The LINNEAN SOCIETY OF NEW SOUTH WALES

SYMPOSIUM on GEODIVERSITY, GEOLOGICAL HERITAGE and GEOTOURISM

Sea Acres National Park, Port Macquarie NSW
September 6-10, 2010

Principal Sponsors

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SYMPOSIUM ON GEODIVERSITY, GEOLOGICAL HERITAGE AND GEOTOURISM: Sea Acres visitor centre, Port Macquarie

PROGRAM

Monday September 6

9.30 – 11.00 **Registration** *(coffee and tea available from 10 am)*
11.05 – 11.15 **Welcome**: David Keith, President, Linnean Society of NSW
11.15 – 11.35 **DECCW overview address and book launch**
11.35 – 12.00 **Geology and landscape, people and resources – a perspective from within the Geological Survey of NSW**: Rob Barnes
12.00 – 12.20 **Geodiversity, Geoconservation and NSW parks**: Stephen Meehan
12.20 – 12.30 Symposium logistics: Ian Percival
12.30 – 1.30 *Lunch*

Afternoon technical session – chair: Ian Percival, Geological Survey of NSW

1.30 – 1.50 **Relationships between geodiversity and vegetation in south-eastern Australia**: David Keith
1.50 – 2.10 **DECCW remote sensed imagery resources – availability and potential application for geodiversity**: Jeremy Black
2.10 – 2.30 **Geophysics – a versatile method to explore geodiversity**: David Robson
2.30 – 2.50 **Mapping geodiversity using soil landscape maps**: Glenn Atkinson
2.50 – 3.10 *afternoon coffee/tea break*
3.10 – 3.30 **Coastal geoheritage of the mid North Coast, NSW**: Mitch Tulau
3.30 – 3.50 **Preservation of Rocky Beach, Port Macquarie NSW as a geoheritage reserve**: David Och
3.50 – 4.10 **Diversity within geodiversity, underpinning habitats**: Lin Sutherland
4.10 – 4.30 **Geodiversity of Barrington Tops – origin of the lava field**: Michael Bruce

Tuesday September 7 **Field excursion to Port Macquarie and Lorne Basin**

8.45 board bus at Pacific Drive, Sea Acres for 9.00 departure
5.00 return to Sea Acres

Wednesday September 8

Morning technical session – chair: David Keith, DECCW

9.00 – 9.20 **Australian geotourism – current challenges and future opportunities**: Angus Robinson
9.20 – 9.40 **Geotourism in Australia – perspectives from the field**: Carol Simpson
9.40 – 10.00 **Marine geotourism development at the Sapphire Coast Marine Discovery Centre, Eden NSW**: Anne Felton
10.00 – 10.20 **The Ulladulla rock platforms and their geological tourism potential**: Phil Smart
10.20 – 11.00 *morning coffee/tea break*

11.00 – 11.20 **Geology to the masses: Geotours via the Web**: Bob Brown
11.20 – 11.40 **Geodiversity of the Lightning Ridge area and the importance of geotourism to the region's prosperity**: Simone Meakin
11.40 – 12.00 **Geotourism and geodiversity at Wellington Caves, central western NSW**: Mike Augee
12.00 – 12.20 **The essential role of interpretive guiding in ensuring understanding and conservation of geosites**: Dan Cove
12.20 – 1.30 *Lunch*

Afternoon technical session – chair: Stephen Meehan, DECCW
1.30 – 1.50 **Is geotourism a threat to geoheritage?**: Monica Yeung
1.50 – 2.10 **Down the track: a review of older geoheritage projects in NSW**: John Pickett
2.10 – 2.30 **The 'Pagodas' of the Greater Blue Mountains, geoheritage just out of waiting**: Haydn Washington
2.30 – 2.50 **Landforms are not static – geodiversity and geoheritage in a changing world**: Stephen Swabey
2.50 – 3.10 *afternoon coffee/tea break*
3.10 – 3.30 **The Tasmanian Geoconservation Database**: Michael Comfort
3.30 – 3.50 **Rocks, reserves and refugia – conserving Australia's national heritage through the Great Eastern Ranges Initiative**: Gary Howling
3.50 – 4.10 **The NSW Reserve Establishment Plan 2008 – directions for building a diverse and resilient system of Parks and Reserves under the National Parks and Wildlife Act**: Rob Dick
4.10 – 4.30 **A thematic assessment of the geodiversity of NSW**: Stephen Reilly

Thursday September 9 **Field excursion to Kempsey and South West Rocks**

8.45 board bus at Pacific Drive, Sea Acres for 9.00 departure
5.00 return to Sea Acres

Friday September 10

Morning technical session – chair: Mike Augee, Linnean Society of NSW
9.00 – 9.20 **The National Heritage List and Australia's geological heritage**: Anthony Whalen
9.20 – 9.40 **A catalogue of Australia's fossil heritage**: Kate O'Callaghan
9.40 – 10.00 **Wee Jasper–Lake Burrinjuck Fossil Fish Sites: nomination for National Heritage Listing**: Gavin Young
10.00 – 10.30 *morning coffee/tea break*
10.30 – 10.50 **Palaeontological geoheritage in Australia: is the Paleopark concept the solution to combining preservation and education?**: Ian Percival
10.50 – 11.10 **A tool-kit for use in assessing geoheritage values and in geoconservation: a case study using the Leschenault Peninsula and its leeward estuarine lagoon in south-western Australia**: Vic Semeniuk
11.10 – 11.30 **Geoheritage conservation in NSW: lessons from the past and prospects for the future**: Armstrong Osborne
11.30– 12.00 Discussion and wrap-up

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SYMPOSIUM ABSTRACTS

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MAPPING GEODIVERSITY USING SOIL LANDSCAPE MAPS

Glenn Atkinson
ex DECCW Kempsey, glenn.atkinson@aapt.net.au

The concept of 'geodiversity units' was developed by Osborne, Docker and Salem (1998) to facilitate place classification and gap identification of geoheritage features. They define a 'geodiversity unit' as "*land that exhibits particular and related geodiversity characteristics (eg. geological/geomorphic history, rocks, landscape, soil, hydrology etc.)*". Geodiversity units enable predictions of where places with particular types of geoheritage significance are likely to be found. This definition of geodiversity unit is remarkably like that of a 'soil landscape', as has been extensively mapped by DECCW in NSW, viz: *a "repeating pattern of soil and landforms resulting from a common geological and geomorphic history".*

Soil landscape descriptions document and interpret the diversity of landform elements within a mapped unit and their related soil variability. Soil landscape maps can be used to identify many geodiversity attributes of an area by delineating important landform features and soil forming processes including the effects of climate, biota, topography, parent material and time. A typical 1:100 000 Soil Landscape map may document over 50 different soil landscapes displayed on the map in colour groupings named after the dominant land-forming processes acting within an area. These will be elaborated on in the paper.

Reference:
Osborne, R.A.L, Docker, B. and Salem, L. (1998) Places of Geoheritage Significance in New South Wales Comprehensive Regional Assessment (CRA) Forest Regions. NSW Department of Urban Affairs and Planning, Sydney.

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GEOTOURISM AND GEODIVERSITY AT WELLINGTON CAVES, CENTRAL WESTERN NEW SOUTH WALES

Michael L. Augee
Wellington Caves Fossil Studies Centre, 89 Caves Road, Wellington NSW 2820

Throughout the world cave tours were probably the first, and for a long time the only, organised geotourism activities. Today they are still the major geotourism activity. This is unlikely to change in the forseeable future. Therefore it is appropriate to include the concept of geodiversity into cave tours and related activities. This is an important part of the tourist experience at Wellington Caves. Geology of the karst

and surrounding landscapes is included in guide training, and inspiring an interest in geological processes is seen as an important part of guiding.

Caves are just one part of a larger reserve or property, and there will always be opportunities to make use of the diverse geology outside the cave. At Wellington this is based on fossils. Limestone exposures on the Reserve contain a number of Devonian marine fossils. A fossil trail has been constructed and a free pamphlet is available for self-guided walks. Features relating to plate tectonics and mountain-building are included in this pamphlet.

A new walk dealing with surface karst features is being prepared. That will provide another opportunity to increase the diversity of the cave visit.

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GEOLOGY AND LANDSCAPE, PEOPLE AND RESOURCES – A PERSPECTIVE FROM WITHIN THE GEOLOGICAL SURVEY OF NEW SOUTH WALES

Robert G. Barnes
Chief Geoscientist – Minerals, Geological Survey of NSW, Maitland

The settlement of Australia has been a function of landscape and climate. Climate has played a dominant role, but geology has determined many of the ways humans interact with the physical environment including the location of towns and cities, and the dominance of particular land uses including agriculture, forestry and mining and conservation reserves. The landscape we now see has evolved as the most recent expression of the complex geological history which has formed our continent.

Geological history is recorded primarily on geological maps and the Geological Survey of NSW has been systematically mapping since 1875. Geological maps combined with geophysical surveys provide a vast amount of information on the characteristics of rock sequences. Knowledge of geology underpins predictions of a range of physical outcomes including soil types and fertility, distinctive landforms, and the probability of sequences containing mineral deposits.

Almost 30,000 mineral deposits and occurrences representing a wide range of deposit types and commodities are recorded in NSW. Knowledge of deposit geology allows the recognition of geological tracts capable of hosting additional mineral resources. This knowledge can improve planning and inform land use recommendations – for example a land use which may preclude mining would be better located in an area where mineral deposits were unlikely to occur.

Knowledge of geological history can also guide our understanding of possible outcomes resulting from climate variation. Mapping of coastal areas has revealed a dynamic environment and major changes of sea levels in the relatively recent geological past. In inland areas, surficial material (regolith) is extensive and records a vast transport of material across the western slopes and plains and drying of major river systems. Geodiversity is captured in geological maps and records but apart from major scenic sites, this diversity is poorly known or appreciated. Through geological eyes you can read the landscape, and interpret the distant past and also gain vital insights into current land capabilities and uses.

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A TOOL-KIT FOR USE IN ASSESSING GEOHERITAGE VALUES AND IN GEOCONSERVATION: A CASE STUDY USING THE LESCHENAULT PENINSULA AND ITS LEEWARD ESTUARINE LAGOON IN SOUTH-WESTERN AUSTRALIA

Margaret Brocx[1] and Vic Semeniuk[2]
[1]Department of Environmental Science, Murdoch University, WA 6150
[2]V & C Semeniuk Research Group, 21 Glenmere Rd, Warwick, WA 6024

To place geoheritage and geoconservation on a robust footing, a "tool-kit" has been developed firstly to define the scope of geoheritage in order to develop a comprehensive inventory of geological/geomorphological features in a given area, the scales at which geoheritage features can be identified, and the levels of significance that can be assigned to such features, and secondly to identify geoheritage features from small scale to large scale that occur as an inter-related suites in a given area that should be conserved as an ensemble. The Leschenault Peninsula, a retrograding dune barrier in south-western Australia, and its leeward estuarine lagoon provide a case study of the application of this tool-kit. This is because the dune barrier and its estuarine lagoon contain a wide variety of geological and geomorphological features ranging in macroscale to microscale, and varying in significance from international to State-wide. Along a coast normally dominated by offshore islands and onshore cuspate forelands, the barrier-and-lagoon system is unique in Western Australia. Some of its key features include: an active parabolic dune landscape, retreating on its seaward edge and encroaching into the lagoon to landward; an interface between dunes and estuary that is the most complex sedimentologically, hydrologically, and ecologically in the State; a stratigraphy that records a complex Holocene sea level history; a retreating seaward edge that is recorded by parallel ridges and bands of submerged stranded beach rock; and a thin sheet of calcrete forming in the zone of capillary rise.

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GEOLOGY TO THE MASSES: GEOTOURS VIA THE WEB

R.E. (Bob) Brown
Geological Survey of New South Wales, Armidale

Bob and Nancy's Geological Tour Site (http://ozgeotours.110mb.com) is a web-based source of freely downloadable geological and landform tours. The web site was established in 2007 as a hobby conducted in personal time and self-resourced. The tours have been developed for the layman, with a minimum of geoscientific jargon and stratigraphic names. The site currently includes 21 tours, with one in preparation, and a number of proposed tours in planning. The web site and tours are co-developed by Dr Nancy Vickery and Adjunct Professor Paul Ashley of UNE. Most tours are situated throughout northern and northwestern NSW and four tours have

been developed in both north and south islands of New Zealand. One tour is hosted for a tourist group in northern Tasmania. Several tours in the Milparinka-Tibooburra-Broken Hill region, Lightning Ridge, Tamworth and Bingara were compiled after direct requests. These tours were produced on a *gratis* basis, which is a fundamental principle of Ozgeotours as a means of encouraging the spread of geotourism.

The successful deployment of freely available, self-drive geotours has proven immensely popular, both as downloads from Ozgeotours, and from tourism offices. Many tours have been professionally reprinted by tourism groups as glossy handouts available from their offices. The benefits to local tourism are very apparent to those organisations dispensing our tours, with a high demand for the tour guides.

By making colourful, simple, and interesting guides available to the general public it is hoped that the role of geology and geological processes in our continent will be clarified to people otherwise unaware. We hope that our tours will help to overcome the pervasive correlation of geology with mines, and the endemic lack of appreciation of the rock types and processes which formed Australia and are ongoing at present. Ultimately, we hope that we can play some role in elevating the status and teaching of geoscience in primary and secondary schools, and amongst the general public.

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GEODIVERSITY OF BARRINGTON TOPS – ORIGIN OF THE LAVA FIELD

Michael C. Bruce
Geological Survey of New South Wales
WB Clarke Geoscience Centre, Londonderry NSW 2753

The Barrington Tops lava field is located partly within the National Park of the same name, and partly within State Forests north of the Hunter River Valley and west of Gloucester in eastern NSW. Geological mapping of the southern Barrington Tops lava field has resulted in the recognition of 33 basaltic flows each 10-20m thick. These flows are separated by either an agglomerate (phreatomagmatic flows) or by sub-horizontal palaeosols (passive flows). Petrography and whole-rock geochemistry reveal basanites are the most abundant volcanic rocks in the stratigraphic sequence, with subsidiary alkali basalts, pyroxene-phyric basalts (ankaramites) and tholeiites. Alkali gabbros also occur as intrusions near the top of the sequence and represent conduits from which the lava reached the surface. Modelling of major and trace elements from the alkaline magmas reveal a co-genetic relationship, which is chiefly controlled by a low pressure olivine + plagioclase mineral assemblage. Incompatible trace elements are consistent with low degree melting of an enriched mantle source with some evidence of entrained amphibole-enriched sub-continental lithospheric mantle. A third, more depleted mantle component that produced the tholeiites may also have been involved. These petrological findings and the number of flows recorded are consistent with observations of previous authors in the north-western part of the lava field, and support the established model for evolution of the Barrington Tops volcano. High erosion rates have contributed to valley reversal and

led to the current geodiversity of the area, with a range of geomorphological features (derived from relic volcanological relief modified by ongoing erosion) supporting a diverse suite of floral and faunal communities. Such diversity is underpinned by the geology and in particular the lava field, which in addition to shaping the natural landscape, provides fertile soils and is the source of gem-quality sapphires, zircons and rubies.

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THE TASMANIAN GEOCONSERVATION DATABASE

Michael Comfort
Department of Primary Industries, Parks, Water and Environment, Hobart, Tasmania

The Tasmanian Geoconservation Database (TGD) is a source of information about earth science features, systems and processes of conservation significance in the State of Tasmania. It evolved when a number of sources were compiled as a single geoconservation digital dataset as part of the National Estate component of the 1997 Commonwealth-Tasmanian Regional Forest Agreement. The latest version of the TGD (version 7) was published in 2010 and lists some 1049 sites ranging in scale from individual rock outcrops and cuttings that expose important geological sections, to landscape-scale features that illustrate the diversity of Tasmania's geomorphic features and processes. Prior to endorsement for listing on the database, nominated sites are reviewed by an independent reference group comprising earth science specialists. Sites occur both on public and private land tenure though there is a bias towards public lands as these areas have generally been better surveyed for geoconservation features. The TGD is accessible to the public through Departmental websites. It is used as a planning tool in land management and in assessing development proposals at various scales. Under Tasmania's three major environmental codes of practice, the TGD must be consulted and certain actions are prescribed where a TGD site is present. A limitation of the database is that it lists sites of known significance, but is not based on a comprehensive State-wide inventory of geoconservation values, and the absence of identified values at a particular location may reflect gaps in the database rather than as conclusive evidence that geoconservation values are not present. Development of the database is ongoing and currently the site sensitivity and classification fields are undergoing major revision. As resources become available, it is hoped to conduct more comprehensive thematic surveys to identify potential new sites for inclusion in the TGD.

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THE ESSENTIAL ROLE OF INTERPRETIVE GUIDING IN ENSURING UNDERSTANDING AND CONSERVATION OF GEOSITES

Daniel Cove
Jenolan Caves Reserve Trust

It is an unfortunate reality that an automatic love of the natural world and a desire to see it protected is not instinctive to the majority of individuals. This does not suggest that the majority of the population are malicious or desirous of causing harm to the environment, rather that there is no instinctive appreciation of the fragility of one's surrounds and the ease with which they may be irrevocably altered and damaged. Such an appreciation may be reached and indeed it often proves very easy to cultivate. However recognising this need to educate and foster understanding and appreciation in individuals does place an onus on the managers, custodians and guides of significant sites. Any commitment to conservation requires public support, and this support requires a public that feels a connection to the values of the environment in question. One extremely effective means of achieving this is through well planned and delivered interpretive guiding, and highly trained guides.

The importance of interpretive guiding is of special relevance to geosites, as geodiversity has a generally lower popular perception of potential fragility than does biodiversity. This problem is often due to the extreme duration of the physical processes involved, and thus a view that geosites are timeless. Visitors to limestone caves are often genuinely surprised when asked to refrain from touching calcite formations, as the concept that a person touching a rock is damaging can be a very difficult one to grasp. The on-site experience can be the single greatest factor in establishing a long-term connection to both the site and the broader associated environment and therefore the quality of the guide and the guided experience are of enormous importance.

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THE NSW RESERVE ESTABLISHMENT PLAN 2008 - DIRECTIONS FOR BUILDING A DIVERSE AND RESILIENT SYSTEM OF PARKS AND RESERVES UNDER THE NATIONAL PARKS AND WILDLIFE ACT

Rob Dick
NSW Department of Environment, Climate Change and Water, Hurstville

The NSW Reserve Establishment Plan 2008 was released by the NSW State Government in July 2008. It provides a guide to policies and planning priorities for growth of the terrestrial NSW public reserve system established and managed under the NPW Act and outlines long-term quantitative reservation goals and broad directions for ecosystem and landscape-scale reservation priorities for the next decade for natural, cultural and geological heritage. These include poorly reserved ecosystems and habitats, including those threatened by climate change; new conservation nodes: areas that conserve a range of ecological communities and

cultural values and provide a focus for the later addition of smaller areas, habitat connections and supporting conservation arrangements on nearby private and public lands; wetlands, floodplains, lakes and rivers; critical landscape corridors which facilitate the movement of plants and animals in response to landuse and environmental changes; lands within important water catchments; culturally important places; places of geological significance; and areas which are important for the effective and efficient management of existing reserves. The Plan identifies the importance of a well-planned and managed comprehensive established reserve network in providing a very strong buffer to the effects of climate change.

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MARINE GEOTOURISM DEVELOPMENT AT THE SAPPHIRE COAST MARINE DISCOVERY CENTRE, EDEN NSW

E. Anne Felton
Sapphire Coast Marine Discovery Centre, PO Box 239, Eden, NSW 2551

Marine geotourism is a niche area of geological tourism that is being developed at the Sapphire Coast Marine Discovery Centre (SCMDC) in conjunction with the Centre's coastal and marine biology displays and outdoor activities.

The Far South Coast of NSW is a hotspot of marine biodiversity partly due to the seasonal influences of the warm Eastern Australian Current and the cool waters of the Southern Ocean. The region is also a hotspot of marine geodiversity. A specially commissioned DVD and a series of thematic posters introduces the SCMDC's visitors to the region's marine and coastal environments and their interdependence on geology and oceanography. Professionally qualified staff and trained volunteers engage visitors in discussion about the material presented. A tsunami demonstration graphically illustrates the destructive power of tsunami. We use this demonstration to introduce general safety issues for beachgoers and rock fishers. The indoor offerings are complemented by beach visits, rocky shore rambles and guided snorkel tours.

The region's spectacular coastline is a superb natural laboratory where visitors can observe how diverse bedrock types and dynamic ocean processes shape sandy beaches, estuaries and rocky shoreline geomorphic features. Recent seabed mapping in and around Twofold Bay offers the opportunity to show that geology doesn't stop at the shoreline. The diversity of bedrock types allows us to demonstrate the links between geology, undersea landscapes, and the habitats that support marine ecosystems.

The SCMDC is well-placed to offer marine geotourism experiences to increasing numbers of international visitors. Our region, Australia's Wilderness Coast, is one of eight National Landscapes being promoted overseas by Tourism Australia. Cruise ships visit Twofold Bay each summer, bringing international visitors to our doorstep. In conjunction with local boat and aircraft operators, we are planning for a range of adventurous marine geotourism field trips for all who wish to experience and learn about the Wilderness Coast.

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DECCW REMOTE SENSED IMAGERY RESOURCES- AVAILABILITY AND POTENTIAL APPLICATION FOR GEODIVERSITY

Richard Hicks[1] and Jeremy Black[2]
[1]Remote Sensing and Land Assessment Section; [2]Imagery and Spatial Information Services,
Scientific Services Division, NSW DECCW

Over the last four years, NSW Department of Environment, Climate Change and Water has significantly expanded the acquisition and application of remote sensed imagery. In addition to whole state collections of Landsat for multi-epochs back to 1988, the Department has purchased multi-year collections of SPOT5 multispectral data for whole state (2004/05, 2007/08, 2008/09) and in partnership with NSW Land and Property Management Authority, incorporated their digital aerial imagery (Leica ADS40) and LiDAR capture programs.

The imagery underpins a number of key government programs for native vegetation monitoring and general natural resource management programs.

This presentation will describe the range and availability of the imagery with DECCW and NSW government and the new infrastructure being implemented to support the expanded role imagery is now taking within the organisation.

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ROCKS, RESERVES AND REFUGIA – CONSERVING AUSTRALIA'S NATIONAL HERITAGE THROUGH THE GREAT EASTERN RANGES INITIATIVE

Gary M. Howling, Ian F. Pulsford and Robert Dunn
NSW Department of Environment, Climate Change and Water, Dubbo

The Great Eastern Ranges Initiative spans more than 2,800km of eastern Australia, making it one of the longest continental scale biodiversity conservation efforts in the world. The Initiative involves more than 100 community, conservation, industry and government organisations working together to link existing public conservation reserves and private land efforts, creating a 'connectivity conservation corridor' along the eastern ranges from central Victoria to the Atherton Tablelands and beyond. The great eastern ranges contain the most biologically diverse landscapes on the continent – they span the greatest altitudinal sequence, the longest potentially connected latitudinal variation, and the most reliable rainfall on which a wealth of plants and animals depend. Protecting and managing the region's diversity and its critical contribution to the environmental, social and economic security of the Australian continent will require a deeper understanding and appreciation of how the diversity of geology, landscapes and associated land uses found in the ranges have contributed to this critical part of Australia's national heritage.

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RELATIONSHIPS BETWEEN GEODIVERSITY AND VEGETATION IN SOUTH-EASTERN AUSTRALIA

David Keith
NSW Department of Environment, Climate Change and Water, Hurstville

The soils produced by weathering of geological substrates vary greatly in levels and proportions of mineral nutrients, and in their structural characteristics that govern their capacity to retain moisture and conduct subterranean oxygen. Different plant species vary in their ability to extract and tolerate extreme levels of these three essential resources. At biogeographic scales, geological substrates are thought to play a key role in the evolution of Australian ecosystems and their biota, due to the widespread occurrence of old soils with impoverished levels of nutrients and the comparatively restricted occurrence of fertile soils.

This study uses a spatially explicit approach to examine the relationship between vegetation and geological substrates over New South Wales, a region of 80 million hectares in south-eastern Australia spanning a diverse range of geology, vegetation and climate. The spatial data were drawn from maps produced by geological and vegetation surveys. Geological maps were re-classified into 16 broad units reflecting textural and mineral characteristics considered likely to be influential on plant growth. Vegetation maps were re-classified in 16 broad formations reflecting structural, physiognomic and functional characteristics of vegetation, and into a larger number of 100 classes reflecting species composition. The two spatial data sets were analysed to determine the diversity of vegetation types within geological units and fidelity of each vegetation type to each geological unit. The influence of climatic co-variables was also examined using spatial surfaces spline-fitted to long-term weather station data. The results indicate a strong non-random relationship between vegetation and geology. While none of the vegetation formations was restricted to a single geological unit, the occurrence of each was limited to a small number and none were distributed across all 16 geological units. Some of the 100 vegetation classes showed unique associations with geological units, indicating that relationships are scale-dependent. These relationships appeared to be mediated by climate, which also plays a strong role in vegetation distribution. Consistent with current theories, sclerophyllous vegetation formations and classes showed a strong association with geological units characterised by low levels of mineral nutrients.

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GEODIVERSITY OF THE LIGHTNING RIDGE AREA AND THE IMPORTANCE OF GEOTOURISM TO THE REGION'S PROSPERITY

N. Simone Meakin
Geological Survey of New South Wales, Maitland

The Lightning Ridge region displays rich geodiversity which makes it unique globally. Low ridges of weathered Cretaceous marginal marine sedimentary rocks stand proud of an extensive floodplain of Cenozoic alluvium (including 'sand monkeys') and low dunes, forming distinctive landscapes which exert strong influence on fauna and flora distribution, and which were first appreciated by the Aborigines. Hot artesian waters supply local bore baths.

Though best known as the only place in the world which produces commercial quantities of high quality and extremely valuable black opal, it is also world-renowned for hosting a diversity of opalised fossils, including invertebrates, reptiles, mammals and dinosaurs. At several sites, Cenozoic silcretes preserve impressions of fossil plants in great detail. About 100 km SSW of Lightning Ridge, at Cuddie Springs, remains of extinct megafauna are found in association with Aboriginal tools, making it one of Australia's most significant prehistoric sites. Numerous Aboriginal sites are also scattered around the ridges and along waterways.

Over 100 years of mostly small-scale opal mining at Lightning Ridge has resulted in modified landscape on the ridges, including numerous historic workings and equipment which are rarely preserved elsewhere. This valuable record of Australian mining history has been recognised as such by the declaration of a zone of 'Preserved Fields'. These areas in particular record our geoheritage and are of interest to tourists, historians, scientists and artists.

Geotourism is intimately linked with opal-mining and the lure of the landscape and its characters, and indeed is a growing source of income to the region, on par with documented sales of opal itself. It has the potential to ensure the prosperity of the region long after the opal resources are exhausted.

Managing such a diverse region presents a challenge, as the broad range of stakeholders sometimes have conflicting objectives. A whole-of-government approach is therefore vital in ensuring sustainable development of the region.

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GEODIVERSITY, GEOCONSERVATION AND NSW PARKS

Stephen F. Meehan
Manager, Karst and Geodiversity Unit, Bathurst
NSW Department of Environment, Climate Change and Water

The Karst and Geodiversity Unit of the NSW Department of Environment, Climate Change and Water (DECCW) was established in July 2006 and has the primary aim of protecting, conserving and promoting the karst and geodiversity values of NSW parks. The formation of the Unit is indicative of a growing community awareness of the role of geodiversity in supporting ecological systems and

processes, which have typically been viewed in isolation. More importantly perhaps, it recognises that geodiversity, like biodiversity, has the potential to be lost or degraded due to human activity and as such, will often require active management.

A key challenge for the DECCW and more specifically, the Karst and Geodiversity Unit, is to ensure that geoconservation principles are fully and appropriately considered in planning and management processes. Consequently, the education of relevant officers to better understand the role of geodiversity in the broader conservation paradigm is considered a high priority. It is equally important that decisions in relation to planning or management processes are well informed and supported by the full range of stakeholders.

Recent DECCW initiatives such as the development of a Karst Resources Database, the undertaking of a Geodiversity Gap Analysis and the publication of the Geologic Fact Sheet Series and Guide to NSW Karst and Caves, are proving beneficial in raising staff and community awareness of geodiversity and the related concept of geoconservation. 'Geo-networks' consisting of representatives from the public and private sector and community, are proving equally valuable, yielding important information on known or potential geoheritage sites.

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A CATALOGUE OF AUSTRALIA'S FOSSIL HERITAGE

Kate O'Callaghan and Kirsty Douglas
Department of the Environment, Water, Heritage and the Arts, Canberra ACT

The National Heritage List was created in January 2004 to recognise, celebrate and protect places of outstanding natural or cultural heritage value to the nation. National heritage encompasses those places that reveal the richness of Australia's extraordinarily diverse natural heritage. One aspect of this natural heritage that has, as yet, been little explored is Australia's wealth of exceptional fossil sites. While a small number of fossil sites have risen to public prominence, there are many lesser-known sites that may be of outstanding heritage value.

Building on initial work to aid in the assessment of Australian fossil heritage sites for nomination to the National Heritage List, a publication showcasing Australian fossil sites is in development. Although it is by no means a comprehensive list, the catalogue provides information for more than 70 outstanding fossil sites across Australia.

This publication will provide a useful national reference to the outstanding fossils sites it catalogues, and give a clearer understanding of how the heritage values of such sites might be assessed. More generally, this publication will contribute to a greater appreciation of Australia's geological and fossil diversity and will enable readers to learn more about Australia's prehistory.

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PRESERVATION OF ROCKY BEACH, PORT MACQUARIE, NSW AS A GEOHERITAGE RESERVE

David J. Och[1] and Ian T. Graham[2]
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The Rocky Beach Metamorphic Melange is located at Rocky Beach, Port Macquarie on the mid north coast of NSW. It covers an area of just under 1 hectare and is locally bounded by the Pacific Ocean to the east, Oxley Beach to the north, Flynns Point headland to the south, and steep densely vegetated slope up to Pacific Drive which provides a buffer from the surrounding residential development on the western side of the road.

The 'melange-in-melange' structure preserved at Rocky Beach consists of a serpentinite mass that has invaded the Watonga Formation, enveloping two lenses of metamorphic rocks that consist of metre-scale phacoids of lawsonite eclogite, omphacitite and glaucophane schist embedded in a chlorite-actinolite schist matrix. This exposure has excellent formational contacts that demonstrate age relationships that are not observable for similar rock types elsewhere in Australia. The importance of this outcrop is the occurrence of rare high-pressure low-temperature metamorphic rocks. Globally, there are just ten recorded occurrences of lawsonite eclogite in Phanerozoic orogenic belts, with the Rocky Beach Metamorphic Melange being the only one documented in Australia.

The variety of ancient rocks and excellent exposures along this coastline together with their ready accessibility have attracted numerous geological visitors, including university undergraduate groups, geological conference excursions and international research scientists. Allocating a geoheritage reserve status to these rocks at Rocky Beach would help preserve them for future geology students, researchers and geotourists. As the rocks are rare and very limited in distribution, protection would be achieved with their declaration as an Australian geoheritage site. This would require anyone who requires samples for analysis to obtain necessary permission from the relevant authority. To allow for easy access to this site, a staircase would need to be constructed from the coastal walk to the beach below. Plaques describing the distinctive geology of this geological tourist trail (ie. Town Beach, Rocky Beach, Miners Beach and Tacking Point) would also help to promote geotourism in the Port Macquarie region.

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GEOHERITAGE CONSERVATION IN NSW: LESSONS FROM THE PAST AND PROSPECTS FOR THE FUTURE

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Geoheritage conservation has a history in New South Wales extending back into the mid 19th century. After much effort in the 1980s and early 1990s, by 2000 things in NSW were going backwards and sites were being damaged and lost, while at the same time a major and continuing blossoming of geoconservation and geotourism was occurring in Europe and North America. Recent progress with karst and caves, changes to the NPWS Act and establishment of the Karst and Geodiversity Unit within DECCW have heralded a new beginning for geoconservation in NSW. To successfully build on this we need to learn from the past here, from successes elsewhere particularly in Europe and from success in other areas of conservation, particularly archaeology and biodiversity. The key points, vital for future success, can be summarised in a few short maxims: preservation without management is death; fine words without legislative power are death; conservation requires a constituency; educate-inform-persuade-convince-conserve and all you need is jobs!

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PALAEONTOLOGICAL GEOHERITAGE IN AUSTRALIA: IS THE PALEOPARK CONCEPT THE SOLUTION TO COMBINING PRESERVATION AND EDUCATION?

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Australia has many examples of world-famous palaeontological sites, including the Flinders Ranges Ediacaran fossils of SA, the Kimberley region of northern WA with its Gogo fish and nearby Devonian reef, fish and plants (ancestral to the Wollemi Pine) at Talbragar in central NSW, the Lune River petrified fern site in Tasmania, the polar dinosaur locality of Victoria's Otway coast, Lark Quarry near Winton in Queensland with its unique dinosaur stampede, and the giant fossil birds of Alcoota in the Northern Territory, to name but a few. Western Australia even has a state fossil, and other states are considering candidates. New fossil discoveries, especially dinosaurs, are regularly highlighted in the media and attract considerable public interest particularly amongst school-age children. Yet the approach of various state jurisdictions to preservation of fossil sites varies considerably, ranging from minimal restrictions to strongly policed protective measures. Interpreting palaeontological localities for public education has, with a few notable exceptions, received little support from all layers of government and the private sector.

The PaleoParks initiative of the International Palaeontological Association may provide an Australia-wide mechanism whereby fossil sites that are not currently protected within conservation areas (such as World Heritage Sites and National Parks) are afforded some recognition. Unlike Geoparks, PaleoParks are not overseen by UNESCO, and do not have to comply with rigid guidelines for recognition. This concept is therefore ideal for fossil sites on both private and Crown Land where they can be administered by civic associations or local authorities. The approach taken to restrict access at these localities is entirely flexible – some would be suitable for public visitation (even limited collecting) with appropriate interpretation, whereas

access to other areas with high scientific values or more sensitive to damage may need to be closely supervised. Examples will be provided of Australian sites which would benefit from designation as PaleoParks.

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DOWN THE TRACK: A REVIEW OF OLDER GEOHERITAGE PROJECTS IN NEW SOUTH WALES

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In 1997 the Geological Survey of NSW, the National Parks and Wildlife Service and the School of Geology, University of Sydney launched a popular handbook entitled *Layers of Time: the Blue Mountains and their Geology*. This was accompanied by erection of explanatory plaques at selected sites of geological significance in the Blue Mountains, and the preparation of an extensive teaching aid kit for use in high schools.

A unique site at Little Bay in the Sydney metropolitan area incorporating Miocene estuarine sediments was declared a heritage site around 1990; the site was drilled and the results published. Planned redevelopment of the area formerly occupied by the Little Bay Hospital impinged significantly on the heritage value, and as a result, two blocks planned for domestic housing were set aside as reserve. A plaque was erected at these blocks, explaining the local geology and its significance.

After a period of some years the present condition and results of these endeavours are reviewed, and some suggestions for longer-term management of such sites put forward.

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A THEMATIC ASSESSMENT OF THE GEODIVERSITY OF NSW

Stephen Reilly
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Department of Environment, Climate Change and Water NSW

The New South Wales National Parks Establishment Plan 2008 (DECC 2008) identifies places of geological significance as one of the priorities for the building of the reserve system over the next ten years.

The Karst and Geodiversity Unit within the Department of Environment, Climate Change and Water is currently undertaking a project to assess geodiversity sites in NSW and their level of representation within the reserve system. The project involves categorising geodiversity into a number of themes and assessing the extent, significance and level of representation within reserves at a broad level. The assessment is being undertaken within a short timeframe using information sourced from published literature and databases with input from specialists in some fields.

A key goal of the project is to provide a succinct summary of the level of representation within reserves of key landform, geological, fossil and soil types. The results of the assessment are necessary to provide direction for future detailed assessments.

The presentation will discuss the project methods, challenges, considerations and status.

Reference
DECC 2008. New South Wales National Parks Establishment Plan 2008, Department of Environment and Climate Change NSW, Sydney.

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AUSTRALIAN GEOTOURISM – CURRENT CHALLENGES AND FUTURE OPPORTUNITIES

Angus M. Robinson
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Geotourism is a form of natural area tourism that specifically focuses on geology and landscape. It promotes tourism to geosites and the conservation of geo-diversity and an understanding of earth sciences through appreciation and learning. This is achieved through independent visits to geological features, use of geo-trails viewing points, guided tours, geo-activities and patronage of geosite visitor centres. The character of geotourism is such that it is geologically based and can occur in either natural, rural or urban environments. It fosters geoheritage conservation through appropriate sustainability measures and it advances sound geological understanding through interpretation. Tourists, seeking to have the natural environment interpreted for them, can expect explanations of geology as well as flora and fauna, creating a more holistic view of ecosystems.

However, in Australia, geotourism as currently defined is barely emerging and faces a range of challenges, which includes confusion with broader sustainable travel nomenclature as currently being used in the USA, lack of awareness and support within the geological professions and varying degrees of acceptance by park managers.

Overseas the promotion and marketing of geotourism is being accelerated by the development and growth of a global geopark network, but in Australia, this concept is yet to be supported by Australian government agencies because so far a framework for incorporating geopark concepts within Australia's federal system of land management is yet to be formulated, and its potential as a contribution to national GDP has not been recognised. To achieve broader acceptance, the backing of the geological professions is essential.

Geotourism has great potential as a new niche ecotourism product, but will require the same disciplines that apply to other niche, 'high value-added' tourism activities. The incorporation of the geotourism experience with traditional nature tourism and elements of cultural tourism represents a further move towards the 'experiential tourism' model.

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GEOPHYSICS – A VERSATILE METHOD TO EXPLORE GEODIVERSITY

David Robson
Chief Geophysicist and Team Leader Exploration Geoscience
Geological Survey of New South Wales, I&I NSW, Maitland

Geophysics is an intriguing scientific and technical field. It is an unusual blend of the theoretical and the practical, the laboratory and the field, and the nonprofit sector as well as the commercial venture. It is often overlooked as a tool for understanding geodiversity, but when combined with geological ground-truthing, geophysics provides a remarkably versatile means of viewing and visualising subtle differences between rocks on the surface and subsurface, as well as the regolith overlying them. Geophysics is a sophisticated, constantly evolving technology. Apart from mineral exploration and geological mapping, it is used to monitor the physics of the earth such as earthquakes, tsunamis and nuclear explosions, and to locate objects such as grave sites and unexploded ordnance. Recently, geophysics was instrumental in the discovery of HMAS Sydney (II).

In the 1960s and 1970s the Geological Survey of New South Wales embarked on a major program to map the state using regional airborne magnetic and gamma-ray surveys at an interline spacing of 1.6km. This provided the basis for establishing the 1:250 000 geology map series of NSW. As an integral component of the second-generation regional geological mapping program undertaken over the past two decades, higher resolution airborne geophysical surveys have been conducted at an interline spacing of 250m. Now 84% of the state has been surveyed and the higher resolution data can be used to clearly identify major volcanic belts and basins, significant faults, regolith/soil types and major drainage systems. The data now plays a pivotal role for both mineral and petroleum exploration, and also better informs decisions on land use planning and natural resource management.

My talk will include examples of a variety of geophysical images that depict the geodiversity of NSW, and demonstrate the utility and versatility of geophysics in recording the state's underlying structure, geological evolution, and present-day geomorphology.

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GEOTOURISM IN AUSTRALIA – PERSPECTIVES FROM THE FIELD

Carol Simpson
Geological Survey of NSW, Industry & Investment NSW, Maitland

The philosophy behind Earth Discovery Tours, which Chris Woodfull and I ran from 1992 to 1997, was to show people a wide range of natural landscapes and explain the geological processes that formed them. We were conscious of an earth sciences 'gap' in the education system that was at odds with growing awareness of our natural environment. The tours provided a grounding in geology, a better

understanding of the historical significance of mining in Australia and an awareness of the importance of geo-conservation. Our tour leaders were experienced geoscientists, capable of conveying complex geological research to lay-people. The target market was well-educated and well-travelled people, with disposable income, often retirees or empty nesters.

Earth Discovery Tours initially offered up to 12 short (1-3 days) tours per year to various geologically interesting parts of Victoria. Later, the emphasis changed to longer (1-2 weeks) tours, in collaboration with the University of Melbourne Alumni Association. Trips to Broken Hill, Lake Mungo, Flinders Ranges and Great Ocean Road were led by very experienced academic geologists.

Successful geotourism relies on the availability of high-quality geological maps and data, mostly provided by state geological surveys, which can be disseminated by tourist information centres and national parks. There are a large number of tourist sites within NSW that are already well set-up with high-quality geological information for tourists, for example, Broken Hill, Lake Mungo and the Age of Fishes Museum at Canowindra. Tour operators, however, should also be encouraged to look beyond these more obvious sites and take advantage of mapping conducted by the Geological Survey of NSW to conduct thematic tours of less well known parts of the state. Recent mapping completed by the Geological Survey of NSW in the Koonenberry, Manilla, Goulburn, Braidwood and Moss Vale regions of NSW provide many interesting sites that could be used in future geological-based tourism.

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THE ULLADULLA ROCK PLATFORMS AND THEIR GEOLOGICAL TOURISM POTENTIAL

Phil Smart
Southern Shoalhaven Fossil Walks Project, Ulladulla and Districts Community Forum Inc.

The abundance and quality of Permian fossils at Ulladulla has long been recognized by geologists. Rock fishermen and local residents also couldn't help but notice the fossils on the rock platforms but few understood their geological significance. Until last year they remained a largely untapped scientific and educational resource visited by only a few university and school groups. However, in March 2009 the fossils made the front page of the local paper with a local Councillor's call for the introduction of a Fossil Walk in the Harbour to increase tourism to the area. Until then the geological tourist potential of the rock platforms and their abundant fossils had been completely overlooked.

By October it was agreed to conduct a pilot program of Guided Fossil Walks on the Harbour rock platforms during the summer holiday season. With the logistical support of the local Lions Club, 16 guided 3-hour Fossil Walks were conducted for groups made up of mixtures of local residents and visitors of all ages from 5 years to more than 80. More than 400 participated in the Walks which were so successful that the last 7 were fully booked out days in advance.

Already, Geoscience Australia has become the major "in-kind" sponsor of this innovative geological tourism venture and initial funding of $40,000 has been allocated for the project in the Shoalhaven City Council's budget.

Plans for the development of geological tourism in Ulladulla include: a dedicated web site linked to GAs site; 30,000 glossy leaflets and appropriate signage to support the Guided Walk and Fossil Discovery Trail for school groups; a 500 million year "Walk Through Geological Time in the Southern Shoalhaven" rock garden in a harbourside park; and a spectacular fibreglass 3-D geological/terrain model with suitable vertical exaggeration to cover 1000sq km of the region including Pigeonhouse Mountain.

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DIVERSITY WITHIN GEODIVERSITY, UNDERPINNING HABITATS

Frederick L. Sutherland[1] and Benjamin E. Cohen[2]

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New South Wales National Parks and State conservation areas lie in diverse geological settings. One major geological component includes prominent, eroded Cenozoic shield volcanoes, which formed in a similar manner to the Hawaiian Island volcanoes. The NSW volcanoes either represent basaltic shields with central cores of silicic rocks or more simple basaltic shields.

The former provide biological refuge areas at Tweed, Ebor-Dorrigo, Nandewar, Warrumbungle, Comboyne and Canobolas. These volcanoes decrease in both age and size southwards due to deep geodynamic processes. This leads to systematic habitat variations. The largest, most eroded Tweed volcano (23-25 million years old) provides contrasting lava aprons, erosional caldera rims, basement valley floors, and an isolated central peak. Further south the central shields show progressive reductions in such features, so that the southernmost Canobolas shield (11-13 m.y.) retains a more complete profile without marked internal habitat contrasts.

The simpler basaltic shields are represented in Barrington Tops National Park, where a plateau of lava flows 50-60 m.y. old is embayed by deep valleys rimmed by escarpments, forming a variety of habitats. Similar basaltic shields lie in National Parks elsewhere, e.g. Mummel Gulf and Ben Halls Gap, but fertile basalt soils mostly prompted agricultural development. Another basaltic shield, well offshore, forms Lord Howe Island, a World Heritage Site and NSW State Marine Park. The only part of this 6-7 m.y. old edifice that remains above sea level is a mountainous caldera lava fill, but its wide submarine-bevelled flanks support fringing coral reefs and diverse marine habitats.

The volcanic shields mark regions of related rocks, soils, and landforms that are spread across coastal escarpments, highland divides and inland surfaces. These differing landscapes underpin biodiversity preserved in NSW parks and conservation areas. The eroded volcanic landforms also form scenic landscapes and provide a platform for comparative biological research and geo-education/geo-tourism.

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LANDFORMS ARE NOT STATIC – GEODIVERSITY AND GEOHERITAGE IN A CHANGING WORLD

Stephen Swabey[1], Dingle Smith[2], Andy Spate[3] and Dave Lambert[4]
[1]Umwelt (Australia) Pty Ltd; [2]formerly of Centre for Resource and Environmental Studies, ANU;
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Landform geodiversity and geoheritage values are affected by rates of rock surface lowering. Surface lowering may be controlled by natural processes or by human interference. However, precise long-term observations of changes to landform surfaces are rare.

Micro-erosion meter (MEM) sites are installed in various geomorphological and climatic settings in Australia and in Antarctica. In NSW the sites include Kosciuszko National Park (NP); Jenolan Karst Conservation Reserve; Bouddi NP; Brisbane Water NP; Yengo NP; Ku-ring-gai Chase NP; and Mutawintji NP. In WA they include Tunnel Creek NP; Windjana Gorge NP; Geikie Gorge NP; and the Napier and Oscar Ranges.

Sandstone sites north of Sydney include archaeologically significant settings, such as aboriginal engravings and a rock shelter. The remaining sites are on limestone. Some sites indicate macro weathering of landscapes, while others are on individual landforms such as karst rillenkarren and kamenitza. Most of the sites were installed in 1978.

MEM installations were also made on limestone rocks obtained from four NSW locations and one Victoria location, placed in a paddock at Ginninderra, Canberra in 1979. These installations 'normalise' climatic effects on surface lowering rates.

Many sites recently have been re-examined for the first time in 18 years (limestone) and 24 years (sandstone). The highest rate of sandstone surface lowering experienced was about 10 mm in 32 years (~310 mm in 1,000 years) at the Daley's Point rock shelter. Lowering rates in sandstone containing engravings are between 10 mm and 50 mm in 1,000 years.

Rates of karst landform lowering vary widely, depending on the dominant geomorphological process. The highest rate was 94 mm in 1,000 years in a kamenitza. The limestone rocks at Ginninderra lowered by rates of about 3 mm to 5 mm in 1,000 years.

The rates of surface lowering observed here are significant for geodiversity and geoheritage management.

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COASTAL GEOHERITAGE OF THE MID NORTH COAST, NSW

Mitch Tulau
NSW Department of Environment, Climate Change and Water (Kempsey office)

This paper focuses on specific items of geomorphic interest and geoheritage developed in Quaternary materials along the Mid North Coast. In particular, many Quaternary coastal sand barriers and Holocene alluvial features are sites of both scientific and aesthetic interest. In scientific terms, the Mid North Coast provided

much of the data that were used to establish early models of Holocene marine transgression, with more recent discoveries helping to refine these. For example, recently acquired Light Detection and Ranging (LiDAR) data has been used at Lake Innes to support a case for higher mid-Holocene sea levels.

These findings may be corroborated by a palaeogeomorphological reconstruction of the Hastings River floodplain, supported by soil-landscape investigations and radiocarbon dating on the nearby Limeburners Nature Reserve, which establishes a radical rearrangement of the lower catchment in the mid-late Holocene.

Other examples of Mid North Coastal geoheritage that are significant for reasons of size, complexity, aesthetics or uniqueness are also discussed. However, despite the scientific and aesthetic interest attached to such sites, many remain unrecognised and unprotected by specific regulatory or planning instruments.

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THE 'PAGODAS' OF THE GREATER BLUE MOUNTAINS, GEOHERITAGE JUST OUT OF WAITING

Haydn Washington
Greater Blue Mountains World Heritage Advisory Committee

The 'pagodas' have been called pinnacles, stuppas and beehives. In the early '80s the name 'pagodas' applied by the Colo Committee stuck for these sometimes spectacular rock formations. They occur from Mt Wilson north through Newnes Plateau and the western side of Wollemi to Nullo Mountain. Mostly they are found at around 1000 metres but are located at 750 metres at Dunn's Swamp. The pagodas are visually spectacular, giving range to the imagination and inspiring names such as the 'Lost City' and the 'Temple of Doom'. They are of two types, the 'smooth' beehive shaped pagodas, and the 'platy' pagodas. The smooth pagodas are reminiscent of the conglomerate domes of the Budawangs on the NSW South Coast. The 'platy pagodas' are generally step-pyramid in shape, with regular ironstone bands 1-2 cm thick that occur every 40-60 cm for up to 50 metres height. Geomorphologists have noted that the pagodas are a distinct geomorphological unit. Their formation remains a matter of debate. Certainly it is tied in with iron chemistry and the movement of iron in solution through the coarse-grained Burra-Moko sandstone, where it precipitates out along bedding planes and cracks. The presence of iron-rich swamps in the landscape may play a role in the formation of the iron bands. The sandstone is then differentially weathered to form the pagodas.

While the National Trust proposed a Pinnacles Park in the 70s, it was not till the 1980s that the geoheritage value of the pagodas was slowly acknowledged. The Gardens of Stone National Park, created in 1994, covers only part of the pagoda formations protecting just 11,780 Ha. Threats to the pagodas come mainly from longwall coal mining, which can drop the surface 1.5 metres. The pagodas and the associated slot canyons of the Greater Blue Mountains remain ideal candidates for new geodiversity research.

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THE NATIONAL HERITAGE LIST AND AUSTRALIA'S GEOLOGICAL HERITAGE

Anthony Whalen, Rachel Sanderson and Jane Ambrose
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The Heritage Division of the Department of the Environment, Water, Heritage and the Arts has worked over the last five years to identify, document and present places which reveal Australia's geological history and the evolution of its biota. In 2003 amendments to the *Environment Protection and Biodiversity Conservation Act 1999* created the National Heritage List (NHL) to recognise, celebrate and conserve places of outstanding heritage value to the nation. A place has National Heritage value if it meets one or more of nine (a to i) statutory criteria covering historic, scientific, aesthetic and social value, including one specifically for places 'important as part of Indigenous tradition'. The threshold for NHL is very high, determined by rigorous comparative analysis of places across the continent. Good quality nominations are critical to the systematic recognition of geological heritage places. Strong, systematic justification of values and comparative analysis in NHL nominations are central to achieving this aim. This presentation will showcase successful National Heritage nominations for places with geological heritage values, explain the application of criteria and comparative analyses which are at the core of National Heritage assessment and seek feedback on a strategic approach to National Heritage listing of Australian geological heritage places.

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IS GEOTOURISM A THREAT TO GEOHERITAGE?

Monica Yeung[1] and Alex Ritchie[2]
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Geotourism started to take off in the 1990's but unlike Ecotourism this industry still lacks a "Code of Ethics". There is no doubt that fossils and pretty minerals are what attracts the masses, but Geotourism Operators need to be very aware of their potential impact on these sites. These days the wider population generally accepts that flora and fauna need to be protected for posterity, this understanding is still widely lacking when it comes to fossils and minerals (they are only dead rocks after all). Geotourism Operators need to be gentle educators! They need to interpret Australia's fossil and mineral wealth in their geological heritage context. Mineral and fossil sites should not be the primary focus of a Geotour Operator (with a few well controlled exceptions).

Geotour participants should go home with the following messages: 1) you cannot clone a fossil; 2) minerals don't just grow back overnight and 3) Geology underpins everything, from biodiversity to landforms, climate, marine science, soil

science, agriculture and food production, industry and all the have-to-have items in our lives today.

The Age of Fishes Museum Project is providing an interesting insight into the interaction between Geotourism and Geoheritage. As a fossil site it is unique in the world (nowhere else has such an extensive mass-kill site of complete Devonian fishes ever been uncovered), and for this reason it is fast becoming a popular tourist attraction. Like dinosaurs, the bizarre looking ancient fishes fire up the imagination of young and old and the fossil digs and other hands-on activities are very popular with visitors. The museum appeals to people specifically interested in geology and fossils as well as just about every other segment of the tourism market, including mass tourism. All this brings with it a very interesting set of management issues.

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WEE JASPER–LAKE BURRINJUCK FOSSIL FISH SITES: NOMINATION FOR NATIONAL HERITAGE LISTING

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The Burrinjuck area includes one of the NSW geological heritage sites (Taemas-Cavan) listed by Percival (1985). The Devonian fossil fish from Burrinjuck also compare to some World Heritage palaeontological sites in Australia and overseas. The Burrinjuck Devonian sedimentary sequence is some 5 km thick, and contains numerous fossil horizons encompassing the first terrestrialization of the earth's biota, and documents environmental change from a deep volcanic lake (oldest), through a tropical reef marine ecosystem, to river and lake deposits (youngest). The limestones of the Wee Jasper valley display one of the best known exposures of a Devonian tropical reef system, and have produced a fossil fish assemblage including uniquely preserved internal braincase structures for early vertebrates in a diversity of forms unequalled from any other fossil site in the world (Young 2008a,b, 2010). This is also the world's oldest known coral reef fish assemblage (Young 2009). Numerous associated invertebrate fossils (e.g. corals, bryozoans, stromatoporoids, brachiopods, gastropods, trilobites etc.) give a total of some 266 genera of vertebrate and invertebrate fossils documented so far.

The Burrinjuck area produced five key fossil fish specimens used in the 1940's in London to develop the acetic acid preparation technique (now standard in laboratories throughout the world for extracting fossil vertebrates from calcareous rock matrix). As a result two collecting expeditions to Burrinjuck by the British Museum (Natural History) in 1955 and 1963 resulted in some 560 specimens being removed to London. Repatriation of type specimens may be a future issue. Currently the largest collection of this unique early vertebrate braincase material is housed at the Australian National University. The long-term protection of this collection in the National Capital as part of Australia's natural heritage remains an issue of concern (e.g. Russell and Winkworth 2009).

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