

Australia's Geoheritage: History of Study, A New Inventory of Geosites and Applications to Geotourism and Geoparks

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Abstract Databases of geosites for the continent of Australia provide an inventory covering key sites and terrains on the Australian mainland, Tasmania and Australian territories and islands. The inventory is based on an early listing by Cochrane and Joyce (1986), a short list prepared for the Global Indicative List of Geological Sites (GILGES) and UNESCO by Joyce (1991), a revised GILGES list published in Cowie (1991), discussions in Joyce (1994a, b and 1995b), the Australian Heritage Commission's Register of the National Estate and, most recently, an independent review of earlier work for the Australian Heritage Commission by Yeates (2001a, b). The Geological Society of Australia has had a major involvement for over 50 years in developing this inventory, and many geological sites are listed on the Register of the National Estate. Other groups that have been involved are the Australia Government's geological survey, state government geological surveys and departments of environment and conservation, including forestry groups in Tasmania and also the Australian Government's World Heritage section. Locating and listing these databases, developing them further and making them available via the Internet will assist in the future development of geotourism and geoparks in Australia.

Keywords Geoheritage · Australia · History · Geosites · Inventory · Geotourism · Geoparks

Introduction

Geosites of Australia include key sites and terrains on the Australian mainland, Tasmania and Australian territories and islands.

The Geological Society of Australia (GSA) has been largely responsible for building the national inventory, and many geological and geomorphological sites are also listed on the Australian Heritage Commission's Register of the National Estate (RNE). The Australian Heritage Commission (AHC), the Australian Government's national (Commonwealth) heritage body, was established in 1975. From 1 January 2004, it has been reorganised and renamed the Australian Heritage Council, but in this article, the earlier name Australian Heritage Commission will be used.

Australia has a coastline of around 32,000 km, with varying rock types and structure, coastal types and climate. Outstanding and representative coastal sites form a significant part of the Australian inventory. Examples of major terrains include inland deserts (Simpson Desert dune field), northern tropical savannah (Kakadu World Heritage Region), glacial and periglacial uplands in the far south (southwest Tasmania), broad inland riverine plains (Murray–Darling river system) and the young volcanic provinces of southeastern Australia and northeastern Australia. There are also many karst and cave sites (Nullarbor Plain) and many palaeoweathering landforms in central Australia (Uluru), as well as representative stratigraphic sites, rock and mineral sites, and structural and tectonic sites. Viewpoints are included and also sites related to the history of geology (for example Charles Darwin and the Blue Mountains near Sydney; Fig. 1). Important fossil sites include the Proterozoic stromatolites of the Pilbara of northwestern Australia, the World Heritage Tertiary mammal fossils of Riversleigh and Naracoorte and the Devonian fossil fish beds of Canowindra, New South Wales (Fig. 2).

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Fig. 1 World Heritage Area of the Blue Mountains, near Sydney, New South Wales; a site of historic geological interest, visited by Charles Darwin in January 1836. Major lookouts provide viewpoints to spectacular valleys, scarps and plateaus developed in Triassic fluvial sandstone. This landscape was to influence Darwin's understanding of the effects of marine and fluvial erosion (photo by E. B. Joyce)

Geological Heritage Work in Australia

Australia is often referred to as “the oldest continent”. Zircons dated between 4,300 and 4,200 million years have been found in the Archaean rocks of the Mt Narryer area of Western Australia, and the microfossils and stromatolites of the Pilbara, also in Western Australia, are amongst the earliest known life on earth. The old shield that forms a major part of the Australian continent is mainly a flat and low-lying plateau, tectonically quiet and with one of the lowest erosion rates known. Deep weathering profiles dating to the Mesozoic and even earlier have survived over long periods of geological time, as have other relics of ancient landscapes (Joyce 1999).



Fig. 2 Devonian fossil fish beds outside the small town of Canowindra in New South Wales, with its excellent Age of Fishes Museum (photo: E. B. Joyce)

This contrasts with the northern hemisphere continents where late Tertiary and Quaternary uplift and extensive glacial erosion have given very different landscapes. Only in Tasmania and the higher parts of the southeastern Australia mainland can landscapes similar to those of much of Europe be found.

The study of geological heritage in the former Gondwana continents such as Africa, South America, India and Australia may well need a different approach from that used elsewhere (Joyce 1999), and the thematic frameworks to be used to select global geosites may also be different from those used in geosites programmes in Europe and elsewhere.

Geosites

The “Geosites” programme began in 1995 (Wimbledon 1996) and operated under the International Union of Geological Sciences (IUGS) until 2004 (Dingwall et al. 2005), with the aim of developing an international database based on a systematic inventory of the world's geological resources. The primary objective of the programme was to provide a factual basis to support national and international initiatives to protect geological resources for research and education. An intended end-use of the database was also to provide advice to the IUGS, and other bodies such as UNESCO, on priorities for conservation of geological sites in a global context (Dingwall et al. 2005), and so the geosites database was to be of potential benefit to the World Heritage Program.

The “Geosites” programme has developed overarching *criteria* and *principles* to guide the objective selection of the best geological sites for the international database (Dingwall et al. 2005). Key criteria are Representativeness, Uniqueness, Suitability for correlation, Complexity and geodiversity, Degree of research/study, Site availability and Potential.

The process of selecting geosites (sometimes referred to as “global geosites”) relies on a systematic inventory of geological phenomena. Individual countries have been encouraged to adopt their own stratigraphic, tectonic, fossil, or other *frameworks* for this purpose.

Rather than using rigid classification systems, geosites place emphasis on the development of *thematic frameworks* that enable sites to be selected as evidence of major geological events or processes, for example climate change, development of a volcanic province or an orogenic arc and Pleistocene glacial ice limits (see later examples in discussion on themes in Australian heritage work).

Cleal et al. (1999) discuss the GEOSITES methodology using examples from Great Britain. Frameworks used in British studies have included Carboniferous palaeobotany, Upper Jurassic-Lower Cretaceous stratigraphy and Caledonian igneous history.

The term “geosite” began to appear in publications of the early 1990s. For example, Cowie and Wimbledon (1994), in the book of the Malvern International Conference of 1993, discuss the compilation of sites for the Global Indicative List of Geological Sites (GILGES) which was developed for UNESCO and ICSU by Cowie and others, beginning in 1990 (see also Cowie 1991). Although the term geosite itself is not listed in the index to the Malvern conference book, Cowie and Wimbledon (1994) use the term (p. 71) in their discussion of the connection between GILGES and the then new IUGS GEOSITES database.

A general discussion of the term geosite is given by Reynard (2004). He lists as synonyms geotopes, earth science sites and geoscience sites and describes geosites as “portions of the geosphere that present a particular importance for the comprehension of Earth history”. They are defined as “geological or geomorphological objects that have acquired a scientific, cultural/historic, aesthetic and/or social/economic value due to human perception or exploitation”. Reynard’s discussion does not specifically refer to the term geosites as used by IUGS and UNESCO.

An IUGS Global Geosites Working Group (GGWG) was set up by the International Union of Geological Sciences, with the following terms of reference (Wimbledon 1999a):

- To compile the Global Geosites list;
- To construct the Geosites database of key sites and terrains;
- To use the Geosites inventory to further the cause of geoconservation and thus support geological science in all its forms;
- To support regional and or national initiatives aiming to compile comparative inventories;
- To participate in and support meetings and workshops that examine site selection criteria, selection methods, or conservation of key sites;
- To assess the scientific merits of sites in collaboration with specialists, research groups, associations, commissions, subcommissions, etc.; and
- To advise IUGS and UNESCO on the priorities for conservation in the global context, including World Heritage.

Wimbledon (1999b), in his Appendix 1, provides a draft format for the “Global GEOSITE Inventory and Database” (as at October 1997). Wimbledon (1999a) outlines the suggested procedure for an individual country to follow in selecting geosites and using such a listing to propose World Heritage (WH) sites:

- Create of a network of informants in countries
- Definition of regional/time Frameworks
- National provisional Geosite selections
- Regional comparisons and finalisation

- Country selection of a WH indicative list of regional Geosite lists
- Acceptance by GGWG
- Proposal of WH sites by countries

The term “geosites” was first used in reference to Australia by Joyce (2005) at the ProGEO Meeting in Braga, Portugal, and the first public discussion within Australia was by Joyce (2006b) in Melbourne.

Most recently, the promotion of “global geosites” by UNESCO has waned and support is no longer provided, and it has been left to interested countries or groups to continue this work if they so desire.

Nevertheless, for Australia, it is seen as important to have an agreed listing of major geological sites (Joyce 2005, 2006b) whether these are called geosites or some other name.

And at a time when Australian Government support for such heritage work is weakening, the GSA, as the major organisation in this field for 50 years, is the body best placed to maintain such a database.

History of Australian Geological Heritage Studies

Geological heritage studies in Australia go back to the first work by local GSA groups in Queensland and South Australia in the 1960s (Table 1). Even earlier, efforts had been made in promoting local reserves and setting up notice boards and signs on individual sites.

The earliest geological heritage signboard for Tasmania (and perhaps Australia) was at Mt Wellington and was erected about 1960 as a result of work by the late Alan Spry. This metal sign with painted lettering was vandalised by shooting and later removed.

In the mid-1960s, a number of signs were put up on roadsides and in National Parks in Tasmania, for example at Stanley (on the west coast) and in Mt. Field National Park. A Tasmanian Government interdepartmental committee coordinated this work into the 1980s (Max Banks, personal communication).

Several signs were also erected on the Tasman Peninsula. The original signs were metal plates with painted lettering, as at Mt Wellington. A splendid bronze plate with raised lettering and a depiction of the site was erected at the best viewing point for the Tessellated Pavement at Eaglehawk Neck on the Tasman Peninsula in November 1971. As the sign records, it is credited to the Geology Department of the University of Tasmania.

In the mid-1960s, GSA Divisions (corresponding to the Australian states and territories) organised subcommittees of interested geologists and began a programme of seeking out and promoting individual sites. The earliest work was

Table 1 Timeline of the geoheritage work of the Geological Society of Australia between 1952 and 2009, updating Joyce 2006a (see for comparison Fig. 5.1 in Brocx 2008)

1952	Geological Society of Australia (GSA) founded
1959	Report of the sub-committee of the Academy of Science(?) elected to examine the problem of conservation of geological objects in the Australian Capital Territory
1960	List of sites for New South Wales
1962	Publication of “National Parks and Nature Reserves in Western Australia” by the Western Australian Subcommittee of the Australian Academy of Science
1963	New South Wales Division’s Committee for Preservation of Areas of Geological Significance
1966	Geological Monuments Subcommittee formed in the South Australian Division
1970	Geological Conservation Subcommittee formed in the Victorian Division
1972	Subcommittee on Preservation of Important Geological Sites (Or “Geological Monuments”) formed in the Queensland Division
1974	Convener appointed for a new Federal Committee for the Preservation of Geological Monuments
1974	Publication of the “Report of the National Estate” including extracts from submissions made by the GSA Federal Committee and Divisions
1974	Letter from Chairman of the Interim Committee on the National Estate, “to ask if the Society would assist in compiling a list of geological monuments deserving preservation and protection”
1974– 1975	First Annual Report of the Federal Committee for the Preservation of Geological Monuments. Contacts with Divisional Subcommittees, the Chairman of the Interim Committee of the National Estate and other groups
1975	Australian Heritage Commission Act 1975 in June 1975
1975	National Estate grants to the Queensland and South Australia Divisions
1976	Australian Heritage Commission (AHC) established in July 1976
1975	At the 25th International Geological Congress in Sydney, New South Wales, a series of informal lunchtime meetings of Divisional subcommittee conveners arranged by Federal Convener
1977	Symposium on “Geological Conservation in Australia” at the Second Australian Geological Convention at Monash University, Melbourne, and a seminar on “The Future of Geological Conservation in Australia”. A definition of “Geological Monuments” is adopted
1977	AHC grants to Divisions in New South Wales, Victoria, South Australia, and Western Australia for 1977/78 and 1978/79
1977	AHC sets up State evaluation panels to consider submissions made to the Register of the National Estate, including geological sites
1978	Report on “Geological Conservation in Australia — Progress and Problems in 1978” with reports from Divisions, at the Third Australian Geological Convention in Townsville, Queensland
1980	“Geological Conservation in Australia and Overseas with a Selected Bibliography” — Appendix B by Joyce (1980) in Joyce and King (1980), noting the need for “a national programme” and “a survey and report on geological features of the National Estate in Australia as a whole”
1980	A meeting of representatives of Geological Monument Subcommittees and others at the Fourth Australian Geological Convention in Hobart, Tasmania
1982	First Workshop on “Geological Conservation in Australia” in Canberra in November. After discussion of the need for an Australia-wide survey, the meeting concluded with an unanimous agreement to work towards a list of features of International and National importance, with an application to the AHC for funding to hold a Second Workshop and publish a report on the listing
1983	Conference abstracts at the Sixth Australian Geological Convention held in Canberra, including a report from the AHC, Divisional reviews, a report on the first workshop in November 1982 and poster displays. Meeting No. 1 of the Standing Committee for Geological Monuments
1983	Typescript report by E. B. Joyce on the Workshop on “Geological Conservation in Australia” held in Canberra in 1982
1984	Australian Heritage Grant of \$5,000 to run a second workshop and prepare a report on geological features of National and International significance in Australia
1984	Second Workshop held in Canberra on 21–23 May and document “Interim Analysis” tabled. Meeting No. 2 of the Standing Committee
1984	Address by Standing Committee Convener on “Geoscientists and Government” at Seventh Australian Geological Convention at Macquarie University, Sydney, in August
1985	Report on Second Workshop held in Canberra in 1984
1986	Conference papers at 8th Australian Geological Convention at Flinders University, South Australia
1986	Publication of report by Cochrane and Joyce on “Geological Features of National and International Significance in Australia”
1988	Conference papers at 9th Australian Geological Convention at Brisbane, Queensland
1990	Report to Council for 1988–1989, including a discussion of John Cowie’s UNESCO Working Group on World Heritage and his listing of sites for Australia

Table 1 (continued)

1991	First International Symposium on the Conservation of Our Geological Heritage held from 11–16 June 1991 in Digne les Bains, France, and attended by Maud McBriar and P. Hasenohr who presented a paper on their Australian work and in his absence a further paper by E. B. Joyce
1991	UNESCO World Heritage Working Group Task Force meeting in Paris, France, February 1991. List of Australian sites for Global Inventory of Geological and Fossil Sites (GILGES) presented by Joyce
1992	Conference papers at 11th Australian Geological Convention at Ballarat, Victoria. Call for a debate and the development of an appropriate policy for the Society
1992	GSA Policy on “Geological Heritage in Australia” published (see Legge and King 1992). A definition of “Significant Geological Features” given
1993	AHC grant of \$27,000 from the AHC to run workshops and prepare a report on assessing the significance of geological heritage in Australia
1993	Second International Conference on “Geological and Landscape Conservation” held in Malvern, UK, with presentations by six GSA members
1995	Reports by GSA to AHC—“Assessing the significance of geological heritage: A methodology study for the Australian Heritage Commission” (Joyce 1995) and “A Classification of Geological and Geomorphological Features (Grimes 1995)
1996	“Australian Natural Heritage Charter”, AHC with Australian Committee for IUCN
1996	AHC workshop on “Pattern & Processes — Towards a Regional Approach to National Estate Assessment of Geodiversity” (see Joyce 1997)
1996	Conference papers on geotourism at the 13th Australian Geological Convention, Canberra—first mention of geotourism in Australia?
1999	Review article by Joyce, “Different thinking: The oldest continent” published in <i>Earth Heritage</i> 12
2001	“An assessment of progress made towards the nomination of Australian geological sites having national or international significance” for the AHC (Yeates, vols. 1 and 2)
2003	“Landscape and geological heritage”—a Baragwanath seminar sponsored by GSA heritage workers, The University of Melbourne
2003	“Conservation and Heritage, registering sites of significance”. Chapter in book “Geology of Victoria”, a GSA publication
2004	Conference paper on “Landscape, history and heritage: linking earth and human history in the landscape” at 17th Australian Geological Convention, Hobart
2005	Conference paper on “Geosites of Australia: preparing an inventory and framework for the Global Inventory of the IUGS”. IV International Symposium ProGEO on the Conservation of the Geological Heritage, Braga, Portugal. First application of term “geosites” to Australia
2006	Seminar on “History and Heritage” at GSA Australian Earth Science Convention meeting in Melbourne, Victoria, and two field trips. Paper by Joyce (2006b) included discussion of geosites, geotourism and geoparks
2006	Kanawinka Geopark—application to UNESCO for Global Geopark Status (Volcanoes Discovery Trail Committee 2006)
2008	“Geological Monuments in South Australia”, GSA and Government of South Australia (published as a DVD)
2008	Conference papers by members of GSA and AHC at Inaugural Global Geotourism Conference, ‘Discover The Earth Beneath Our Feet,’ Fremantle, Western Australia, 17–20 August 2008
2008	Kanawinka Global Geopark approved as Australia’s first geopark in June
2009	Conference papers at the International Association of Geomorphologists meeting in Melbourne, Victoria, in July, with two field trips

apparently in the state of Western Australia, with a report by the W.A. Subcommittee of the Australian Academy of Science in 1962 (see note in Joyce 1980). New South Wales formed the first GSA committee, and a Geological Monuments Subcommittee was initiated in South Australia under Maud McBriar in December 1966; Victoria and Queensland followed soon afterwards (Table 1).

Swart (1994) reviewed the conservation and management of geological monuments in South Australia, describing five sites of different significance and protection, ranging from the highly significant Ediacara Fossil Reserve, under threat of over-collection due to its remoteness, to the small fossil site of Horse Gully on private land effectively under the control of the landowner.

Correspondence and visits to the UK by Maud McBriar of South Australia and other Australian workers helped provide new ideas. In the mid-1970s, with the aid of government grants, programmes of identifying, documenting, evaluating and recommending management of sites began across Australia (see historical review in Joyce 1994c). Joyce (1980, 1995b) provides further details of work in Australia, as do papers from two international conferences, the first held at Digne in France in 1991 and the second at Malvern in the UK in 1993 (McBriar 1991; McBriar and Hasenohr 1994; Joyce 1994a, b).

Douglas (2006) has recently published a theory of geological heritage concentrating on three landscapes in Australia—Adelaide’s Hallett Cove, inland South Australia’s

Lake Callabonna Fossil Reserve and the World Heritage listed Willandra Lakes of western New South Wales. Once thought of as “wasteland, desert, forsaken, degraded, unproductive and isolated”, such features have now become “world renown” or “classic ground”. Douglas points to an evolving methodology of geological heritage in Australia, citing the work of the GSA and the AHC. An extensive bibliography on heritage and geology in Australia is included.

In discussing the geoparks movement in Australia, Douglas (2006), p. 275, contrasts the utilitarian approach, to preserve sites, educate and support sustainable development for tourism and job creation, with an aesthetic and culturally connected approach.

In her conclusion, Douglas (2006) notes that geological heritage in Australia can be hard to divorce from tourism, politics and nationalism and that landscapes may need more than their geological significance to be celebrated and gives as an example the World Heritage nomination of the Willandra Lakes, which had to harness archaeology, patrimony, landscape aesthetics and cultural heritage to ensure the preservation of important features.

Growth of Geological Heritage Work in Australia

By the 1970s, each GSA Division had an active subcommittee, with work being carried out in each of the six states and also the Australian Capital Territory and Northern Territory.

The establishment of the National Estate Grants Program in 1973 and the AHC in 1975 provided the first of a long series of Australian Government grants for the study of features of Australia’s National Estate and nomination of these to the then newly established RNE (Table 1). Grants totalling more than \$320,000 over the next 25 years resulted in more than 30 substantial volumes of documentation (Joyce 1995c).

The state-based GSA subcommittees each developed their own approaches to heritage studies. Some produced overall inventories in one volume while other systematically worked across their state producing a series of volumes. Some volumes were printed in hundreds of copies and distributed and sold widely, while others were only in a few reference copies; for example, in South Australia, only 16 copies of each report were printed, but with photocopies of appropriate sections sent to selected state government and local government bodies. A list of reports by the subcommittees and the Standing Committee is given in Appendix 5 in Joyce (1995b). A full list of “Geological Monuments in South Australia” (Parts 1 to 9, with details of 432 sites) has recently been issued on DVD (Hiern and Cowley 2008). Some subcommittees have made many nominations to the RNE in Canberra, while others have made few. Where state registers

are available, they have sometimes been used to register geological sites.

Books and leaflets on local geology, including geological heritage information, have been produced in Queensland and other states (Joyce 2007). Recent guidebooks sponsored by GSA on scenery in National Parks in southern Queensland are part of a series prepared and published by the Queensland Division of the Geological Society of Australia. For the recently declared World Heritage area of the Blue Mountains in New South Wales, a 34-page A4 colour booklet has been prepared by the New South Wales Department of Mineral Resources, in conjunction with the Geological Society of Australia, New South Wales National Parks and Wildlife Service and the University of Sydney.

The major icons of central Australia, Uluru and Kata Tjuta, listed as World Heritage in 1987, have a detailed geological account as the first in a number of publications by the Australian Geological Survey Organisation (now Geoscience Australia). This series includes the relatively newly recognised Bungle Bungle Range, in the East Kimberley of Western Australia, only proclaimed as the Purnululu National Park in 1987. With GSA as a sponsor, a guide for the World Heritage area of Kakadu and Nitmiluk National Parks, in the Northern Territory of Australia, was published in 2000 and covers rocks, landforms, plants and animals, the Aboriginal culture of the region and the effects of human impact.

Standing Committee for Geological Heritage

A Standing Committee of the GSA was established in 1974 under Dr. Colin Branch (Joyce 1994c) to help with the exchange of ideas between the seven subcommittees operating at that time—Queensland, New South Wales, Australian Capital Territory (with Northern Territory), Victoria, Tasmania, South Australia and Western Australia. Later, the formation of a separate GSA Division in the Northern Territory, and so a new subcommittee, brought the number of subcommittees to eight (Fig. 3).

In 1992, a policy prepared by the GSA laid down plans for the Standing Committee’s work, including its relationship to the subcommittees (Legge and King 1992). The main objective of the Standing Committee for Geological Heritage is to promote the understanding and conservation of the geological heritage of Australia. As a professional society, GSA can promote and assist with conservation and management, but not readily or directly pay for or maintain such work (GSA’s experience with early signs in Tasmania shows how this can be a problem). Such work must remain in the hands of government organisations such as the AHC, National Parks and Forestry departments, as in Tasmania.



Fig. 3 Standing Committee for Geological Heritage, GSA Inc., meeting in Adelaide in July 2002. Maud McBriar (South Australia) in front in red jacket, Bernie Joyce, retiring Convener of the Standing Committee, second from left at rear, and Susan White (Victoria), incoming Convener of the Standing Committee, front left (photo: Jim Painter)

The GSA's role continues to be helping with such work by providing information and expert advice.

The policy also clarified the GSA's role in relation to World Heritage activities. The Standing Committee through its convener is responsible for providing advice to the Executive or Council of the GSA in response to requests on information about World Heritage matters from the Australian Government. The history of the Standing Committee has been reviewed by Joyce (1994c) and a related timeline published (Joyce 2006a); see also Table 1.

Methodology Used in Geological Heritage Studies in Australia

Initially, GSA subcommittees in each state of Australia independently developed methods of identifying, documenting and determining the significance of a geological heritage site or feature. The AHC also developed methods of assessing significance, from local or regional to national or international level, for the RNE, building in part on the expertise of the GSA subcommittees. The AHC approach to the classification and assessment of natural sites, using a detailed set of criteria, in turn exerted its influence on Society work. Techniques developed by the UK's Nature Conservancy Commission were also an important influence on GSA work in Australia. A review of early Australian geoheritage work and its background can be found in Joyce (1980).

In Australia surveys and inventories of geological heritage, various terms have been used, including "site", "feature", "geological monument", "place" and "area"—for example, the Queensland Subcommittee has used area and site, and South Australia refers to area, site and place. Some subcommittees have used the term "geological monument", for example South Australia.

Perhaps the term "feature" best covers geological heritage, combining as it does no particular connotation of size or extent and with the further idea of actively displaying something of geological or geomorphological interest.

A useful distinction may be made between a site and a feature (Joyce and King 1980 p. 154). A site is an area which may be large or small, but a feature shows an aspect of geology or geomorphology (such as a fossil locality, a type section, a landform or other geological feature) without itself necessarily having a particular extent.

In conservation work, the significance of geological features, or indeed any other things to be conserved, is generally thought of as lying along some scale from highly significant to of little or no significance, or as being divisible into two groups such as significant/not significant.

A detailed look at the basis on which significance is assessed shows that two approaches are used, whether consciously or not. These are the *representative* and the *outstanding* approaches.

In evaluating geologically oriented places, the relevant criteria set by the AHC are that the RNE should ultimately contain:

1. a representative list of the places which demonstrate the main stages and processes of Australia's geological history;
2. rare or outstanding natural phenomena, formations, features, including landscapes and seascapes.

The RNE can be called a "representative" list, but it should also be a comprehensive list and include all examples which are above the threshold of significance. This comprehensive listing reflects the fact that the RNE was intended to be an alerting device to assist decision making about all places with National Estate values to ensure that they are not adversely affected or destroyed through ignorance.

Each Australian state and territory GSA subcommittee also looked to some extent at the work of subcommittees in other parts of Australia. In two workshops sponsored by AHC and held in Canberra in 1982 and 1984, discussions were held between the subcommittees in an attempt to achieve some degree of uniformity in approach (Table 1). However, state and territory subcommittees continued largely to follow their own methods.

The two workshops, however, did lead to the preparation of a report on sites of international and national significance in Australia. This report summarised the approaches used up to that time by each GSA subcommittee and provided a consolidated list of Australian sites of international and national significance (see Table 2), drawn from published and unpublished subcommittee documentation (Cochrane and Joyce 1986).

Table 2 Number of sites of International and National Significance in each State/Territory of Australia, from Cochrane and Joyce (1986), p 37

	International	National	Total
State/Territory			
Queensland	1	21	22
New South Wales	3	18	21
Australian Capital Territory	2	1	3
Victoria	12	33	45
Tasmania	5	13	18
South Australia	18 (19)	32 (49)	50 (68)
Western Australia	23	28	51
Northern Territory	12	7	19
Australia	76 (77)	153 (170)	229 (247)

Note that for South Australia, some of the large and complex sites have been divided into sub-sites, and these data are shown in parentheses

In 1991, a list of 28 geological sites of possible World Heritage significance was prepared for the GILGES meeting in Paris in February 1991 by Joyce (1991)—see Table 3. Following discussion at that meeting, a revised list of 26 sites for Australia appeared in the report by Cowie (1991). A related but more detailed list of 16 sites also appeared in McBriar and Hasenohr (1994).

In Australia, a definition of *geological monument* had been adopted at the Second Australian Geological Convention held at Monash University in 1977. This definition was supposedly based on that in use by the Nature Conservancy Council. The adopted definition was as follows:

Geological monuments are those features of a region which form the essential basis of geological education, research and reference: the total network of geological monuments incorporates the minimum number of sites to adequately represent the Geology and Geomorphology of the region.

The Society's statement on policy (Legge and King 1992) recommended the use of the term *significant geological feature*, and the definition given (see also Joyce 1999) was:

Significant geological features are those features of special scientific or educational value which form the essential basis of geological education, research and reference. These features are considered by the geological community to be worthy of protection and preservation.

These two definitions emphasised the use of geological features in education and for scientific research and as reference sites, for example type localities and sections. The GSA's Heritage Policy detailed these principles further (see *Geological Society of Australia Inc.*).

A further review of the work of the GSA and the AHC in assessing the significance of geological heritage sites in Australia, from the local level to World Heritage, was published in 1994 (Joyce 1994b).

The term "significant geological feature" has not become widely used, but variants such as "sites of geological (and geomorphological) significance" and "important geological sites" are in use in Australia. The term "geological monument" is now less commonly used and not at all by the AHC and some GSA subcommittees. One problem arises when it is used for small features such as a road cutting, which do not fit the usual concept of monumentality. However, the term is sometimes retained, for example in South Australia, because of popular local usage.

In 1994, the GSA was commissioned by the AHC to prepare a methodology volume which would detail techniques for locating, describing, classifying and assessing sites and features of geological and geomorphological significance. As well as rock, mineral and fossil sites, this methodology was also to cover landforms, dynamic processes and viewpoints, including evaluating their vulnerability to natural and human activity. A grant from the AHC enabled GSA's Standing Committee members and other interested heritage workers to meet at a workshop in Canberra in 1994 and led to the preparation of a two-volume methodology report which was to assist with future geological heritage work in Australia. The assessment volume (Joyce 1995a) was prepared in limited numbers, but its contents are available on disk and CD and on the Web (see Joyce 1995a). The report includes a review of geological heritage methodologies used in Australia and overseas (Joyce 1995b) and a full list of heritage publications by the GSA to that time.

Geomorphological sites as well as geological sites can be classified using the methodology developed for the AHC by Joyce (1995a), and a geomorphological and landscape approach has been discussed further by Joyce (2003). Themes are also being considered for use in Australian heritage work (see below) and lend themselves to a landscape approach to heritage.

The early work of the GSA often concentrated on fossil and stratigraphic sites, particularly in road and railway cuttings, cliffs and quarry exposures, while also describing

Table 3 GILGES for Australia: extract from Joyce (1991), pp 2–4)

Australia

The following list of sites is based on detailed work carried out in Australia by regional subcommittees of the Geological Society of Australia Inc. over more than fifteen years.

The list was prepared on 12th December, 1990 in Canberra in discussions between Bernie Joyce, Federal Convener of the Geological Monuments Committee of the Geological Society of Australia Inc., and Wanda Filsell, Jo Mummery and Phil Creaser, of the Department of the Arts, Sport, the Environment, Tourism and Territories.

Since then Lake Callabonna has been added at the request of Maud McBriar, Convener of the S.A. Subcommittee.

All the sites in this first list are documented elsewhere for the Working Group use.

1. Devonian reef complexes and Gogo fossil fish sites, W.A.
2. Ediacara Fossil Reserve, S.A.
3. Koonwarra Cretaceous fossil locality, Vic.
4. Lake Acraman meteorite crater and related depositional sites in Bunyeroo-Brachina Gorge, Flinders Ranges, S.A.

Two separate localities.

5. Lake Callabonna, S.A.
6. Lord Howe Rise, N.S.W.

On World Heritage List

7. Macquarie Island, Tas.

Being nominated to World Heritage List

8. Mt Narryer and Jack Hills, W.A.
9. Naracoorte, S.A.

Major fossil vertebrate site in Victoria Fossil Cave.

10. Archaeal Microfossils and Stromatolites of the Pilbara, W.A.

Includes North Pole site.

11. The Raak and Boinkas of the Sunset Country, Victoria.
12. Riversleigh, Qld.

Cenozoic fossil sites

13. Shark Bay, W.A.

Being nominated to the World Heritage List

14. Uluru (Ayers Rock), N.T.

On World Heritage List

15. Undara Crater and lava tubes, Qld
16. Willandra Lakes, N.S.W.

On World Heritage List

Further possible sites—not proposed above—have been suggested by others.

17. Heard Island

Forms part of the Territory of Heard Island and McDonald Islands, and thus of the area recognised as Australian Territory. An oceanic island on the Antarctic plate. Suggested by Pat Quilty.

The largely Holocene cone of Big Ben is a currently active volcano, with a small lava lake at Mawson Peak, small cones along the coast, fringing moraine deposits, coastal plains, and outcrops of underlying Cainozoic limestone and volcanic deposits (based on LeMasurier and Thomson, 1990 pp.435–441).

18. Blue Mountains, N.S.W.

Suggested by Geoff Mosley, on several criteria including geological aspects of large-scale landforms, with major weathering and erosion processes,

Reference: Mosley, G. 1989. Blue Mountains for World Heritage, Colong Foundation for Wilderness.

19. Lake Eyre region, S.A.

Recommended by Maud McBriar, Convener of the S.A. Subcommittee. Includes the Cainozoic Fossil Reserve of Lake Palankarinna and Dalhousie Mound Springs.

20. Flinders Ranges, S.A.

Recommended by Maud McBriar, Convener of the S.A. Subcommittee. Includes many geological monuments, with a significant major Precambrian/Cambrian boundary site.

21. Hallett Cove Conservation Park, S.A.

Recommended by Maud McBriar, Convener of the S.A. Subcommittee,

Table 3 (continued)

Other sites given on Dr Cowie's lists but not already listed here are listed below.

22. Yea Limestone, Victoria
23. Wolf Creek Meteorite Crater, W.A.
24. Fraser Island and the Great Sandy Region, Queensland
On World Heritage List.
25. Nullarbor Plain, S.A. and W.A.
This is “probably the world’s largest single area of karst and the largest and most significant arid karst area” p.28 in Adrian G. Davey, 1986. Heritage Significance of the Nullarbor Plain Region in South Australia and Western Australia. Being prepared for nomination to World Heritage List.
26. Bungle Bungles, W.A.
27. Darwin meteorite crater, Tasmania
28. Bitter Springs.

geomorphological sites. The earliest report of GSA, in Queensland in 1976, described geomorphological sites such as the Undara Crater and lava tubes. Joyce and King (1980) listed “geomorphological” (landform, weathering/soil profile, process) as a “geological type” on their Keyword Index Sheet for data entry, and of the 199 “geological features” described in their Table 5, 104 are classified as “geomorphological” (Joyce and King 1980, p. 170). Cochrane and Joyce (1986) listed “geomorphic” as the second of 12 “geological types” to be used in the assessment of geological significance, and in their list of important Australian sites, 70 of 229 are landforms or landscapes.

A workshop on “Assessing Geological Heritage” (Pattern & Process—Towards a Regional Approach to National Estate Assessment of Geodiversity) was sponsored by the AHC in 1996 to discuss geological heritage issues, and the approach being used by the GSA was described by Joyce (1997).

Based on the methodology approach discussed in Joyce (1994a, b) and elaborated in Joyce (1995a, b), the procedure can be referred to by the acronym IDEM, and summarised as Identification (of a site or feature of possible significance), Documentation (of its details), Evaluation (assessment of its geological significance) and Management (recommendations for protection and conservation).

Sites or features are classified as a “geological type” or “geomorphological type”, for example stratigraphy, rocks and minerals, fossil and palaeontology, karst, glacial and so on (Joyce 1995a). They can be representative of a group of similar sites, or they may be classed as outstanding. Assessment is carried out by a committee whose members have a wide range of geological experience and expertise. Sites or features are assessed at a level of significance, ranging from local, through regional, state, national, to international (see discussion in Joyce 1995a).

Further discussion of the concepts of sites, features, significance, geological monuments and significant geological features can be found in Joyce (1995a, b), pp. 15–18 and Appendix 1. The most recent discussion of the current

procedure and protocol for the documentation and assessment of geological heritage sites in Australia is by White and Mitchell (2006).

Independent of work by the GSA, a group of government geomorphologists in Tasmania began in the early 1980s an approach to geoconservation which emphasised geomorphology, soils and landform processes (Houshold and Sharples 2008). These workers suggested that such aspects were not encompassed properly in the work of the GSA across Australia. However, the criticism in Houshold and Sharples (2008) that the GSA had initially ignored geomorphological sites and processes is not accepted. Nor can it be claimed that soil sites had been neglected by the GSA. In 1977, the Australian Society of Soil Science Inc. (ASSSI) published a report by its Standing Committee for Reference Soil Sites, established in 1970 (Soil Reference Sites 1977), and suggested a cooperative approach with GSA. In informal discussions, the ASSSI agreed with the GSA that they would be responsible for a planned set of Australia Soil Reference Sites, with future GSA inventories only referring to soils where they formed part of a soil and regolith feature, as exposed in a cliff, quarry or road cutting, or across a broad landscape, and so could be considered of geological significance and described as part of a geological site or feature. Unfortunately, the ASSSI does not have a current programme of soil reference sites (Richard MacEwan, 2009, personal communication) although government, state and national web sites do include data on soil reference sites.

In a similar way, mining heritage sites in Australia are assessed by organisations other than the GSA. The Institution of Engineers Australia has a National Committee on Engineering Heritage which deals with mining sites, and in the State of Victoria, Heritage Victoria has recorded over 3,000 gold mining sites on the Victorian Heritage Register. The Australasian Institute of Mining and Metallurgy also has a Heritage Committee which aims to foster knowledge about the heritage of the mineral industry among members

and the public and to identify and encourage conservation of significant sites, documents and objects. Again, this work does not overlap with that of the GSA.

The most recent discussion of geological heritage work in Australia can be found in Brocx (2008). The author is a geological heritage worker in the Western Australia Division of the GSA in Perth, Western Australia, undertaking a systematic inventory-based approach to the geoheritage of Western Australia for planning and management. Chapter 5 (pp. 81–116) gives a historical review of initiatives and principles that underpin the conservation of geoheritage significance in Australia, and a discussion of “Milestones in geoconservation in Australia” includes a diagrammatic timeline (cf. Table 1, this paper).

A discussion of legislation affecting geoconservation and of the Australian Heritage Commission and its criteria follows, and the chapter concludes with comparative case studies in the Australian states of Tasmania, the Australian Capital Territory and Western Australia, with Chapter 6 providing a further case study of the Pilbara Coast of Western Australia. The book focuses on Western Australia and does not include recent work in Australia on geotourism or geoparks.

Gray (2004), pp. 249–254, described the GSA’s work on geological heritage in Australia, especially in South Australia and Victoria. Gray discussed the criteria used by the AHC to assess geological features and sites for the RNE and the methodology developed for the AHC by Joyce (1995a), and he compared the work of the GSA with the work done by Tasmanian Government departments, discussing a Code of Practice they have developed in Tasmania. Finally, he discussed organisations such as the National Trust which are also interested in geological sites and features across Australia.

The report by Rosengren (1994a, b) on the volcanoes of Victoria is an example of the landscape-related work carried out by the GSA with the Victorian section of the National Trust. Further examples are given in Bird and Joyce (2006).

The term “geosite”, as discussed earlier, is suggested here as most appropriate for the items in current Australian databases which are now to be made available for future use in geotourism and geoparks.

The result of GSA’s work is that Australia has for many years been recognised both within Australia and internationally as a leader in the field of geological conservation (see Table 1 and Geological Society of Australia Inc.).

Heritage Registers

When the AHC was set up by the Australian Government in 1975, one of its tasks was to compile a Register of the National Estate. This was to include *places* of natural,

historic and Aboriginal heritage which should be kept for present and future generations. The GSA’s heritage sub-committees soon became regarded by the AHC as expert nominators to the RNE (Creaser 2008). A total of 691 geological sites are currently on the Register.

Several Australian states also have heritage registers. In South Australia, natural sites, including geological sites, can be listed on the “State Heritage Register”, but in Victoria, the register grew out of an historic buildings register; so far, only archaeological sites and shipwrecks have been added, and geological sites normally cannot be registered.

The National Trust of Australia consists of largely independent organisations in each state, and while mainly concerned with historic buildings and related heritage such as gardens, state National Trusts may also study and classify landscapes, including their geological aspects, and include these landscapes on their registers (Bird and Joyce 2006).

Some other Government-Sponsored Geological Heritage Studies

In Victoria, a major government-sponsored study by Davey and White (1986) evaluated the significance of caves and karst in the state, and regional studies by Rosengren over many years provided geological and geomorphological account of much of the state; these data are now being transferred into GSA databases. Other reports, such as those by the AHC and state governments for regional assessment in Western Australia, Victoria and Queensland (see Joyce 1995b), will also be made use of.

In Tasmania, the Forestry and Parks and Wildlife agencies of the Tasmanian Government have developed a methodology which includes geomorphological and soil features (Dixon et al. 1997), and a Tasmanian Geoconservation Database is available on the web at <http://www.dpiw.tas.gov.au/inter.nsf/WebPages/LBUN-6TY32G?open> (see also <http://www.dpiw.tas.gov.au/inter.nsf/WebPages/SJON-57W4FD?open>). Susan White, current Convener of the GSA’s Geological Heritage Standing Committee, has recently described the Tasmanian work and compared it with the work of the GSA (White 2008).

Australian Natural Heritage Charter

An Australian Natural Heritage Charter was funded by the AHC and published in 1996 (Australian Committee for IUCN 1996). It was based in part on the Australia ICOMOS Charter for the Conservation of Cultural Significance (‘Burra Charter’ of 1992), which provided guidelines for places with both natural and cultural values. The Natural Heritage

Charter provides standards and principles for the conservation of places of natural heritage significance. A “Natural Heritage Places” handbook published in 1998 provided further assistance in applying the Charter to determine significance and prepare conservation and management plans.

Australian Parks and Reserves, Including Geoparks

National parks in each Australian state and territory provide valuable protection and management for many geological heritage sites; indeed, the initial impetus for setting up such parks has often been their geological features and landscape values. National park status is also used to provide management of Australia’s numerous World Heritage areas, many of which are of geological and landscape significance, for example the Riversleigh and Naracoorte fossil areas (Joyce 1999). Other reserves which can provide some protection for geological sites include road reserves, water reserves, state flora and fauna reserves and in Victoria, for example, the small geological sites set up by the state Land Conservation Council.

However, few Australian park services employ or work with geologists, and management and interpretation is strongly biased towards biological and ecological aspects. Geological research including sampling is restricted in National Parks, and new geological work by exploration or mining companies is usually banned. There have been significant problems of management in World Heritage areas such as the Willandra Lakes (Fig. 4), and many National Parks are poorly funded and interpreted (Joyce 1999).



Fig. 4 Well-studied lunette and palaeolake floor of Lake Mungo, in the Willandra World Heritage Area, New South Wales, showing the 40,000 BP burial sites of the oldest human remains in Australia (photo: J. M. Bowler)

In Australia, the National Parks system is commonly a grouping of geological and geomorphological sites, landscapes and ecosystems to provide a convenient management area. The AHC has recently developed a “themes” approach to geological, biological and historic heritage sites (see below). There is a need for new groupings which emphasise geological and geomorphological sites, and the concept of “geoparks” can be usefully applied in Australia to such areas as the youthful Western Volcanic Plains of Southeastern Australia (Fig. 5), a closely settled agricultural region which in June 2008 was accepted as the Kanawinka Global Geopark and thus Australia’s first geopark (McKnight 2008; Joyce and Bröhl 2008; Lewis 2008). Such regions, generally not suitable for national parks, can provide useful groupings of geological sites for future geotourism (Joyce 2007).

Geoparks provide an interesting contrast in approach to national park areas, which are often promoted for their biotic rather than their abiotic (geological) values. In Australia, national parks are identified and managed by State or national governments, are relatively small, tightly defined and with management focused on protecting biodiversity, while in many respects, geoparks are the opposite (Creaser 2008).

The New Australian Government Approach to Heritage

The Australian Heritage Commission has now been replaced by the Australian Heritage Council, and from 1 January 2004, a new National Heritage List (NHL) of places with outstanding heritage values to Australia is being developed by the Australian Government. Places on the NHL will be protected under the *Environment Protection and Biodiversity Conservation Act* 1999 and later amendments.

Places on the NHL will highlight the major stories of Australia—the evolution of the land, the qualities of its people and the diversity of its culture. All Australians will be able to nominate places, but nominations will be sought from professional groups such as the Geological Society of Australia. The earlier RNE included many geological heritage sites, but this Register was frozen on 19th February 2007, meaning that no new places can be added or removed. It continues to be available online (<http://www.environment.gov.au/cgi-bin/ahdb/search.pl>).

After 5 years, there are now 100 properties on the National Heritage List, but only some 20 geological or geomorphological places. The Dinosaur Stampede National Monument in Queensland was one of the first three places to be listed on the National Heritage List in July 2004. Located at Lark Quarry Conservation Park, 110 km south of Winton in Central Queensland, the site features unique evidence of a dinosaur stampede with almost 4,000

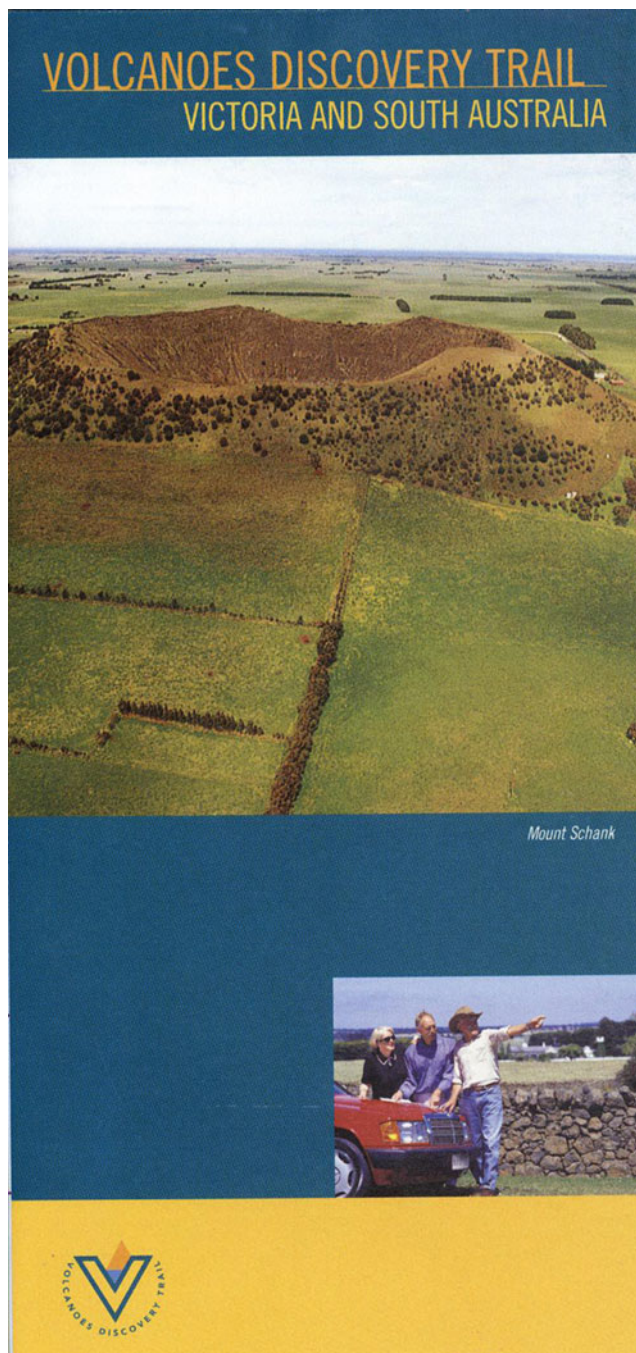


Fig. 5 The government-sponsored colour leaflet for tourist use promoting the Volcanoes Discovery Trail in the young volcanic regions of Western Victoria and adjacent South Australia, now the new Kanawinka Global Geopark

dinosaur footprints clearly visible in an area of just 210 m². Two archaeological sites, in the Budj Bim National Heritage Landscape, are part of the young Mt Eccles volcano and associated lava flows in southwestern Victoria, which are of geological heritage significance. Further fossil sites (Naracoorte, Riversleigh, Yea, Ediacara) have been now added, and World Heritage places such as the Great

Barrier Reef, Greater Blue Mountains, Kakadu, Purnululu, Uluru-Kata Tjuta, and the Willandra Lakes have also been included on the National Heritage List (<http://www.environment.gov.au/heritage/places/national/index.html>, 15th February 2009).

Use of “Themes”

The concept of themes—telling a story—is a recent AHC approach and is similar to concepts used by World Heritage. This approach can help link individual sites to the landscape, to processes past and present, and to cultural aspects across large areas. Two examples of themes are *The onset of aridity in Australia* (dry lakes and lunettes of the World Heritage area of the Willandra Lakes in New South Wales and desert dunes of the inland, for example the Simpson Desert) and *Young volcanicity and tectonics in an active Australian landscape*—volcanoes, lava flows and ash deposits of the last million years in Victoria and also in northern Queensland (Joyce 2003).

In February 2000, the author proposed to the AHC the further theme of *Gondwana glaciation*, covering Australia’s exhumed Permian landforms and the related evidence of glacial palaeoprocesses, leading to a new post-glacial landscape, and in turn followed by Australia and Antarctica rifting and moving apart. The story then continued with Australia’s slow movement northwards and new soils and regolith developing and being colonised by plants and animals, in isolation from other continents and through changing latitudes and climates, to a more recent link with Southeast Asia today.

The AHC also proposed in February 2000 several themes which could be used in future heritage work. Of geological relevance were the themes *Creation of the Australian Landscape* and *A Changing Land*.

In Australia, it is important for future geoheritage understanding to be able to explain to the public the story of the continent’s changing landscape—the marks left by the climate of the last Ice Age, the effects of aboriginal occupation, sea level change and European arrival. The present landscape should be linked to aboriginal dreaming and indigenous archaeology, to past and present climate, and finally to current and active landform changes (Fig. 6). Links can also be made to European eighteenth and nineteenth century exploration and finally to the understanding of the Australian landscape developed over the past 200 years through the experiences of early settlers, miners and farmers, builders and architects, gardeners and landscape planners, poets and painters, and musicians and writers.

The concept of themes proposed for use in future Australian heritage work is very similar to the concept of frameworks, as used in the “geosites” approach to heritage site listing.

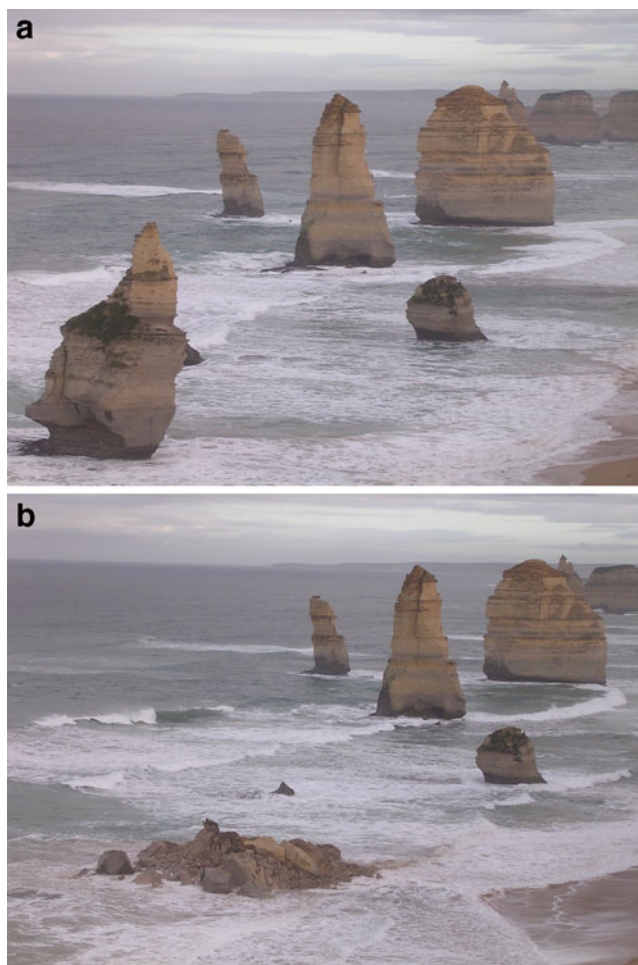


Fig. 6 The famous Twelve Apostles rock stacks developed in Tertiary marine limestone, Port Campbell National Park, Western Victoria, with active coastal erosion illustrated with before and after photos taken seconds apart at 9.16 A.M. on 3rd July 2005 (photos: Parks Victoria)

Recent Reviews and Evaluations

The AHC has commissioned an independent review of geological heritage sites in Australia, providing from its resources a list of sites to be investigated. A two-volume report has been prepared, listing, describing and evaluating sites of possible international and national significance. The first volume covered 198 Australian rock and landform sites (Yeates 2001a), and a companion volume (Yeates 2001b) provided a similar assessment for 150 fossil sites (Table 4).

Between 2005 and 2007, the AHC commissioned palaeontologists from seven state and territory museums to conduct a comprehensive comparison of outstanding fossil sites, in addition to a report that provided a comparison of the most important plant fossil sites nationally (Ambrose, personal communication). These eight documents were then peer-reviewed and edited to produce a

Table 4 Number of fossil sites in each State/Territory of Australia, from Yeates (2001b), p 150

New South Wales	52
Queensland	28
Western Australia	18
Northern Territory	14
Victoria	13
Tasmania	9
South Australia	9
Australian Capital Territory	0
Total	143
No of sites considered	150

single document, titled *Australian fossil sites for potential National Heritage Listing* (Cook 2007) and listing 70 sites. This draft report will enable strategic assessment of fossil sites for the National Heritage List by providing a shortlist of places that best demonstrate the evolution of Australia's biota.

The AHC also held expert workshops in 2006 and 2007 to establish a national framework for the assessment of important karst and pseudokarst sites. Results from both workshops will allow the effective comparative assessment of karst and pseudokarst sites around Australia and produced a shortlist of important sites that illustrate the range of karst and pseudokarst features in Australia, along with a strategy for further research (Ambrose and Douglas 2008).

Geotourism in Australia

In 1996, the GSA national conference was held in the national capital, Canberra, and two presentations were concerned with geotourism—perhaps the earliest mention of the term amongst the Australian geological community (see Table 1). Casey and Stephenson (1996) spoke from their practical experience and provided “tips and practical experience” on putting geology in tourism. They argued for the use of simple explanations of geology, avoiding the use of jargon, and they suggested including links to indigenous (aboriginal) legends and also making use of the public's interest in orchards and wineries. W. Mayer's 1996 paper discussed geology and tourism and suggested Australia was well suited to nature tours, for example in areas such as Kakadu and the Great Barrier Reef. Mayer (1996) also referred to geotours in the Hamersley and Pilbara regions of far northern Western Australia and argued that geotourism needed “small, compact, but well-illustrated guidebooks”; he suggested that GSA might help produce these (<http://vic.gsa.org.au/geotourism.htm>)

Geotourism, or tourism related to geological sites and features, including geomorphological sites and landscapes, can be seen as a new phenomenon and also a subset of geology and tourism. In the Australian context, the definition of geotourism has been explored, and a working definition of geotourism suggested: “people going to a place to look at and learn about one or more aspects of geology and geomorphology” (Joyce 2006b, c, 2007, 2008)

A recent book (Dowling and Newsome 2006) discusses geotourism across the globe, but unfortunately, the section on Australia fails to acknowledge the work of the GSA (see discussion in Joyce 2008), thus demonstrating the need to make databases of Australian geosites better known and more freely available.

In August 2008 the inaugural Global Geotourism Conference, ‘Discover The Earth Beneath Our Feet,’ was held in Fremantle, Western Australia, and several presentations reviewed the work of the GSA and the AHC over the past 40 or more years and its importance for future geotourism in Australia (Ambrose and Douglas 2008; Creaser 2008; Joyce and Bröhl 2008; Lewis 2008).

Future of Geological Heritage Work in Australia

- There is a need to review and update past state and national work in reports and files, now often 20 or more years old. This is particularly important when planning issues arise—any documentation must be able to stand up to close scrutiny.
- Databases of geological heritage information already online include the AHC’s Register of the National Estate and the National Heritage List, Victorian Resources Online and the Tasmanian Geoconservation Database. Other information is becoming available on CD and DVD, for example Hiern and Cowley (2008). More should be done.
- Future lack of national funding—new sources of funding other than the AHC must be found if work is to continue, and Australian workers must increasingly look to state or even local sources of support.
- As the Australian Government continues its current programme of devolving responsibilities to the states, heritage workers will need to increase cooperation with the states and begin making use of state registers.
- AHC’s National Heritage List of places with outstanding heritage values to Australia provides a new opportunity to record and help look after major geological heritage sites.
- World Heritage listing in Australia continues to grow, with the Blue Mountains in New South Wales a recent successful nomination. Australian geologists must play their part in seeing that geological heritage is fairly treated in the management and interpretation of current and new World heritage areas.

Current Listings of Major Geological Heritage Sites in Australia

A number of listings of the main Australian geological heritage sites have been prepared over the last 20 years.

1. Cochrane and Joyce (1986). This was the first report to list sites of international and national significance for all of Australia, with 76 international sites (see Table 2).
2. Joyce (1991). A list of 28 geological sites of possible World Heritage significance was prepared for the GILGES meeting in Paris in February 1991 (see Table 3). Following discussion at that meeting, a revised list of 26 sites for Australia appeared in the report by Cowie (1991). A related but more detailed list of 16 sites also appeared in McBriar and Hasenohr (1994).
3. Yeates (2001a, b). An independent review of geological heritage sites in Australia for the AHC listed, described and evaluated sites of possible International and National significance (see Table 4). A further development is the listing of major fossil sites by Cook (2007).
4. The current World Heritage List for Australia (UNESCO World Heritage List website) shows 17 properties, of which 12 are major geological sites (see Table 5).

Table 5 Current World Heritage Areas of Australia (downloaded from UNESCO World Heritage List website, 15th February 2009)

World Heritage Areas of Australia

There are 17 Australian properties on the World Heritage List at February 2009

1. Australian Fossil Mammal Sites (Riversleigh/Naracoorte)
2. Fraser Island
3. Gondwana Rainforests of Australia
4. Great Barrier Reef
5. Greater Blue Mountains Area
6. Heard and McDonald Islands
7. Kakadu National Park
8. Lord Howe Island Group
9. Macquarie Island
10. Purnululu National Park
11. Royal Exhibition Building and Carlton Gardens
12. Sydney Opera House
13. Shark Bay, Western Australia
14. Tasmanian Wilderness
15. Uluru-Kata Tjuta National Park
16. Wet Tropics of Queensland
17. Willandra Lakes Region

Of the 17 properties listed above, 12 are important for geological heritage, while numbers 3, 14 and 16 have some geological significance and 11 and 12 have none.

In summary, the various documents listing geological heritage sites in Australia suggest there may be a total of 100 or more sites of international significance, including rock, mineral, stratigraphic, landform and process sites, and fossil sites. The actual numbers in Yeates (2001a, b) are not clearly presented.

Comments by Yeates (2001a, b) also suggest that additional sites may need to be added to the current listings to approach a level of completeness. In particular, he suggests that further fossil sites may be needed, especially in some parts of Australia and for certain types and ages of fossils. Yeates (2001b) noted that documentation was not complete for many fossil sites, making assessment difficult. It is likely that further landform and process sites, including coastal, tropical savannah and weathering (regolith) sites in northern Australia, will also need to be added.

Finally, in a recent study for the Australian Government, expert workers selected and discussed ten fossil sites from each of Australia's seven states, giving a total of 70 sites. Some additional fossil sites were included in the related report compiled and edited by Cook (2007).

Where to Now?

The Geological Society of Australia and the Australian Heritage Commission have together been the main bodies concerned with geological heritage since 1975 (Table 1), and some 30 reports have been prepared covering most parts of Australia. Several summary reports have been prepared, and many sites have been listed on the RNE maintained by the AHC.

The independent review for the AHC of geological heritage sites in Australia (Yeates 2001a, b) covering rocks and landforms (volume 1) and fossils (volume 2) provides a starting point for a further review of past work.

To guide future studies, a new *framework* for listing geosites could be developed, appropriate for the geological history and features of Australia, as described in Wimbledon (1999a) and Dingwall et al. (2005). The use of *themes*, already begun in Australian heritage studies, could be an important aspect of the frameworks to be used.

An up-to-date listing of databases of Australian geosites should be made available. Such a database inventory will be of significant value to future geological heritage work in Australia and justify the work involved. The results could also be communicated to IUGS and UNESCO as a contribution to their priorities for conservation in the global context, including World Heritage.

To assist in this work, a web site has been set up through GSA (Victoria Division), which will be used to provide the

background to the proposed programme and begin developing and maintaining an index to current databases and also provide a list of all publications on geological heritage sites in Australia.

The URL is: <http://vic.gsa.org.au/geosites.htm>.

Locating and listing all available databases, developing them further and making them freely available is a necessary condition for the future of geotourism and geoparks in Australia.

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