute to the formation of caves are also responsible for beautiful and spectacular surface landforms.

The range of fascinating natural features exhibited in cave areas and the evidence of some of the processes at work in the landscape make cave and karst resources especially valuable for education and interpretation. Because caves allow people to explore beneath the surface of the landscape with which they are familiar, they provide a new dimension for education about geology and geomorphology. Because of the preservation of sediment, bones or archaeological material, caves can contribute a great deal to education about environmental change and prehistory. The special life in caves is also of educational interest - many of the bats and invertebrate species are interesting in their own right, but the relatively simple ecosystems in caves offer unusual opportunities for ecological studies.

The functional interrelations between caves and surface features in karst areas provide a particularly valuable example of ecological and hydrological relationships in the environment. It is easier to understand the reality of this connection where there are rivers disappearing underground, or bats flying in and out.

Caves as geological and geomorphological features

By their very nature, caves and related features are of considerable geological and geomorphological interest. Such interest comes about in the following contexts, as:

* beautiful and interesting landforms;
* providing access to stratigraphic sections;
* exposing features of geological structure; and
* providing examples of a whole range of particular geomorphological, hydrological and meteorological features and processes;

and have particular significance for:

* scientific enquiry into the nature, rate and mode of operation of natural processes; and
* interpretation and education.

Caves provide a wide range of special opportunities for studies in the earth sciences, right across a spectrum including palaeontology, sedimentology, stratigraphy, structural geology, geomorphology, hydrology, meteorology and mineralogy.

Caves provide unique access into geological formations and can offer outstanding opportunities for investigations of bedrock palaeontology, stratigraphy and structure; e.g. Burns & Rundle 1958 (Mole Creek, Tasmania), James & Montgomery 1976 (Bungonia, N.S.W.), Lowry 1966b, 1968a, 1970a (Nullarbor Plain, W.A.). Fossils and sedimentary structures are often displayed better on clean cave walls than in surface outcrops.

The sediments in caves are of particular interest for their palaeoecological implications (see below), but they also have substantial intrinsic interest to the sedimentologist and geomorphologist for the processes, environments and sequences of their production, transport and deposition (e.g. Frank 1969, 1971a, 1971b; Goede & Murray 1977; Mulvaney & Joyce 1965; Shackley 1978).

Different climatic and geological factors around the continent give rise to considerable regional diversity in karst forms and in the mode and extent of expression of karst processes (Tables V and VI). Comparison of the cave and karst features between various places (Table VII) allows inferences to be drawn about geological and geomorphological processes which may have far wider application than to caves and karst alone.

<u>Australian cave area studies of particular international interest</u> -

SEMI-ARID KARST

Nullarbor Plain, S.A. & W.A.: Jennings 1958, 1961, 1963a, 1967e, 1967f, 1971a, Lowry & Jennings 1974

KARST OF THE SEASONALLY HUMID TROPICS

Chillagoe, Qld.: Ford 1978; Jennings 1966b, 1969; Marker 1976b

Kimberley, W.A.: Jennings 1962, 1967e, 1971a; Jennings & Sweeting 1963a

SYNGENETIC KARST IN COASTAL AEOLIAN CALCARENITES

South-west W.A., S.A. & King Island, Tas.: Bastian 1964, Jennings 1968a, 1968b, 1971a

KARST (ESPECIALLY CENOTES) IN TERTIARY LIMESTONES

Murray Basin, south-eastern S.A. and south-western Victoria: Jennings 1968b, 1971a; Link 1967; Marker 1975; Sexton 1965

LAVA CAVES

Western Victoria: Joyce 1976; Ollier 1963a, 1964a, 1967; Ollier & Brown 1965; Ollier & Joyce 1973

<u>Other area studies of national significance</u> (mainly palaeozoic limestones in temperate areas)

Buchan, Victoria: Sweeting 1960

Bungonia, N.S.W.: Jennings 1965; Jennings & James 1976; Jenning et al. 1972; Pratt 1964

Cooleman Plain, N.S.W.: Jennings 1976

New Quinea, Snowy River, Victoria: Frank & Davey 1977

Timor, N.S.W.: James et al. 1976

Wellington, N.S.W.: Francis 1973

Yarrangobilly, N.S.W.: Rose 1964-65

TABLE VII: Selected Australian studies of cave area geomorphology.

Apart from these regional studies and comparisons there are numerous significant geomorphological studies of individual caves which contribute to a better understanding of their region and other caves of that type (Table VIII).

SEMI-ARID KARST	
Hunt 1970	Mullamullang Cave, Nullarbor Plain, W.A.
Lowry 1964	Cocklebiddy Cave, Nullarbor Plain, W.A.
1966a	Gecko Cave, Nullarbor Plain, W.A.
KARST OF THE SEASONALLY HUMID TROPICS	
Jennings & Sweeting 1963b	The Tunnel, Kimberley, W.A.
1966	Old Napier Downs Cave, Kimberley, W.A.
Lowry 1967a	Cave Spring Cave system, Kimberley, W.A.
KARST IN TERTIARY LIMESTONES	
Ollier 1964c	McEacherns Cave, Glenelg River, Victoria
TEMPERATE KARST IN PALAEOZOIC LIMESTONES	
James & Montgomery 1976	Odyssey Cave, Bungonia, N.S.W.
Jennings 1963b	Dip Cave, Wee Jasper, N.S.W.
1964	Punchbowl & Signature caves, Wee Jasper, N.S.W.
1967a	Barber Cave, Cooleman Plain, N.S.W.
1970a	Verandah Cave, Borenore, N.S.W.
1970c	Cooleman caves, N.S.W.
LAVA CAVES	
Atkinson et al. 1975	Undara, Queensland
Ollier 1963b	Mount Hamilton, Victoria
1963c	Skipton, Victoria
1964b	Mount Eccles, Victoria
Ollier & Brown 1964	Byaduk, Victoria
OTHER PSEUDOKARST	
Colhoun 1977	sea cave in hornfels, Tasman Peninsula, Tasmania
Graham 1971	cave in basalt, south-eastern Queensland
Halbert & Halbert 1972	meltwater caves in the Snowy Mountains, N.S.W.
Hale & Spry 1964	cave in dolerite, Tasmania
Ollier 1965	boulder cave in granite, Labertouche, Victoria
Ollier & Tuddenham 1961	tafoni in sandstone, Ayers Rock, N.T.
Shannon 1975	piping caves in duricrust/granite, Banana Range, Queensland

TABLE VIII: Selected Australian geomorphological studies of individual caves.

Many features of karst other than caves are also of interest to the geomorphologist, especially surface landscape features and minor solutional sculpture (Table VI). In addition to the various regional studies which refer to them, there are a number of significant cases where individual features have been studied in some detail (Table IX).

SEMI-ARID KARST	
Bridge 1973b	halite exsudation as a weathering agent
Jennings 1970b	small cavities and weathering processes
Lowry 1968b, 1969	halite exsudation, small cavities and weathering processes
INDIVIDUAL KARST FEATURE TYPES	
Jennings 1963c	collapse doline
1966a	solution doline & subjacent karst doline
1966c, 1967b	subjacent karst doline
1967c	semi-blind valley
1967d	blind valley
Jennings et al. 1976	karst stream self-capture
Lowry 1967b	soil subsidence doline
Marker 1976a	cenotes
KARST & PSEUDOKARST SURFACE SCULPTURE	
Dragovich 1968	runnels in granite
Jennings 1971a	karst surface solution sculpture
Twidale & Corbin 1963	gnammas or small hollows in granite
CAVERNOUS PSEUDOKARST	
Dragovich 1969	tafoni in granite
Johnson 1974	tafoni in sandstone

TABLE IX: Selected Australian studies of individual karst and pseudokarst features.

The dynamics of landform evolution in cave areas are most readily studied by hydrological observations. The hydraulics of cave streams give characteristic scallops to rock surfaces (Curl 1974, Jennings 1971a) and may influence the shape and form of cave passages (Ongley 1968). The drainage systems of extensive karst areas may be quite different in form to similar areas on other lithologies (Colville & Holmes 1972; Goede 1969, 1973; Holmes & Colville 1970a, 1970b; Jennings 1971a; Jennings & Sweeting 1959). Under some conditions, it is possible to use hydrological observations to measure the rate of change in the catchment (Goede 1973; Jennings 1971b, 1972a, 1972b, 1977). Because karst areas offer opportunities for quantitative denudation studies of a more complete and useful nature than is found on most other lithologies, there is a strong case for the registration of entire karst drainage basins for this purpose.

The physical behaviour of air and water masses in caves is of considerable meteorological interest, especially the processes which control fluctuating inflow and outflow of air. Some Australian studies have resulted in significant new interpretations of the mechanisms of air and water movement in caves and porous rocks (Halbert 1972, 1978a & b; Halbert & Michie 1972; Lowry 1970b; Wigley 1967, 1971; Wigley & Brown 1976; Wigley & Wood 1967; Wigley, Wood and Smith 1966). In a few cases unusual concentrations of CO_2 in the cave atmosphere give rise to special chemical and environmental conditions in the cave (James 1975, 1977).

Caves provide stable environments for the formation of mineral speleothems and, occasionally, the growth of large crystals. Carbonate minerals are the chief constituent of most speleothems and are of particular interest for their crystal form and aesthetic appeal. Some of the less common minerals found in caves (sometimes as speleothems of great beauty and delicacy) may be extremely rare elsewhere, especially halite (Lowry 1967c, Wigley & Hill 1966) and those minerals formed by the interaction of bat or bird guano and urine with the rock of the cave (Bridge 1971, 1973a, 1974a, 1974b, 1975a & b, 1977; Bridge et al. 1975; Bridge et al. in press; Pryce 1972). Many caves are the type localities for the mineral species concerned (some of them very rare), but even for minerals which are well known from other environments, the unusual mode of their occurrence in caves makes them especially interesting. Many of the guano-related minerals in caves are not yet adequately documented or described, and some are unknown from other environments. Knowledge of the chemistry of these compounds and of the conditions under which they were formed may be utilised in future waste recycling processes and is already used in fertiliser studies.

Caves as biological resources

The plant and animal ecosystems associated with caves are very specialised and usually fragile components of cave systems. Cave environments are relatively stable, and many cave organisms - particularly invertebrates - are relics of much larger populations which may have lived on the surface under different environmental conditions at earlier times. Thus, the study of cave organisms can be of considerable importance in understanding evolutionary processes. The distribution of particular species, genera or families in cave locations across a region may also contribute to palaeoecological studies of the former distribution of particular populations and the environmental changes which have occurred(Hamilton-Smith 1972b, Richards 1971).

Despite low light intensities, caves do contain plant communities, especially in the entrance zone. Many of these entrance communities are specialised assemblages of plants dependent on the relatively humid and stable conditions there (Johnson, Wright & Ashton 1968). Even in the deep twilight zone, cave walls may support a community of micro-organisms, some of which are able to photosynthesise at very low light intensities (Cox 1977). These autotrophic organisms contribute one kind of energy input into cave ecosystems; they support other heterotrophic microorganisms, fungi and invertebrates. Fungi are a significant component of most humid cave ecosystems, particularly where streams provide another energy input by carrying organic debris into caves. It also appears that fungi may play a part in the formation of some mineral speleothems (Went 1969); however the most significant biogenic mineral formation in caves - rockmilk - is the product of bacterial action (Geze 1961, Bernasconi 1961).

The isolation provided by scattered caves has a role in speciation, and the relative stability within some caves can lead to long persistence of species in caves as 'living fossils'. Many of the invertebrate species found in caves are of special interest to science because of their physiological adaptations to cave conditions (Gray 1973, Hamilton-Smith 1972b, Hunt 1972, Moore 1972). Chief among these are elongation of appendages, loss of eye function and depigmentation (Mackerras 1967, Main 1969). Australia has a relatively small number of organisms which exhibit these adaptations (Hamilton-Smith 1972). Even species which do not exhibit any particular morphological or physiological adaptations to the cave environment are often confined to caves, and their rarity and the simplicity of the communities in which they exist make them of considerable interest to scientists.

Food webs in cave ecosystems are relatively simple in comparison with most other systems (e.g. Richards 1971), and as a result are generally very precarious. Very often, the only energy inputs are from those organisms which live in caves but which go outside to feed. Some invertebrates fall into this latter category, but the most obvious of these are the various species of cave-dwelling bats, many of which comprise particularly interesting populations (Hamilton-Smith 1965, 1972a, 1974). The cave ecosystems which are centred on bat populations - particularly the guano community in the cave - offer valuable opportunities for the study of relatively simple structure and function in a natural ecosystem (Harris 1970, 1973).

The simplicity and vulnerability of cave ecosystems poses some special problems for conservation and resource management. Species protection (for cave-dwelling bats, for instance) is quite useless unless their cave habitat is also protected from disturbance. In many respects, caves represent very simplified and vulnerable ecosystems in relation to most other terrestrial ecosystems, and all the problems of size, diversity and viability in conservation and resource management are particularly acute (Diamond 1975).

Caves as palaeoecological and archaeological resources

Caves offer special opportunities for the preservation of sediments, pollen, plant and animal remains and human artefacts. In many environments, they are the only places where these biological and cultural remains may be preserved. For this reason, caves offer scientists special opportunities for research into past climate, hydrology, vegetation, fauna and Aboriginal prehistory (e.g. Bowdler 1977, Bowler et al. 1976, Martin & Peterson 1978, Merrilees 1968).

Because of progressive change in the morphology of a cave system, or change in environmental conditions, a sequence of clastic deposits (silt, sand, gravels or breccia deposited by streams, or by periglacial action, subsidence, exsudation and various other processes) may be preserved with sedimentological, mineralogical, chemical or other features which permit some reconstruction of the sequence of events which have led to their emplacement, or of environmental conditions which prevailed during their deposition. In the former case, it is possible to understand something of the processes progressively at work in the formation of the cave concerned (Frank 1972-3, 1974; Frank & Jennings 1978); and in the latter case it is possible to identify the climatic or other environmental conditions which might have prevailed in the general area at earlier times (Frank 1969, 1971a, b & c, 1975; Goede & Murray 1977; Mulvaney & Joyce 1965; Shackley 1978).

Examination of the pollen in cave sediments is another means of studying changes in the relative abundance of plant species (or characteristic genera or families) in the region surrounding the cave, and permits inferences to be made about relative climatic conditions (Martin 1973, Martin & Peterson 1978). Examination of pollen in the stomach contents and faeces of desiccated animal carcases found in caves gives another indication of vegetation and climatic conditions at the time of death of the animal (Ingram 1969). All of these sedimentological and pollen-analytical techniques, if used in conjunction with radiometric dating of such materials as speleothems, charcoal, bone or desiccated animal tissue, can be used to provide a reasonably detailed chronology of the environmental conditions reflected in the nature of the materials preserved in the cave. Radiometric techniques can also be used to date the groundwater in karst regions, giving an indication of the rate of movement, recharge and discharge in slow-moving phreatic systems (Tamers et al. 1975; Wigley 1975). Other geochemical and geophysical techniques are increasingly being used for the direct dating of speleothems in caves, and permit the calculation of palaeotemperatures and other environmental variables (e.g. Gascoyne et al. 1978; Hendy & Wilson 1968; Ikeya 1975; Thomson et al. 1974).

The generally stable alkaline conditions within the sediments which accumulate in caves are especially favourable for the preservation of bone and other animal remains for relatively long periods. The animal remains can be washed into the cave, fall in, or be carried in by predators such as owls or kestrels (e.g. Hall 1975, Wakefield 1960, 1967a) or Tasmanian devils and similar mammals (e.g. Douglas et al. 1966; Lundelius 1966). They may also be brought in by Aboriginal people occupying the cave (Flood 1973b, Merrilees 1968), or by a combination of processes. Sometimes the animals may actually die in the cave (Lowry & Lowry 1967).

Animal remains in caves permit the identification and description of species which may no longer be extant anywhere, or in the region surrounding the cave (Table X), and the occurrence of particular fossil species in one or a series of caves within a region often permits some reconstruction of the former distribution of animals under earlier environmental conditions. If analysis of faunal assemblages is integrated with radiometric dating and/or other palaeoenvironmental studies (e.g. pollen analysis), it is possible to provide a chronology of the changing fauna represented in the cave record, and to infer contributing environmental factors (Table X). Sometimes it is possible to use animal remains other than bones to reconstruct the former distribution of particular species. An example of this is the study undertaken by Bridge (1975a), who was able to demonstrate a much wider range in former times for the Ghost Bat *Macroderma gigas* on the basis of the mineralogy of bat guano in caves in the southwest of Western Australia.

So, in Australia, caves have made a major contribution to our still very incomplete understanding of the environmental changes which have occurred over the last 100,000 years or so, and have given some indication of the composition of the biota at the time of European settlement and of some of the changes those communities had undergone prior to that.

Caves also provide us with some of the oldest and most complete information about Aboriginal occupation of the continent. Because archaeological remains in caves are often preserved together with sediment, pollen, plant remains and bones it is often possible to provide an integrated chronology of Aboriginal occupation and environmental conditions in the area much more accurately than is possible from information in surface sites alone. Numerous important Australian archaeological investigations have been undertaken in open overhangs or rock shelters, but there are also many instances where sites well within caves have provided important archaeological information (Table X).

Much of the rock art of the Australian Aborigines is in caves of some kind, although the majority are overhangs and rockshelters close to daylight (e.g. Brandl 1973, Crawford 1968, Edwards & Ucko 1973, Lane & Richards 1966, McCarthy 1962). Study of this art has contributed a great deal to understanding of Aboriginal culture, and its conservation presents a real challenge (Edwards 1975; Edwards & Ucko 1973). In addition to the heritage of relatively recent Aboriginal are in rockshelters and overhangs, there are a number of much older instances well within caves. We now know of several sites of engravings or linear markings in darkness or near-darkness. The best known, of considerable international fame, is Koonalda Cave, in the Nullarbor Plain; the remarkable engravings in this cave are about 20,000 years old (Edwards 1971; Edwards & Maynard 1967, 1969; Edwards & Ucko 1973; Gallus 1968c, 1977; Maynard & Edwards 1971; Sharpe & Sharpe 1976). Two other interesting engraving sites are in caves in the southwest of

Western Australia and have permitted detailed archaeological and palaeontological investigations: Devils Lair (Dortch 1976) and Orchestra Shell Cave (Hallam 1971). The only known site in eastern Australia has not yet been investigated in any detail (Frank & Davey 1977).

VERTEBRATE TAXONOMY

Archer 1972, Baynes et al. 1975, Cook 1963, Glauert 1910, 1912, 1914, Gorter & Nicoll 1978, Lowry 1972, Merrilees 1967a, 1967b, 1969, Murray & Goede 1977, Pledge 1977, Ride 1960, Smith 1971-72

VERTEBRATE PALAEODISTRIBUTION

Archer 1972, 1974, Archer & Baynes 1972, Baynes et al. 1975, Cook 1964, Douglas et al. 1966, Gorter & Nicoll 1978, Hall 1975, Kendrick & Porter 1973, Lowry & Lowry 1967, Lundelius 1957, 1960, 1963, Lundelius & Turnbull 1974, Merrilees 1967a, 1967b, 1969, Murray & Goede 1977, Pledge 1977, Richards 1971, Ride 1960, Tideman 1967, Van Tets 1974, Wakefield 1960, 1963a&b, 1964a&b, 1967a&b, Walter & Pledge 1967

PALAEOECOLOGY

Archer 1974, Lowry & Lowry 1967, Lawry & Merrilees 1969, Lundelius 1966, Lundelius & Turnbull 1974, Martin 1973, Merrilees 1967b, 1968, 1970, Milham & Thomson 1976, Murray & Goede 1977, Partridge 1967, Ride 1960, Wakefield 1967b, 1969, 1972, Walter & Pledge 1967

ARCHAEOLOGY

Bowdler 1977, Dortch 1974, Dortch & Merrilees 1971, Flood 1973a, Flood 1973b, 1974, 1976, Frank 1980, Gallus 1964, 1968a&b, 1971, Glover 1974, 1975, Goede & Murray 1977, Hallam 1974, Merrilees 1968, Merrilees et al. 1973, Milham & Thompson 1976, Mulvaney & Joyce 1965, Pretty & Gallus 1967, Wright 1971a&b

TABLE X: Australian cave studies of vertebrate palaeontology and palaeoecology.

In many areas of Australia, caves and rockshelters are of sacred significance to Aboriginal people. Aboriginal criteria for the significance of such features should be quite compatible with the criteria discussed here, even if the emphasis is different from that of a European perspective. For instance, significance of a place for Aboriginals will often be based on lore as much or more than on its physical attributes. European cultural values of natural places are often not as rich or complex.

Cave sites which contain valuable sediment, pollen, animal remains and cultural materials or associations are often not recognised as such by the casual visitor. Many of the important features are concealed within the deposit; others are subtle features which are only intelligible to the alert expert. In this situation, it is easy for important sites to be disturbed or damaged, simply because visitors are not aware of the potential scientific importance of a few bones or strange markings. Every known site of scientific significance should be protected and actively managed but it is also desirable that some kind of protection be given to every cave for similar reasons, because of the high probability (relative to most surface locations) that even an apparently insignificant cave will ultimately turn out to be of at least some significance to an investigating geomorphologist, sedimentologist, palynologist, palaeontologist or archaeologist. Each new site contributes a little more to the fragmented and incomplete evidence of past conditions in our environment, and caves contribute far more to these important studies than their relative scarcity might suggest.

CONCLUSION

This report is only the beginning of a long-term task. Continual review will be necessary. Our ideas about the significance of specific features will change. The working classification (Tables V & VI) will need to become progressively more sophisticated. To start with, the task will consist of testing the available data against the classification. Gaps or imbalances in the classification may need to be rectified but it should now be possible to identify representative examples at different levels of significance in a reasonably complete range of categories. At the same time, another list will be identified from an 'outstanding' perspective . The two lists will overlap. Together they will constitute a first attempt at recognising the significant caves and karst in the national estate on a systematic and explicable basis.

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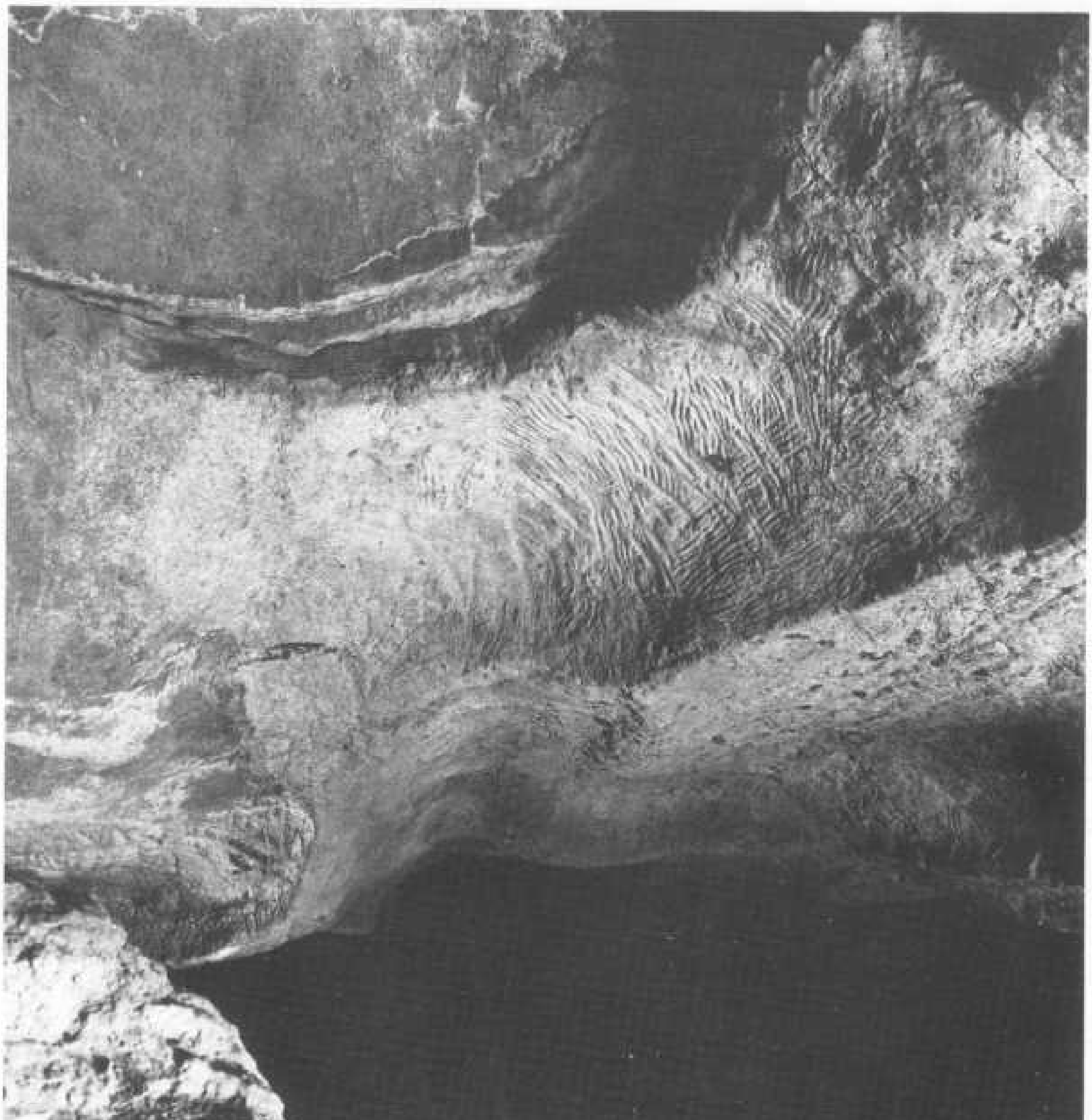

Plate 2. Aboriginal finger markings in NG2 cave, New Guinea, Snowy River, Vic. (Photo R.K. Frank)

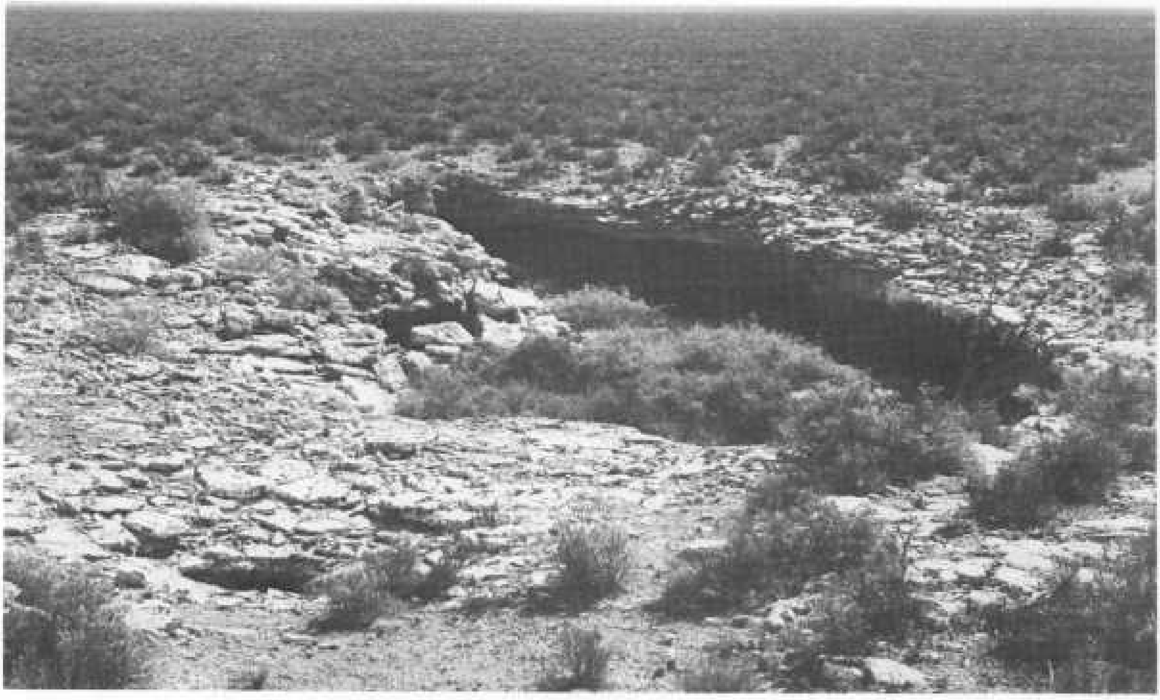

Plate 3. Roaches Rest Cave, Nullarbor Plain, W.A. (Photo: A.G. Davey)

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APPENDIX I

DISCUSSION PAPERS CIRCULATED DURING THE COURSE OF THE STUDY

The majority of these papers remain unpublished. A complete set is available for reference in the Australian Speleological Federation papers in the Manuscript Section of the National Library of Australia in Canberra, and the constituent societies of the Federation should hold a complete set each. Except for those identified as reprints or extracts of material originally appearing elsewhere, they were written specifically for (or in response to) this study. The number and date in brackets after each item refer to the batch in which each was distributed.

A: DISCUSSION PAPERS ABOUT THE MAJOR ISSUES

A1. GOLDIN P. A review of methodology in landscape evaluation. 12pp., refs. (1, May 1976)

A2. (reprint) THOM B.G. (1975) Proposal to establish geomorphic (landform) reserves in Australia. Aust. Quat. Newsletter No: 6, pp. 2-6 (1, May 1976)

A3. FAGENCE M. Consensus methodology - a brief review in cognisance of the particular requirements of geographically dispersed participants. 9pp., refs. (2, September 1976)

A4. MIDDLETON G.J. The definition of place. 2pp. (3, February 1977)

A5. (reprint) HAMILTON-SMITH E. (1977) Evaluation of caves and karst. Proc. 11th Biennial Conf. Aust. Speleol. Federation, Canberra 1976; pp. 1-6 (3, February 1977)

B. INDIVIDUAL VIEWS ON ASPECTS THAT SHOULD BE CONSIDERED IN ASSESSING SIGNIFICANCE (mostly with common titles beginning: The assessment of significance ...)

B1. JENNINGS J.N. ... a geomorphological viewpoint. 3pp. (1, May 1976)

B2. OLLIER C.D. ... lava caves and related features. 1p. (1, May 1976)

B3. PAVEY A.J. ... from a recreational viewpoint. 3pp. (1, May 1976)

B4. SKINNER R.K. ... for tourism purposes. 1p. (1, May 1976)

B5. HAMILTON-SMITH E ... in relation to bat populations. 2pp. (1, May 1976)

B6. LOWRY D.C. ... a geological viewpoint. 2pp. (1, May 1976)

B7. MERRILEES D. ... archaeology and palaeontology. 1p. (1, May 1976)

B8. POULTER N. ... aesthetic considerations. 1p. (1, May 1976)

B9. GOEDE A. ... geomorphological, geological and hydrological aspects. 4pp. (2, September 1976)

B10. SEFTON I. & SEFTON A. Assessing the historical significance of caves. 3pp., refs. (2, September 1976)

B11. GOEDE A. ... biological aspects. 1p. (2, September 1976)

B12. LOWRY J.W.J. ... biological significance in caves. 3pp. (2, September 1976)

B13. GRAHAM A. ... tropical - subtropical east coast vegetation aspects. 1p. (2, September 1976)

B14. BRIDGE P.J. ... mineralogy. 2pp. (2, September 1976)

B15. (extract) DWYER P.D. (1976) Systematics, biology and biological resources. Search 7(7): 294-298 (3, February 1977)

B16. DUNKLEY J.R. ... underground wilderness. 2pp. (3, February 1977)

B17. JOYCE E.B. ... lava caves and related features. 2pp. (3, February 1977)

B18. SKINNER R.K. Further comments on the significance of caves for tourism purposes. 2pp. (4, March 1977)

C: COMMENTARIES ON OTHER DISCUSSION PAPERS

C1. YENCKEN D. (Chairman, Australian Heritage Commission) 4pp. (2, September 1976)

C2. FELLER M.C. (University of Melbourne) 4pp. (2, September 1976)

C3. GOEDE A. 4pp. (2, September 1976)

C4. ASLIN F.W. (as convenor of a study group in Mount Gambier, S.A.) 2pp. (2, September 1976)

C5. Summary of other comments (from numerous unidentified respondents) (2, September 1976)

C6. LOWRY J.W.J. 4pp. (3, February 1977)

C7. PAVEY A.J. (as reporter from a study group from the University of New South Wales Speleological Society) 2pp. (3, February 1977)

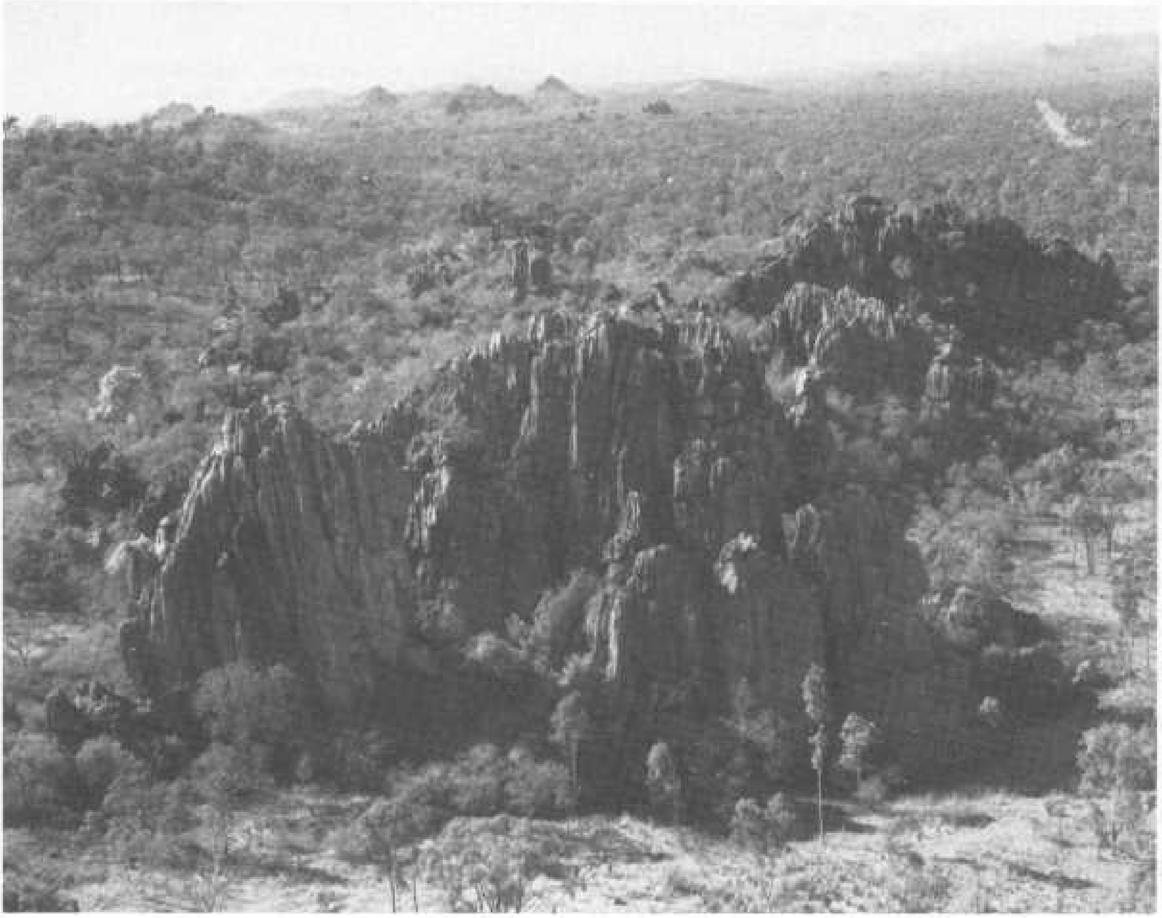

Plate 4. Tower karst at Chillagoe, N. Qld. (Photo: K.G. Grimes)

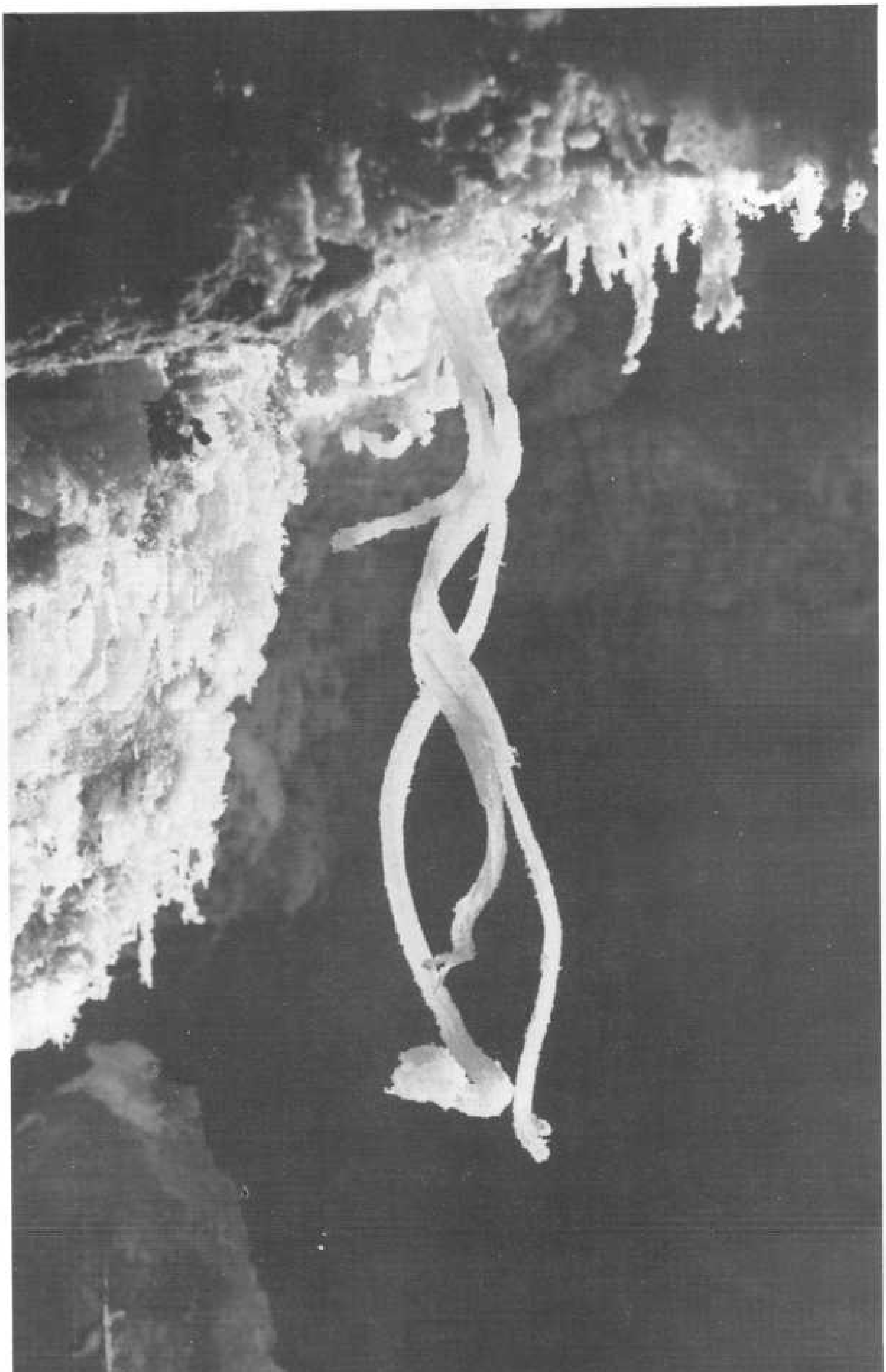

Plate 5. Halite speleothem, Mullamullang Cave, Nullarbor Plain, W.A.
(Photo: A.G. Davey)

HELICTITE

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CONTENTS

Evaluation Criteria for the Cave and Karst Heritage of Australia
- Report of the Australian Speleological Federation National Heritage Assessment Study, ed. A.G. Davey

Speleological Research Council Limited