GEOFEST
2024 SYDNEY WORKSHOP

PROGRAMME

18 - 20 July 2024

CONTENTS

1. Background & objectives

This international geotourism workshop is an Australian-Indonesian collaboration project as a post conference event of the 5th Geotourism Festival and International Conference hosted by the Indonesian Geoparks Network.

The theme of the workshop is 'Volcano as a World Class Sustainable Geotourism Destination'. It is open to scientists, educators, students, professionals, tourism planners, managers, operators, and anyone involved in nature tourism. The focus of the workshop is on 'Geotourism Strategy Development', featuring international speakers from Australia, Indonesia, and New Zealand. It will also include field trips to world-class geotourism areas close to Sydney. The workshop aims to raise industry awareness among attendees and provide a space to discuss new challenges and strategies in geotourism in both Indonesia and Australia.

2. Hosts & Sponsors

Hosts

Australian Geoscience Council (AGC)

Indonesian Geoparks Network (IGN)

The University of Sydney (USYD)

Sponsors

Sydney Mineral Exploration Discussion Group (SMEDG)

The Australasian Institute of Mining and Metallurgy & Sydney Branch (AusIMM)

Australian Institute of Geoscientists (AIG)

Geological Society of Australia (GSA)

3. Programme - Workshop 18 July 2024

Workshop Convenor: Dr Young Ng, Chair Working Group 6, National Geotourism Strategy (NGS) Steering Committee.

Venue: LT 101, New Law Building, The University of Sydney

Morning Session

07:45 - Registration begins.

Master of Ceremony: Dr Melinda McHenry, University of Tasmania and Chair Working Group 5, NGS Steering Committee.

09:00 - Welcome to the Country Ceremony.

09:15 - Welcome speech. Dr Jon Hronsky OAM, Chair of the NGS, Australian Geoscience Council (AGC).

09:20 - Opening speech. H.E. Ambassador Dr Siswo Pramono, Republic of Indonesia.

09:25 - *The AGC's National Geotourism Strategy: A Key Initiative to Grow the Opportunities for Geoscience in Australia.* Dr Jon Hronsky OAM, Chair of the NGS, Australian Geoscience Council (AGC).

09:45 - *The development of Natuna Geopark: a foreign policy perspective. H.E. Ambassador Dr Siswo Pramono, Republic of Indonesia.*

10:05 - *Ijen UNESCO Global Geopark: Impacts of Volcano Geotourism and Geopark on Economic Development for Banyuwangi Regency*. Ipuk Fiestiandani Azwar Anas, Regent of Banyuwangi, Banyuwangi Regency of East Java, Indonesia.

10:25 - Q & A.

10:35 - Tea Break.

10:55 – *The imperative of building sustainable tourism in regional and remote Australia: Cultural landscapes of volcanic tourism. Professor Phil McManus, School of Geosciences, The University of Sydney, Australia.*

11:15 - *Indonesian Geoparks Development: Managing Volcano Geotourism Destination to Sustain Local Communities.* Mohamad Farid Zaini, Chairman of the Indonesian Geoparks Network, Indonesia.

11:35 - Q & A + Panel discussion – *Geotourism and sustainable development* (All morning speakers, hosted by Dr Peter Mitchell OAM, member of the NGS Steering Committee & Dr Noel Scott).

12:20 - Lunch, Foyer, New Law Building.

Afternoon Session

13:30 - Beginning of afternoon session & housekeeping announcements.

13:35 - *Destinations and current development of volcanic geotourism in Australia.* Dr Patricia Erfurt, Research Scientist, Geotourism Australia.

13:55 - *Identified Roles of geoscientists in geotourism and geopark development in Indonesia.* Professor Mega Fatimah Rosana, Dean of the Faculty of Engineering Geology, Padjadjaran University in West Java, Indonesia.

14:15 - *Guiding and interpreting volcanic landscape in Far North Queensland, volcanic geotour organisation and challenges*. Russell Boswell, Manager, Savannah Guides, Cairns, Queensland, Australia. Vulcanism and Tourism in Tropical North Queensland.

14:35 - Q & A.

14:55 - Tea break.

15:15 - *Geotourism in the Waitaki Whitestone UNESCO Global Geopark, New Zealand.* Sasha Morriss, Geoeducator and Geoscientist, Waitaki Whitestone UNESCO Global Geopark, New Zealand.

15:35 - *Estimation of the social and economic impacts of geotourism of Gunung Rinjani National Park of Indonesia.* Dedy Asriady, Head of Genung Rijani National Park Office, Lombok, West Nusa Tenggara, Indonesia.

15:55 - *Harnessing digital technology for volcanic geotourism and opportunities for geoscientists.* Mark Williams, Geoscientist & Lecturer in Physical Geography and Spatial

Science at the University of Tasmania, Hobart, Australia and Chair Working Group1 of the NGS.

1615 - Q & A + Panel Discussion – *Geotourism opportunities for geoscientists* (All afternoon speakers and the Master of Ceremonies hosted by Dr Jon Hronsky OAM and Angus M Robinson, Coordinator of the NGS.

16:45 - Closing & housekeeping (dinner & fieldtrip arrangements).

16:50 - Campus Tour (School of Geosciences & The Quadrangle).

Welcoming Dinner

Venue: Cullen Room, Holme Building, Science Road, The University of Sydney.

18:00 – Reception.

18:15 – Welcome – Professor Phil McManus.

18:20 - Speech – Elizabeth Thurbon PhD, Professor of International Political Economy, School of Social Sciences, University of New South Wales, Australia.

18:45 – Indonesian Cultural Performance.

19:30 - Speech – Ipuk Fiestiandani Azwar Anas, Regent of Banyuwangi, Banyuwangi Regency of East Java, Indonesia.

21:30 - Function Ends.

4. Speakers

Dr Jon Hronsky OAM

Chair, National Geotourism Strategy, Australian Geoscience Council

Presentation title: The Australian Geoscience Council's National Geotourism Strategy: A Key Initiative to Grow the Opportunities for Geoscience in Australia.

Dr Jon Hronsky OAM is a senior Mining Industry geoscientist but is presenting here today in his role as the current chair of the Australian Geoscience Council's National Geotourism Strategy, a role he has held since the inception of this strategy by the AGC more than three years ago. He is a former Chair of the AGC and has long had a passionate commitment to the promotion of geoscience to the broader community. Jon is an Adjunct Professor at the University of WA. In 2019, he was awarded the Order of Australia medal for services to the Mining Industry.

Professor Phil McManus

School of Geosciences, The University of Sydney, Sydney, Australia.

Presentation title: The imperative of building sustainable tourism in regional and remote Australia: Cultural landscapes of volcanic tourism.

Phil is a Professor of Urban and Environmental Geography at the University of Sydney. His research interests include sustainable cities, regional development, Chinese tourism, urban infrastructure, and human-animal relations, particularly the thoroughbred breeding and horseracing industry. He is the author/co-author/co-editor of six books, including Chinese Tourism in Australia: Koalas, Selfies and Red Dresses (forthcoming 2024: Palgrave MacMillan) and Rural Revival? Place marketing, tree change and rural migration in Australia (2011, Ashgate). He has published over 100 journal articles, book chapters and reference works and has supervised 16 PhD students to completion as the Primary Supervisor. He serves on the Editorial Boards of Australian Geographer, Sustainability and Oxford Open Infrastructure & Health. Phil was President of the Institute of Australian Geographers (IAG) 2012-2014, President of the Geographical Society of NSW (GSNSW) 2014-2018, Head of School of Geosciences at The University of Sydney 2015-2019 and is currently a Vice President of the International Geographical Union (IGU) for the term 2022-2026.

Ipuk Fiestiandani Azwar Anas

Regent of Banyuwangi, Banyuwangi Regency of East Java, Indonesia.

Presentation title: Ijen UNESCO Global Geopark: Impacts of Volcano Geotourism and Geopark on Economic Development for Banyuwangi Regency.

Ipuk Fiestiandani Azwar Anas is the Regent of Banyuwangi for the 2021-2024 term, having assumed office on February 26, 2021. She was born in Magelang, Central Java, on September 10, 1974. Ipuk Fiestiandani Azwar Anas earned her bachelor's degree from Universitas Negeri Jakarta and her master's degree in public policy from Universitas Airlangga. As the Regent of Banyuwangi, Ipuk Fiestiandani Azwar Anas has steered Banyuwangi towards several impressive achievements. Banyuwangi as part of Ijen Geopark has been acknowledged as a member of the UNESCO Global Geopark network. Banyuwangi Airport recognized as a building with the best architecture in the Aga Khan Awards for Architecture 2022. Furthermore, Banyuwangi has successfully maintained its status as the most innovative regency in Indonesia for six consecutive years. Additionally, Banyuwangi secured the top spot for local government performance in 2022. During her tenure, Ipuk Fiestiandani Azwar Anas has earned various individual awards reflecting her dedication to regional development. These awards include the Satyalencana Wirakarya from the President of the Republic of Indonesia for her success in innovating the maritime sector in Banyuwangi and the 'Appreciation of Indonesian Figures' award from Tempo, a national media outlet, for her success in reviving Banyuwangi's tourism post the Covid-19 pandemic.

His Excellency Ambassador Dr. Siswo Pramono

Ambassador to Australia, Republic of Indonesia

Presentation title: The development of Natuna Geopark: a foreign policy perspective.

H.E. Ambassador Dr Siswo Pramono grew up in the south coast region of Tulungagung in East Java. He graduated in law from Airlangga University in Surabaya. He undertook postgraduate studies at Monash University in law and later completed a PhD in political science from the Australian National University. Prior to being posted to Canberra as Indonesia's Ambassador to Australia and Vanuatu, he was the Head/Director-General of the Policy Analysis and Development Agency at the Ministry of Foreign Affairs. His earlier placements and postings included Deputy Chief of Mission, Indonesian Embassy in Berlin, Germany, Head/Director of the Center for Policy Analysis and Development on Asia-Pacific and Africa Regions, Policy Analysis and Development Agency, Ministry of Foreign Affairs of Indonesia. He was also the Advisor to the Permanent Representation of the Republic of Indonesia to the Organisation for the Prohibition of Chemical Weapons in The Hague. Ambassador Pramono presented his credentials to the Governor-General of Australia in Canberra on 8 December 2021.

Dr Patricia Erfurt

Research Scientist, Geotourism Australia.

Presentation title: Destinations and current development of volcanic geotourism in Australia.

Patricia Erfurt studied geology, geography and soil science at the University of New England, New South Wales, Australia. She received her Ph.D. from James Cook University (JCU) in Queensland, Australia for the subject of natural hot springs and their role in health, wellness and recreation. Since retirement from university teaching, she has worked as a research scientist and consultant at Geotourism Australia with a special focus on risk prevention and risk management in active volcanic and hydrothermal environments. Her research interests include exploring volcanic destinations and hot spring locations with an emphasis on sustainable management and conservation of endangered sites. She spends much of her time publishing research findings and has authored and co-authored books, chapters and articles about volcano tourism, hot spring tourism and geotourism. She actively promotes the concept of sustainable geotourism, assists with planning and establishing geotrails and works as advisor for the conservation of natural and cultural resources and their geoheritage.

Mohamad Farid Zaini

Chairman of the Indonesian Geoparks Network, Indonesia.

Presentation title: Indonesian Geoparks Development: Managing Volcano Geotourism Destination to Sustain Local Communities.

Mohamad Farid Zaini is the current Chairman of the Indonesian Geoparks Network. Farid facilitates collaboration among 24 geoparks nationwide. Since 2020, he has brought his expertise to the role of General Manager at the Rinjani-Lombok UNESCO Global Geopark Management Agency, overseeing the integrated development and management of geopark areas in West Nusa Tenggara. Additionally, Farid serves as an Advisory Committee member of the Global Geopark Network, contributing extensively to the global network's initiatives. He also contributes to academia as a lecturer and heads the Innovation and Business Incubator Centre at Hamzanwadi University in East Lombok. Over the past five years, he has tirelessly worked with stakeholders to promote sustainable geotourism in Lombok, emphasizing community empowerment and environmental conservation. Farid's multifaceted roles and passion for geoparks and sustainable development make him a valuable asset to the field, driving forward initiatives that prioritize both regional competitiveness and environmental stewardship.

Sasha Morriss

Geoeducator and Geoscientist, Waitaki Whitestone UNESCO Global Geopark, New Zealand.

Presentation title: Geotourism in the Waitaki Whitestone UNESCO Global Geopark, New Zealand.

Sasha Morriss is the geoscientist for the Waitaki Whitestone UNESCO Global Geopark in New Zealand and leads education outreach. She has been in her position for almost five years and played a pivotal role in the UNESCO Global Geopark accreditation process (2023). This included developing content concerning the geological heritage of the Geopark. Sasha has a wide liaison role which includes delivering educational programs to schools and community groups, liaising with the Council, conservation agencies and the many other stakeholders involved with the Geopark. Sashas previous experience includes groundwater Resource Management (NZ) and roles within town planning (UK). She earned her MSc and BSc in Geology from the University of Otago New Zealand. Sasha enjoys making scientific concepts accessible and relevant to locals and visitors.

Professor Mega Fatimah Rosana

Dean of the Faculty of Engineering Geology, Padjadjaran University in West Java, Indonesia.

Presentation title: Roles of geoscientists in geotourism and geopark development in Indonesia.

Professor Rosana is the Dean of the Faculty of Engineering Geology, Padjadjaran University in West Java of Indonesia since 2021. She is the Chair of the Geopark Expert Board of the Indonesian National Geopark Committee. She is currently a member of the Indonesian Association of Geologist (AIGI), the Society of Economic Geology, the Indonesian Society of Economic Geologist (MGEI) and the Indonesian Geotourism Society (MAGI). Her research interests range from petrology, minerology, geochemistry, hydrothermal studies to remote sensing, environmental conservationm geopark and geotourism.

Russell Boswell

Savannah Guides, Cairns, Queensland, Australia.

Presentation title: Volcanism and Tourism in Tropical North Queensland.

Russell Boswell is a regional tourism development expert. He has owned and operated tour companies, created numerous ecotourism experiences and mentored hundreds of tourism businesses across Australia. He has worked in tourism development projects in the Pacific, Indonesia, and China. Russell delivers programs in destination planning, storytelling, and business development. Russell also manages Savannah Guides, a not-for-profit organisation delivering professional development for Tour Guides, including training, field schools and accreditation. Savannah Guides operates the EcoGuide program, benchmarking high standard tour guiding in Australia and internationally. Based in Cairns, Tropical North Queensland, Russell sits on two Working Groups as a part of Australia's National Geotourism Strategy. He is a graduate of the University of Sydney.

Dedy Asriady

Head of Genung Rijani National Park Office, Lombok, West Nusa Tenggara, Indonesia.

Presentation title: Estimation of the social and economic impacts of geotourism of Gunung Rinjani National Park of Indonesia.

Dedy Asriady is currently the Head of Gunung Rinjani National Park in Lombok, West Nusa Tenggara, Indonesia. Previously, Dedy served as the Deputy Director for National Park Conservtion Technique of Lore Lindu National Park, Evaluation Section of South Sulawesi Nature Conservation Agency, Head of Area II of Bantimurung Bulusaraung National Park. Dedy holds degrees from Hasanuddin University. As Director of the Gunung Rinjani National Park, he always involves the local community in the management of the National Park. Working together to preserve Mount Rinjani also means preserving the culture that surrounds it. Thus, involving many stakeholders in management is important. 'Rinjaninte, Rinjani Kita', Rinjani is us, the tagline that he created for the National Park. As a result, protecting Rinjani is not just a duty, but a mandate that must be carried out with full awareness and responsibility. Providing benefits to the surrounding community as well as supporting regional and national development.

Mark Williams

Geoscientist & Lecturer in Physical Geography and Spatial Science at the University of Tasmania, Hobart, Tasmania, Australia.

Presentation title: Harnessing digital technology for volcanic geotourism and opportunities for Geoscientists.

Mark is a Geoscientist and Lecturer in Physical Geography and Spatial Science at the University of Tasmania. He serves as a co-leader of TAARN, a dedicated research group focused on Geoconservation in Tasmania and Australia. Before joining the University of Tasmania in 2017, Mark was an IT professional working in government and industry sectors in Australia and abroad across a variety of roles. Professionally, Mark is actively engaged with the industry as a geoheritage specialist, practitioner, and consultant, concentrating on geoheritage protection, sustainable geotourism, and geoeducation. As part of this professional engagement, he chairs a working group on Digital Technologies for Australia's National Geotourism Strategy of the Australian Geoscience Council.

5. Fieldtrips (19 July 2024, Friday. Assemble 8 am at Chau Chak Wing Museum)

Blue Mountains World Heritage Area

Led by Dr Peter Hatherly, a specialist of landforms of the Blue Mountains World Heritage Area, experiencing the World Heritage Exhibition Centre with morning tea in the Blue Mountains Botanic Gardens located on the volcanics outcrops of Mt Tomah, the Blue Mountains Cultural Centre, and various geosites and short walking trails including the Triassic sedimentary landscapes of the Upper Blue Mountains at the iconic Govetts Leap and Echo Point.

Ku-ring-gai GeoRegion

Led by Dr Peter Mitchell OAM, a geologist, an environmental specialist, and a member of the GeoRegion Steering Committee, join him at Long Reef on Sydney's Northern Beaches to gain an appreciation of how a geotrail along the coastline with 17 identified sites in a highly populated area is being constructed. The Ku-ring-gai GeoRegion is well known for its significant natural and cultural heritage values. The GeoRegion covers protected areas, principally the Ku-ring-gai Chase National Park as well as the coastal cliffs and lagoons along a section of the Northern Beaches of Sydney. An integral part of a GeoRegion is the development of geotourism projects such as educational geotrails focusing on the geology, landscape, flora and fauna, and cultural heritage.

Royal National Park & South Coast Volcanics

Led by Dr Sabin Zahirovic, this field trip will take participants to the NSW South Coast, more specifically to Kiama and Bombo. This area records the end-Permian mass extinction in the rock outcrops, driven by volcanism on the other side of the planet (via the Siberian flood basalts) 251 million years ago, as well as preserving the Late Cretaceous rift-related basalts formed during the opening of the Tasman Sea. Further inland, the region also hosts significant and geologically recent intraplate volcanics, highlighting the significant impact of volcanism and tectonics on shaping this region. In addition, the Kiama Blowhole is a significant geotourism destination on the NSW coast, and importantly is accessible via public transport (notably the train from Sydney to Kiama).

6. Special Wildlife Tourism Australia Session (20 July 2024)

Venue: Room 331, School of Geosciences, Madsen Building, The University of Sydney

Theme: Wildlife Tourism in Australia and Indonesia and its relationship to Geotourism

Led by Dr Ronda Green, President of Wildlife Tourism Australia with specialised knowledge of wildlife in the Asia Pacific region. Indonesia and Australia are both amongst the world's highest-ranking countries in terms of biodiversity and endemism. The two countries mostly harbour quite different fauna and flora, but also share quite a few taxonomic groups such as fruit bats, marsupials, monotremes, cassowaries, megapodes, bowerbirds, birds of paradise, cuckoos, crocodiles, and monitor lizards. The session will discuss these shared groups and some of the endemic creatures of both countries. Some of the species will also be considered in relation to their dependence on kinds of soils or landscapes, and in some cases their own influence on soils. Finally, the session discusses some ideas on incorporating wildlife interpretation into geotourism displays and activities.

7. Organising Committee

Dr Young Ng, Danxiashan UNESCO Global Geopark (Chair)

Meihva Ang, Indonesian Geoparks Network

Pat Hanna, Australia Indonesia Association of NSW

Dr Michael Leggo, Geoscience & Sustainable Development Consultant

Professor Phil McManus, The University of Sydney

Farid Z Mohammad, Indonesian Geoparks Network

Ian Neuss, Sydney Minerals Exploration Discussion Group (SMEDG)

Ana Oktaillah, Indonesian Geoparks Network

Angus M Robinson, Coordinator, NGS Steering Committee

Mark Williams, University of Tasmania & NGS Steering Committee

8. Wi-Fi for delegates

Wifi network: UniSydney-Guest

Username: geofest2024 - Password: 99676384

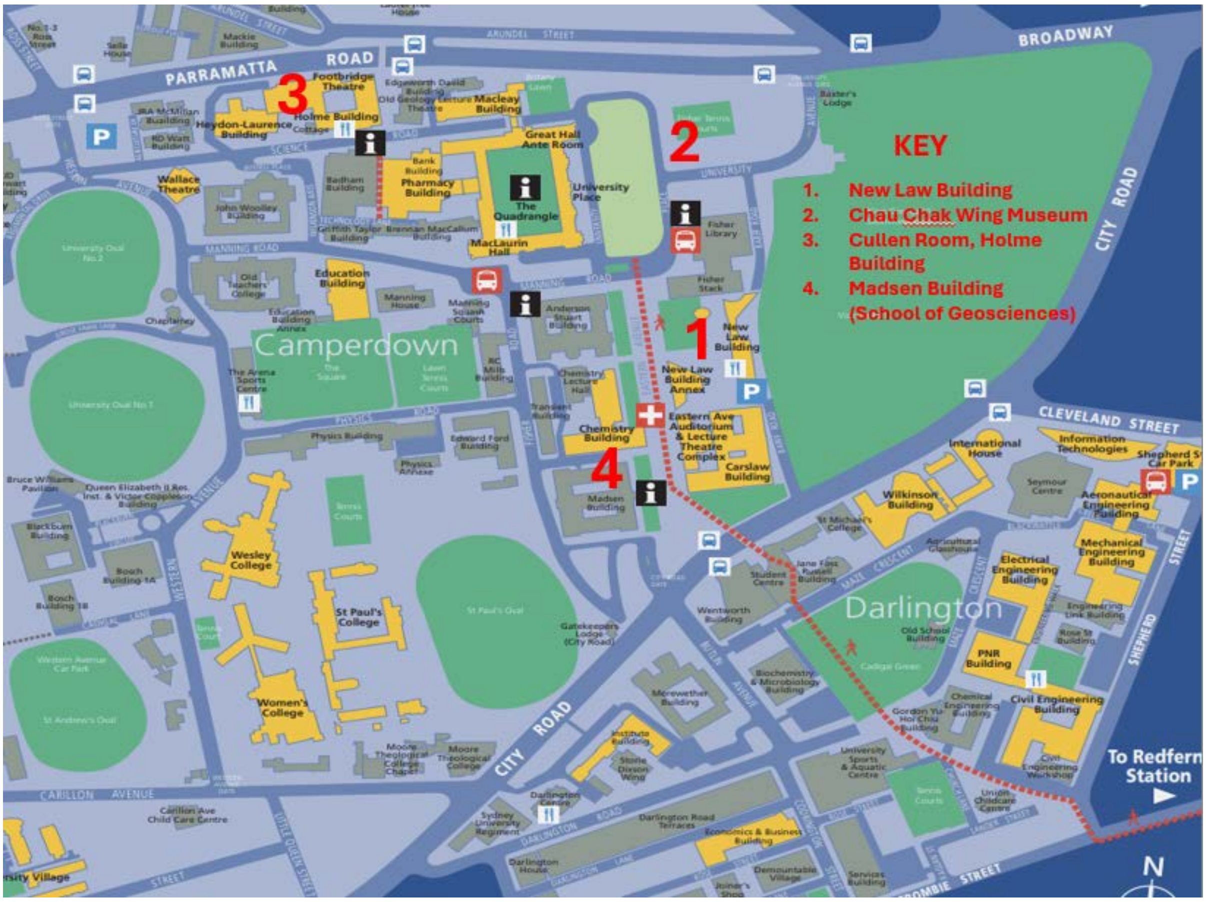
9. Contacts & enquiry

Official web site www.geofest.com.au

Email: geofest2024sydney@gmail.com

10. Acknowledgements

The hosts and the Organising Committee would like to express their gratitude to all the sponsors for their generosity in financing the project and the volunteers in assisting the organisation of all activities to make this workshop successful. Special thanks are to be extended to Dr Ronda Green for hosting the Wildlife Tourism Session, Dr Sabin Zahirovic for all the logistic supports and Raiza Satori for all the graphic designs being used in promoting the event.



Campus map – The University of Sydney

Dedy Asriady

Estimation of Social and Economic Impacts of Geotourism of Gunung Rinjani National Park

Dedy Asriady, Head of Genung Rijani National Park Office, Lombok, West Nusa Tenggara, Indonesia.

Abstract

Indonesia is one of country which has a lot of geotourism potential. Many places are becoming an attraction for local and foreign tourists to come to Indonesia. Gunung Rinjani National Park (GRNP) is one of the tourism object in West Nusa Tenggara that has many interesting attractions with the Sembalun-Torean-Senaru Track as the most popular hiking track for tourists. Gunung Rinjani National Park not only offers unique geotourism experience through hiking the volcano that rises to 3,726 meters but also offers fishing experiences at the Segara Anak Lake and the hot springs of Aik Kalak. Segara Anak Lake is a volcanic lake formed in the caldera of Mount Rinjani on over 2,000 meters above sea level. The lake spans across an area of 11 square kilometers, and reaches depths up to 230 meters. The mystifyingly blue colour of the lake gives Segara Anak its name: Small Ocean. A large number of visitors has created economic impacts on local community. The existence of Gunung Rinjani National Park provides an opportunity for local communities to establish business units around the area. Tourism is one of the important economic drivers, especially for local communities that are located in the area. The existence of tourist areas has the potential to bring economic value as a supplier of tourism services. Tourist expenditure generated a steady flow of money in the area and created significant economic impact. Based on the figures available in 2023, there were 69,274 visitors that arrived at the mountain park area, among this 34,584 were domestic tourists and 34,690 international tourists. In addition, there are 166 trekking operators, 320 guides, and 694 porters involved in geotourism and climbing activities. The economic value of geotourism in Gunung Rinjani National Park was able to generate tourism income amounting to IDR. 78.902.044.000 (AUD 7.68 million) in 2023.

Dr Jon Hronsky OAM

The AGC's National Geotourism Strategy: A Key Initiative to Grow the Opportunities for Geoscience in Australia

Dr Jon Hronsky, Chair National Geotourism Strategy, Australian Geoscience Council

Abstract

The Australian Geoscience Council (AGC) is the peak professional body for Australian Geoscientists, representing over 8 000 individual geoscientists from all disciplines. A central goal of the AGC is the promotion of Geoscience to the broader community. For this reason, the AGC committed to the development of the National Geotourism Strategy in 2021 and has since prioritized this effort. Geotourism is seen as a fantastic (and perhaps unique) opportunity to engage the broader community with geoscience, and as such is arguably our most outward-facing initiative. We see no fundamental reason why geoscience could not become as entrenched in popular culture as the life sciences. The benefits to the geoscience profession of this are obvious, most importantly in helping to motivate a much-needed new generation of young geoscientific students. The AGC also understands and strongly supports the important regional and rural economic development opportunities offered by Geotourism. We are particularly interested in, and supportive of, those geotourism opportunities that help provide economic activity to post-mining communities and traditional owners.

Ipuk Fiestiandani Azwar Anas

Ijen UGGp: Impacts of Volcano Geotourism and Geopark on Economic Development for Banyuwangi Regency.

Ipuk Fiestiandani Azwar Anas, Regent of Banyuwangi, Banyuwangi Regency of East Java, Indonesia

Abstract

Ijen Geopark is one of the UGG geoparks in East Java Province, precisely in Banyuwangi and Bondowoso Regency. The geological history of the Ijen Geopark began during the Oligocene-Miocene, which was marked by outcrops and hills from the volcano in the south of the geopark area due to the subduction of the Indo-Australian Plate to the Eurasian Plate. About five million years ago these mountains had died, then due to changing of subduction's, volcanoes were formed which are now to the north as far as fifty kilometers from their initial position. There are several mountains that are formed in the north, such as Mount Baluran, Mount Ringgit, Complex Ijen Purba, until the youngest is Mount Raung. Three main pillars of geopark, namely geology, biology and culture, are important components for the sustainable development of Banyuwangi Regency as part of the Ijen Geopark UGGp. The amazing natural beauty - Mount Ijen with its blue fire phenomenon or Alas Purwo Forest which is one of the UNESCO Man and Biosphere Reserves - is developed through the concept of ecotourism. This is further supported by various sport events held in Banyuwangi such as Geopark Run, Tour de Banyuwangi Ijen and Quicksilver/ROXY Pro-G- Land World Surf League (WSL). The original cultural heritage of the Osing Tribe, an indigenous Banyuwangi tribe, is maintained through traditional dances that are displayed during various events in Banyuwangi. Strategic infrastructure such as an airport is also built with an environmental-friendly concept in the form of a Green Airport. In addition, public facilities and hotels are required to accommodate the use of traditional ornaments and local architectural designs. Economic empowerment of local communities is also considered. For example, the development of below-3-star-rating hotels is forbidden, and the establishment of modern retail is prohibited, giving ways for community-owned homestays and small shops to develop, which are further supported by the so-called Hotel Asuh Homestay (Hotel Care Homestay) Program for their hospitality improvement. These various efforts are bringing positive impacts for Banyuwangi, namely the per capita income continues to rise and the poverty level decreases. Banyuwangi is committed to continue these three pillars, because it believes that they can help create a decent home for future generations.

Keywords: Banyuwangi, Ijen Geopark, sustainable development, environmental and cultural sustainability.

Mark Williams

Harnessing digital technology for volcanic geotourism and opportunities for Geoscientists

Mark WILLIAMS, School of Geography, Planning, and Spatial Sciences; University of Tasmania, Australia

Abstract
In the dynamic landscape of volcanic geotourism, the integration of digital technology not only enriches the visitor experience but also opens a myriad of opportunities for geoscientists and geopark practitioners. This presentation explores the innovative application of virtual reality (VR), augmented reality (AR), and web and mobile applications in the development and promotion of volcanic geotourism areas and geoparks.

Volcanic regions, with their rich geological heritage and breathtaking landscapes, offer unique opportunities for geotourism. However, making these sites accessible and informative for tourists, whilst ensuring the conservation of their natural and cultural values, presents a significant challenge. Digital technology, by bridging the gap between accessibility and conservation, provides an effective solution. Through the use of VR and AR, tourists can experience the awe-inspiring beauty and geological complexity of volcanic sites in a highly interactive and immersive manner, without leaving a physical footprint. This approach can also be used to promote these landscapes through visitor centres and encourage further visitation.

Furthermore, the presentation delves into the development and utilisation of web and mobile applications. These technologies can be integrated into a digital ecosystem where data collected in the field can be used for management purposes, and then streamlined into web applications that facilitate geotrail planning as a decision support tool for the planning and visualisation of geotrails. A public interface can also be developed to serve as a gateway for tourists to explore the geological wonders of geoparks, thereby fostering a deeper appreciation and understanding of Earth's geological processes.

The presentation will highlight the increasingly important role of digital technology in transforming volcanic geotourism. By offering immersive experiences, educational value, and efficient data collection and dissemination, digital tools not only enhance the tourist experience but also empower geoscientists and geopark practitioners to contribute more effectively to the conservation and promotion of geological heritage.

Key words: Digital tools, Web and Mobile, VR, AR
Email: Mark.Williams@utas.edu.au

Mohamad Farid Zaini

Indonesian Geoparks Development: Managing Volcano Geotourism Destination to Sustain Local Communities.

Mohamad Farid Zaini, Chairman of the Indonesian Geoparks Network

Abstract

In the realm of geotourism, Indonesia's 24 geoparks stand as unparalleled marvels, showcasing breathtaking geological landscapes while safeguarding cultural heritage and biodiversity. Among them, seven are recognized as volcano geoparks, designated as UNESCO Global Geoparks and National Geoparks, including Batur, Gunung Sewu, Rinjani-Lombok, Toba Caldera, Ijen, Merangin Jambi, and Tambora. As global demand for sustainable geotourism destinations rises, Indonesian geoparks, particularly those centered around volcanic landscapes, have emerged as pivotal sites for exploration and conservation.

However, challenges persist, including inadequate infrastructure, governmental management lacking professional insights, regulatory limitations, socio-cultural conflicts, and insufficient visitor awareness regarding waste management, hindering their full potential realization. To address these challenges, a comprehensive strategy for managing volcano geotourism has been developed and implemented, drawing from empirical data, case studies, and collaborative efforts with local communities, governmental agencies, and geotourism professionals.

Principal results indicate ongoing progress in infrastructure enhancement, governance restructuring, regulatory refinement, increased community involvement, and improved visitor education programs. Notably, enhanced waste management practices, cultural sensitivity training, and sustainable tourism initiatives have contributed to the preservation of natural resources, cultural heritage, and socio-economic development in local communities.

The significance of this ongoing improvement process extends beyond Indonesia, providing valuable insights for sustainable geotourism development globally. By demonstrating the efficacy of collaborative approaches, community empowerment, and holistic management strategies, Indonesian geoparks serve as a beacon for other volcanic destinations aspiring to balance conservation efforts with socio-economic benefits. This study underscores the global imperative for sustainable geotourism practices, emphasizing the critical role of scientific research and stakeholder engagement in nurturing resilient and inclusive tourism ecosystems.

Keywords: geopark, geotourism, volcano, geofest

Dr Patricia Erfurt

Destinations and current development of volcanic geotourism in Australia.

Dr Patricia Erfurt, Research Scientist, Geotourism Australia

Abstract

Australia's ancient volcanic landforms are a unique natural resource, that offer abundant opportunities to learn about the natural and cultural geoheritage of individual regions. The majority of Australia's volcanic geoheritage is located along the eastern seaboard, stretching for around 3,800 km from Far North Queensland over New South Wales and Victoria to southern Tasmania. Many of Australia's national parks include areas rich in volcanic geoheritage with an abundance of remnant volcanic landforms such as crater lakes and maars, columnar jointing, lava flows, scoria cones, central volcanoes, and lava tubes. Volcanic provinces on the Australian mainland are the result of various stages of active volcanism, resulting in a vast diversity of landscapes, reaching from the coast inland over long distances. Generally, the most plausible and acceptable explanation for the source of Australia's volcanism has been based on intraplate hot spots fed by upwelling mantle plumes, although opinions regarding the origin remain divided to date, with a few different geophysical processes proposed. At this point in time, Australia's volcanoes most likely do not pose any imminent danger, even though some geoscientists have suggested that reactivation may be a possibility in certain areas. Australia's only active volcano is Big Ben, located on Heard Island, which is part of the external Australian territory of Heard Island and McDonald Island (HIMI), a marine reserve and scientific research station in the southern Indian Ocean, around 4,000 kilometres west of Perth. Worldwide, the interest in volcano tourism grows with each eruption. But while Australia has a long history of using its natural and cultural heritage as tourist attractions, the focus remains largely on ecotourism with only a few recent attempts to establish geotourism destinations. This presentation provides an overview of Australia's most remarkable volcanic destinations.

Keywords: Australia's volcanism, volcanic geoheritage, geotourism destinations, geotourism attractions

Professor Phil McManus

The imperative of building sustainable tourism in regional and remote Australia: Cultural landscapes of volcanic tourism.

Professor Phil McManus, School of Geosciences, The University of Sydney, Sydney, Australia.

Abstract

Many parts of regional and remote Australia are looking for opportunities to rejuvenate their local economy. Volcanic landscapes, which exist from north Queensland to Tasmania and west to Mount Gambier in South Australia, offer sustainable geotourism potential. Sustainable tourism, which includes the impacts on the local environment and community, access to and from the site, off-site impacts, and the generation of ongoing employment opportunities, may enable communities located in, near or on route to volcanic landscapes to prosper. Cultural landscapes, being a symbiosis of human activity and physical environmental settings and processes, can be the basis for sustainable tourism, but only if they are understood, respected and inclusive processes of tourism development acknowledge Aboriginal ownership and limits to tourism impacts. This presentation explores what it might mean to build sustainable tourism around volcanic landscapes in parts of eastern Australia, what are the opportunities and challenges and how this may enhance the protection and awareness of crucial geological features and processes.

Keywords: volcanic landscape, cultural landscape, regional and remote Australia, sustainable geotourism, employment opportunities

Professor Mega Fatimah Rosana

Roles of geoscientists in geotourism and geopark development in Indonesia

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Abstract

Geotourism and geoparks are currently becoming popular in several countries, including Indonesia. In particular, geoparks, as a new concept in managing a single and integrated geographic area where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. Currently there are 195 UNESCO global geoparks spread across 48 countries, including Indonesia.

In developing a geological site into a geotourism destination and geopark in Indonesia, the role of geoscientists becomes very important. In accordance with applicable regulations in geopark development in Indonesia, an area is required to have geological sites that have been formally designated as geological heritage by the Ministry of Energy and Mineral Resources. Therefore, geoscientists have a very important role in inventorying, identifying, classifying and making comparisons to determine the significant value of these sites in terms of local, national or international value, as well as recommending the use of these sites, whether as research objects, earth science education, or can also be used as a geotourism destination. Geoscientists also need to be involved in managing and conserving these sites to avoid damage due to incorrect use or damage due to natural factors or human activities.

Geoparks through geotourism activities, which are considered the most suitable for developing sustainable tourism in the region with the aim of stimulating the local economy and community. By highlighting Geopark elements, such as geology, natural ecosystems, cultural elements—archaeology, promotion of local cultural identity, it is an important basis for development which has a direct impact on the preservation of geological heritage and cultural values. Here the role of geoscientists is also very necessary in identifying and analyzing the relationship between geological, cultural and biological objects to create story telling which will add to the uniqueness and attractiveness of these objects for tourists.

Keywords: Geotourism, Geoparks, Sustainable tourism, Indonesia

Russell Boswell

Volcanism and Tourism in Tropical North Queensland

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Abstract

Tropical North Queensland is best known internationally for the Great Barrier Reef; however, the neighbouring landscapes feature a range of volcanic attractions and influences. Some of the richest sections of the World Heritage Listed Wet Tropics Rainforest sit on rich basaltic soils, dotted with waterfalls negotiating volcanic remnants. The world's longest lava tubes are just 3.5 hours west of Cairns at Undara. The volcanic activity here began 8 million years ago and ceased just 8000 years ago. There are over 80 extinct volcanoes in the region. Most sites are protected in National Parks and local government reserves. Tourism capitalises on this geological heritage in several ways. Some sites feature self-guided walks and picnic areas, servicing visitors and locals. Others are only accessible using Tour Guides, trained by the renowned Savannah Guides organisation. The rich habitats sustain great biodiversity including spectacular forests, birds, and other wildlife, drawing niche visitor segments. World championship mountain biking events, wellness retreats and adventure activities take advantage of the landscape and regional agriculture includes signature products that are popular with visitors. Geotourism can highlight the deeper context of these popular experiences and great storytelling can bring underlying meaning to the surface. The Geotourism movement can also foster the collaboration of researchers, Protected Area Managers, and the tourism industry to drive sustainability and maximise community benefit.

Keywords: Tropical North Queensland, volcanoes, lava tubes, geoheritage, geotourism

Sasha Morriss

Geotourism in the Waitaki Whitestone UNESCO Global Geopark, New Zealand

Sasha Morriss, Geoeducator and Geoscientist, Waitaki Whitestone UNESCO Global Geopark of New Zealand

Geotourism in the Waitaki District of New Zealand spans over 20 years with the discovery of ancient marine fossils on rural farmland and the subsequent development of the Vanished World Trail – a self-guided trail showcasing geological highlights throughout the Waitaki District. This was soon followed by the establishment of the Vanished World Centre. Set up by local volunteers, this Centre showcases fossils recovered by staff and students from Otago University. In 2023 the Waitaki Whitestone Geopark received UNESCO accreditation and became part of the Global Geopark network. The geology and landforms within the Geopark tell the story of the 8th continent of the world – Te Riu-a-Māui / Zealandia. Through the diverse geosites within the geopark, locals and visitors can explore past environments and come to understand the formation of Te Riu-a-Māui / Zealandia through geological time, and learn about earth processes that are continuing to shape our land today. The Geopark is moving towards more holistic geotourism where stories connected to the land – including cultural and social heritage may be shared, with expected outcomes bringing economic benefit across our communities.

Keywords: Waitaki Whitestone Geopark, Te Riu-a-Māui / Zealandia, geotrails, geosites

The Long Reef Geotrail -

part of the Ku-ring-gai GeoRegion

This tour is part of the GEOFEST 2024 Sydney Workshop hosted by the Australian Geoscience Council (AGC), the Indonesian Geoparks Network, and the University of Sydney. The tour leader is Geomorphologist and Environmental Scientist Dr Peter Mitchell OAM.

The tour departs from in front of the Chau Chak Wing Museum (F21) at 08.00. We expect to return by 16.00. Food will be provided.

Sydney weather has been rather erratic recently so bring clothing suitable for showers and if possible, footwear that you don't mind getting wet. A sun hat and sun screen is recommended, and even in Sydney it is a good idea to carry a bottle of water. We will be walking around the base of the cliffs (easy going on sand with a few rocky sections), and low tide is at mid-day so there should be no problems with waves. If the weather gods are unkind an alternative bus tour will be undertaken.

Long Reef is an Aquatic Reserve at Collaroy established 44 years ago to protect the rich inter-tidal fauna. The reserve is one of nine in Sydney, it extends 100m offshore and is administered by the Department of Primary Industries and Regional Development. It has been used by generations of school children as an excursion locality and presently has 4,000 visits per year. It is a favourite location for bird watchers and whale watchers as well as the general public.

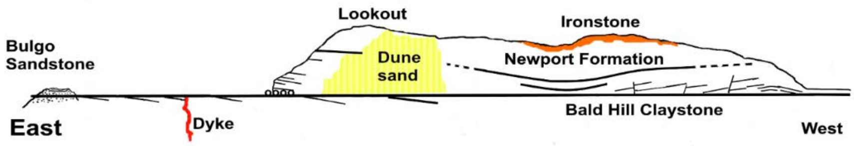
This Geotrail is one of several planned within the Ku-ring-gai GeoRegion which interpret the geology and explain how the rocks influence the landscape and environment. Geological data has been provided by a working group of FOKE (Friends of Ku-ring-gai Environment) and signage with QR codes that will provide site information is being installed by Northern Beaches Council.

Long Reef Geotrail

1

Be wary of waves, rising tides and falling rocks. No collecting.

Sketch section North face Long Reef



The Sydney coast is a seemingly endless succession of bold sandstone headlands and cliffs punctuated by white sand beaches. Long Reef, 17km northeast of the city is an exception, the cliffs are subdued and surrounded by wide shore platforms formed on Triassic Bald Hill Claystone 245 million years old. The shore platforms have innumerable crevices and pools that support a rich diversity of inter-tidal life. The rocks reveal stories about sediments and fossils deposited on the edge of Gondwana when this part of Australia was 30 degrees further toward the Pole than it is today.

For most of the time when Gaimaraigal clans of Aboriginal people lived here, Long Reef was just another forested ridge extending 10-15km offshore as sea level was 120m lower than present. The sea returned to near its present position about 8,000 years ago and formed the headland and shore platform we see today.

More than 140 species of birds have been recorded at Long Reef including at least 40 threatened species. Of particular note are sooty oystercatchers, osprey, sea eagles, Australasian gannets, terns, cormorants and silver gulls. Plus, migratory species such as double-banded plovers from New Zealand, and short tailed shearwaters from the margins of the Arctic.

The Aboriginal name of Long Reef is unknown. Lieutenant James Cook sailed past in *HMS Endeavour* in 1770 but was about 5km offshore and made no comment. Governor Phillip passed by in 1788 and Lieutenant Bradley's journal mentions 'a reef of rocks which break some distance out' but no name was recorded. The first written use of the was in 1814.

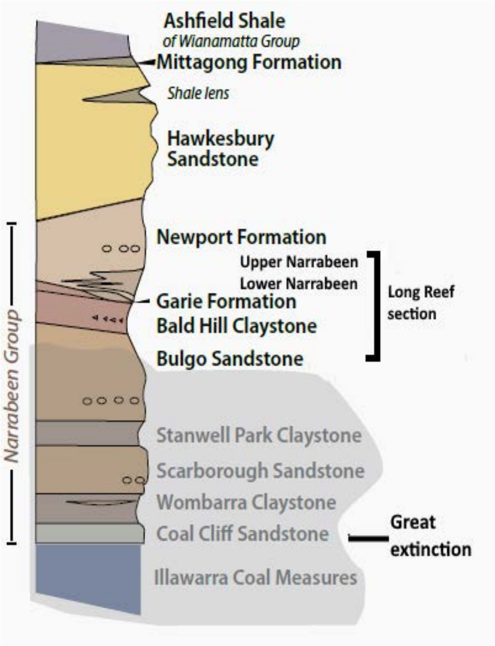
In 1815 the headland and part of Dee Why Lagoon were granted to the Government boat builder William Cossar. He sold his 202ha to Matthew Bacon in 1822, then it passed to D'Arcy Wentworth formerly the principal surgeon, who almost immediately sold it to ex-convict James Jenkins. The Jenkins family used it for grazing until 1900, when it was bequeathed to the Salvation Army. In 1912 the State resumed 72ha to create Griffith Park which now includes the golf course.

Geosite 1.

The coarse sand on Fishermans Beach contains a high proportion of rounded and platy shell fragments and granules of local bedrock. The beach is narrower and steeper than others. Geobags were installed after storms in 2016 which eroded the beach to the edge of the car park. This is a 'softer' engineering solution to coastal erosion than concrete or rock sea walls and the bags have an effective life of at least 25 years. Two or three decades from now it is expected that sea level will be 20-30cm higher and when that is added to storm waves and a king tide it will make quite a difference in the level of wave run up. Whether this level of protection will be enough, is a question that is yet to be answered.

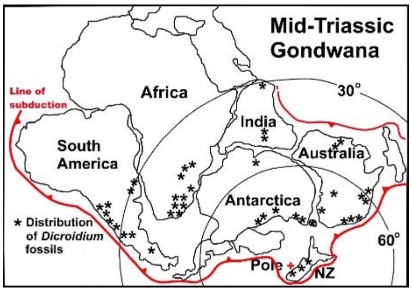
At the end of Fishermans Beach a single historic hut is the last of several used by a small community of fishers from as early as 1872. In 1917, some 30 people lived here in 16 dwellings (including tents) and Council began charging rent and required the occupants to improve sanitation. As leases expired, huts were demolished, this last one is now managed by the Long Reef Fishermen's Association.

In 1997 the expansion of exotic plants around the huts including large clumps of *Agave americana* led eight locals under the guidance of Peter Miller to form 'Reefcare' and begin bush regeneration.



The main rocks on Long Reef belong to early to the mid-Triassic Bald Hill Claystone and the Newport Formation. Formerly known as the 'chocolate shales' or the 'Collaroy Claystone' these consists of fine grained, reddish-brown sediments deposited on the edge of Gondwana under a cold climate in rivers, lakes, and shallow marine conditions about 245 million years ago. The rocks contain a diversity of fossils that tell us about conditions on Earth shortly after the Permian extinction event when the swamp forests that formed the Illawarra and Newcastle coal measures were replaced by new plant communities that included *Dicroidium* seed ferns, lycopods such as *Cyclomeia*, and horsetails such as *Neocalamites* and *Phyllotheca*.

These sediments may have taken half a million years to accumulate and were intruded by an igneous dyke probably in the Jurassic. The beds are no longer horizontal but were bent and fractured when the crust stretched and the Tasman Sea opened between 84 and 52 million years ago.



In the claystone you can find; alleged fossil soils, numerous structural features (faults and folds), and rare copper minerals that hopeful prospectors once tried to mine. Variations in rock type and structure control the shape of the cliffs and shore platform and provide habitat for the intertidal fauna.

Geosite 2

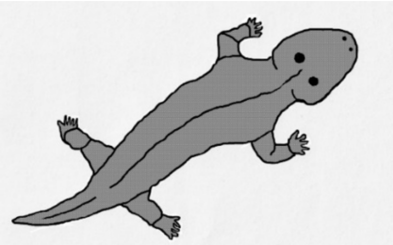
Claystone beds and thin conglomerates in this section of the cliffs dip (slope) toward the fold at Geosite 3 and multiple layers of alleged fossil soil are exposed.

Sedimentary beds in this section are disrupted by several faults each with limited displacement. The fault planes often have polished faces that show the relative direction of movement, or are layered in iron oxides deposited by groundwater.

Jointing in the claystone is readily visible in the cliff and in grid patterns on the shore platform. These fracture planes were caused by the rock adjusting to stress as they were folded and deformed and may be linked to the opening of the Tasman Sea along a now extinct mid-ocean ridge between 84 and 52 million years ago.

The claystone is almost entirely composed of iron oxide and kaolin clay. Coarser beds within it contain pebbles that have a volcanic origin that may have come from a vanished landscape offshore.

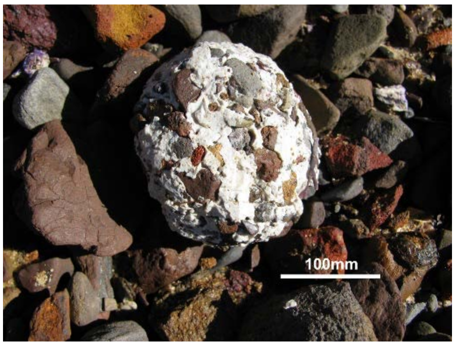
Many trace fossils are present but not easy to find. The partial fossil of a primitive amphibian estimated to be 3m long was recovered here and named *Bulgosuchus gargantua.* The name implies that it was found in the Bulgo Sandstone but in fact it came from the Bald Hill Claystone. Today most amphibians are found in freshwater and if this was true in the Triassic then this evidence may conflict with the marine environment suggested by other fossils in these beds.



What did *Bulgosuchus* look like? A difficult question as only a lower jawbone was found, but by comparing it with fossils of the same age from other places it was a short, wide crocodile like creature with a large, broad, head. Not a reptile, and strictly not an amphibian, but a top predator in its time.

Common trace fossils include inclined burrows about 250mm across informally named *Turimettichnus* sp. The rough exterior is the inside surface of a filled burrow and the linear marks are claw scrapes made by the organism that lived there in Triassic times.
The nature of the animal is uncertain as only one poorly preserved body fossil has ever been found. It is thought to be a crustacean rather like a lobster. This is part of the evidence that at least some of the Bald Hill Claystone was deposited in shallow marine conditions. The best exposure of these burrows is sometimes covered by sand.

Near the western end of the cliff closer to the fisherman's hut, the higher parts of the claystone are weathered to white kaolin clay which is subject to land slips. The large slip has been moving for at least 15 years and is reactivated every time storm waves cut the base of the cliff or when exceptional rainfall occurs.

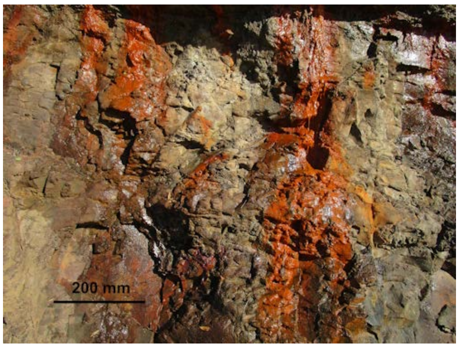


The white clay is remarkably smooth and may have been used by Aboriginal people as a pigment. When the slump is being eroded by waves, balls of clay roll back and forth on the beach and collect sand and pebbles. The technical name for these unusual forms is 'armoured mud balls'.

This cliff also fails on a smaller scale more or less constantly because the mudstone is subject to shrink and swell through wetting and drying cycles. In dry weather it fractures into small particles that form cones of debris that are washed away when the waves reach them. In wet weather it flows as a muddy red-brown slurry.

Geosite 3.
The rocks in the cliff face are gently folded into a syncline (a downward warp). Several small faults are visible where individual beds are displaced vertically.

Structures like this remind us that our conventional view of the rocks in Sydney as a horizontal layered sequence is inaccurate. The paler layers in the Bald Hill Claystone are thought to be soil horizons formed in Triassic times and now fossilised (see also Geosite 6). The base of the Newport Formation can be conveniently placed at the bottom of the prominent sandstone bed. Most interpretations of Sydney's coastal geology would place the Garie Formation at this level, but it has not been confirmed on Long Reef



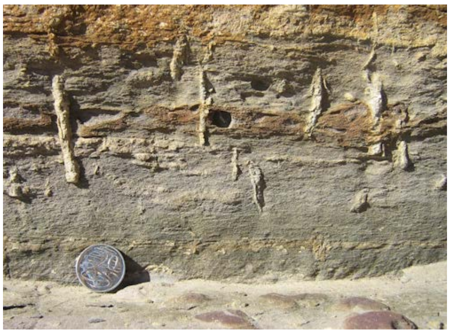
At the lowest point of the fold several water seepages depositing bright orange stains of iron oxide drain groundwater held in the rocks. The flow rate is low, but these springs could have been a source of freshwater for Aboriginal people.

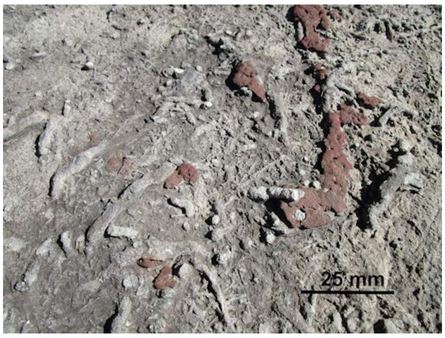
The shore platform is quite wide and covered by Neptunes's necklace (*Hormosira banksii*), a seaweed that effectively protects the rock surface from erosion. The most important process of platform formation is wetting and drying of the soft rock through every tide cycle. As the rocks dry out, they fret and spall, and the process ceases when saturated rock is exposed thus forming an almost level surface.

Long Reef Point and surrounding waters have a long history of shipwrecks beginning in 1816. More than 24 ships have been wrecked here including five coastal colliers, *Mountain Maid* 1868, *Susannah Cuthbert* 1875, *Duckenfield* 1889, *Euroka* 1913, and *Myola* 1919. At least eleven lives were lost in these events. In 1942 with war raging, a fleet of coastal traders was assembled in New Zealand by the US Army Small Ships Section. This included the wooden auxiliary ketch *Altair* (S117), and the fleet crossed the Tasman. *Altair*, built in 1903, had been engaged in collecting sand and gravel from Northland's beaches for concrete making. Her shallow draft was attractive to the Army for delivering war material into coastal waters around New Guinea but she ran aground here in October 1942 and was never re-floated.

On the edge of the shore platform near the fold, large boulders of ironstone have fallen from the top of the cliffs. These are very honeycombed and contain blocks of white sandstone, and traces of sedimentary bedding essentially the same as other Triassic rocks in the cliff. This same material can be seen at Geosite 8.

Adjacent sandstone boulders contain trace fossils on their bedding planes and sub-vertical infilled tubes cutting through the bedding.





Various informal scientific names have been given to these burrows but it is not easy to distinguish one from another. They can be classified by size and shape but without finding a preserved organism it is not certain what made them. Worms are often nominated, but there may be other explanations. The surface of the bedding planes often reveal tracks, trails, and faecal pellets (coprolites). Some were deposited by fish and analysis shows that they are rich in phosphorous and carbon which is characteristic of vertebrate predators. Other components include; fish scales, insect remains, and plant fragments, all suggesting a diverse environment that may have been either fresh water or marine. Fragmentary leaf fossils and small logs converted to coal may be found in finer grained rocks.

To the east of the synclinal fold a 160m length of vegetated cliff collapsed in a series of landslides on the 8th and 9th of March 2022 when the soil was saturated by 315mm of rain. The toe of the slide is being removed by waves, the lower part of the cliff face will become steeper, and new slides will occur. The estimated volume of debris involved in this event was 3,000m^3 and the cliff retreated by 1 to 2m. Older debris from an earlier landslip is buried by the recent material.

Geosite 4.
The black sand beach contains a large proportion of 'heavy minerals' such as ilmenite (iron titanium oxide) and magnetite (magnetic iron oxide). Both minerals are denser than quartz or shell fragments and resistant to weathering. They are derived from the claystone and have been concentrated on the beach by wave action and the wind moving lighter fractions into the dune that climbs the headland.

On the point with the heaviest wave attack is a boulder beach with all the platy slabs stacked on one another and sloping seaward (imbricated). The boulders extend 2m above the highest observed wave attack, and they may have been placed by storms larger than any experienced to date, or perhaps their position relates to a recent period of higher sea level. Several different rock types are present, including occasional lumps of coal from historic shipwrecks in the bay and basalt from the dyke. The largest brown 'boulder' in the photos is a 2m long upper-shell (carapace) of a leatherback turtle (*Caretta caretta*) that washed ashore in 2004.

Beneath the vegetation above the boulders there is an Aboriginal shell midden buried by sand. Little of the deposit is visible and as an **Aboriginal site it should not be disturbed**. It consists of broken shell (nerites, abalone, cartrut shell and others), charcoal, and a few stone flakes. It is neither large nor old, perhaps a few hundred years, and given the richness of the food supply in the intertidal zone it is suprisingly small.

Soil conditions on the headland are harsh. The profile is a thin mantle of dune sand over weathered rock with high salt content and limited water storage. The original vegetation would have been a coastal grassland of kangaroo grass (*Themeda triandra*), which is now listed as an endangered ecological community. In the 20th Century the slope was heavily eroded and used by children for 'sand hill surfing' on sheets of cardboard. It was invaded by boneseed or bitou bush (*Osteospermum moniliferum*), a native of coastal South Africa, that was widely used to stabilise sand dunes in the 1970s. The headland is now undergoing restoration by Reefcare.

Geosite 5

A rock 'island' on the end of Long Reef Point. You can visit it for a couple of hours around low tide and as you cross the shore platform you will find a linear igneous dyke about 1m wide trending northwest. The dyke is a vertical sheet of basaltic rock that intruded all the sedimentary strata as a molten magma, baking and hardening the margins (contact metamorphism). The alignment of the dyke is offset several times but the offsets do not appear to be on fault planes. The centre of the dyke is less weathered rock and contains vesicles (bubble holes) and plate shaped minerals aligned parallel to the dyke walls. It is probably of Jurassic age (about 160 million years ago) and the rock may have been used by Aboriginal people as raw material for making ground-edge axes (known as mogo).

Large boulders scattered across the platform can move during extreme storms and at other times they protect clusters of shellfish.

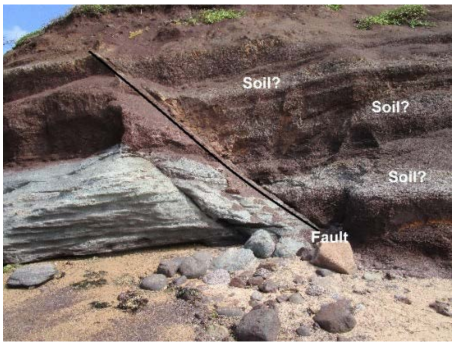
Small hollows and gutters on the platform are occupied by many other invertebrates.

Viewed from the sea at high tide, this part of the shore platform can look like an open passage and a number of small boats have come to grief in these shallows as recently as December 2023.

The sandstone 'island' is the oldest rock exposed on Long Reef. The feature is a favoured roost for seabirds and their faeces encourage a growth of orange and grey-green lichens on the highest and driest parts of the outcrop. In cross section the outcrop is lenticular and individual beds are cross-bedded, both properties indicating that this sandstone was deposited in a stream channel. It is quartz lithic sandstone with a mineral composition unlike the claystone and has been mapped as Bulgo Sandstone which lies below the Bald Hill Claystone. However, this outcrop may have been misidentified on the geology map as exploratory drilling on Turimetta Head to the north, indicated that the Bulgo Sandstone should be deeper.

At the seaward edge of the outcrop a vertical zoning of intertidal organisms can be seen on the rocks and is attributed to different conditions of exposure to tides and wave splash. Inundation is important in understanding this pattern but so too are the conditions of the rock surface and the varied cracks and crevices formed by joint and bedding planes. At the lowest tide and with little wave action, you may see hundreds of sea urchins (*Heliocidaris erythrogramma*) living in burrows that they have excavated into the rock.

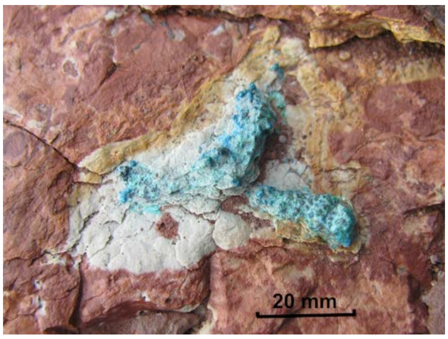
Geosite 6



In the cliff face at the back of the sand spit multiple pale coloured layers in the claystone have been described as fossil soils (palaeosols) of Triassic age. The sequence is referred to as the Long Reef palaeosol series allegedly composed of grey brown podzolic soil profiles which supported a coniferous forest. The paler layers have been described as bleached topsoils over red-brown subsoils. Various lines of evidence such as texture change, supposed traces of soil structure, fossil root traces, and preserved plant remains are claimed to support this interpretation. Although the palaeosol literature is extensive, this interpretation has been questioned and other studies favour a shallow marine environment for deposition of these sediments rather than a terrestrial one.

A point in favour of the sediment being deposited in marine or estuarine conditions is that burrows of the lobster like *Turimettichnus* are common as subcircular or dumbbell shaped traces on the shore platform and as near vertical filled tubes that penetrate the 'soil'. Other strong colour mottles in these beds appear to be various forms of infilled invertebrate burrows.

Somewhere along this southern cliff face there was an attempt to locate copper ore when a tunnel was driven into the cliff probably between 1903-1911.



Little is known about this prospecting venture and no sign of the workings remain. The only clue to the presence of copper being rare blobs of bright green minerals (copper chlorides) in the mudstone that can be seen on the shore platform. You may need to search diligently!

At this point you may climb the path to the lookout at Geosite 7 or walk along the beach on the southern face of Long Reef toward Geosite 8 which will give you another perspective on the sequence along the north side. Dune sand is barely present, the downward fold is there but difficult to identify, and several small faults with polished surfaces (slickensides) can be seen.

Geosite 7

The wide section of the shore platform below the lookout is formed on the relatively soft rocks by a combination of wave erosion and water layer weathering. Waves adjust to the shape of the point and usually break parallel to the shore on both sides. Wave energy is concentrated at the point where erosion rates are rapid and the widest shore platform forms. Most of the shore platform is exposed at low tide and the rock surface is planed almost level by water layer weathering. The sand spit changes shape frequently depending on wave conditions and even the largest boulders on the platform can shift during major storms.

Looking south, the next headland is Dee Why Head which has quite a different shape and only a narrow shore platform. It is formed on Hawkesbury Sandstone which is the younger rock unit above the Newport Formation.

Some researchers have speculated that a fault may explain this apparent disjunct in the geology between Long Reef and Dee Why Head but with the Long Reef rocks dipping (sloping) at about 4^{o} to the south that alone is sufficient to explain the difference.

Proceed west down the path on the south side of the golf course past various sculptures and return to the beach on the boardwalk.

Geosite 8

To the east (toward the Point) a rugged outcrop of bright red rock extends onto the beach. This has been described as a ‘laterite’ allegedly of Miocene age (about 17 million years ago).

The word ‘laterite’ usually carries assumptions about the material having been formed as a soil in a warm humid climate. This outcrop does not have the supposed characteristic physical properties of a laterite profile and it is capped by a thin layer of very young dune sand that some researchers have described as an integral part of the ancient profile. The red rock the same as the boulders seen at Geosite 3 and therefore needs to be considered as a weathered version of a Triassic unit that is conformable with the rest of the sequence. That does not explain what it is, or how it formed, but it is a lead to finding answers. Meanwhile, it remains a geological puzzle.

To the west of the boardwalk ramp on either side of the creek, a layer of muddy peat overlying a sticky grey clay outcrops beneath the dune sand.

The peat contains pollen from; sedges, she-oak, eucalyptus, and tea-tree. Sub-fossil snails found in the peat bed are either *Glyptophysa* or *Isidorella* sp. The pollen and the snails indicate that the peat accumulated in a freshwater pond or swamp, and it has been carbon dated as 3,980 $^{+}/_{-}$ 150 years old, suggesting a changed coastline and/or a different recent sea level.

Further west Long Reef Beach fronts Dee Why Lagoon, which was formed when the beach and foredune closed the mouth of Dee Why Creek about 8,000 years ago. During the last Ice Age (about 20,000 years ago), sea level was 120m lower than present and Dee Why Creek would have run in a valley out to a shoreline perhaps 10km offshore.

Beneath the present beach the bedrock valley is probably ~50m deep. It is the nature of small coastal lagoons that they will gradually fill with marine sediment washing inshore, and terrestrial sediment delivered from the catchment. Dee Why Lagoon is a very shallow, non-tidal ICOL (intermittently closed and open lagoon), and can sometimes drain almost completely exposing a mud bed.

Sand on this beach and in the dunes is nearly all quartz which is quite different from other beaches seen on the Geotrail. The main source is weathered Hawkesbury Sandstone found in the catchment. Before WWII the dunes contained a colony of little penguins.

The lagoon has been subject to recent change and little of its present appearance is ‘natural’. During the ‘Dandenong Storm’ of 1876 the dunes fronting the lagoon moved inland leaving high water mark survey lines in the present surf zone. The storm was named after the sinking of the *SS Dandenong* off Jervis Bay with the loss of 43 lives and should not be confused with another big storm in the Dandenong Ranges in Victoria in 2021. In the 1940s the dunes were flattened and quarried for defence purposes, and it was not until the mid-1970s that any dune stabilisation work and later bush restoration was attempted.

It may be concluded that although a lot is known about Long Reef Headland, there are many knowledge gaps. The good news is that anyone with critical powers of observation can make new discoveries. For example; in 2020 a High School student, Antonio Rajaratnam, was awarded Young Scientist of the Year, by the Science Teachers Association of NSW for rediscovering the sand fairy cicada (*Sylphoides arenaria*) https://dr-pop.net/arenaria-250.htm and

working out its life cycle in this rather messed up area of dune sand, after it had been locally ‘missing’, presumed extinct, for a century.

What other secrets are hidden on Long Reef or indeed in the Ku-ring-gai GeoRegion? Perhaps other geotourists will make new discoveries as they experience the wonders visible along the Long Reef Geotrail.

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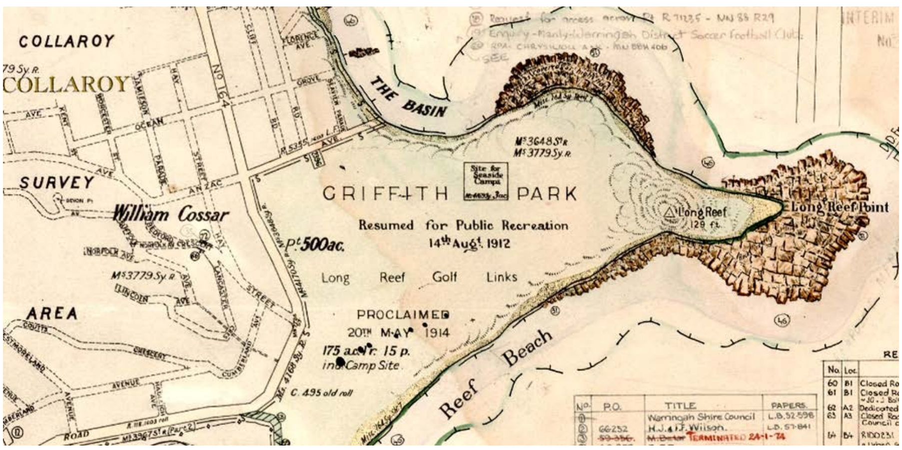


GEOTOURISM EXPERIENCE

of the

GREATER BLUE MOUNTAINS WORLD HERITAGE AREA

linked to

the GEOFEST 2024 SYDNEY WORKSHOP

19 July 2024

Objectives of the Greater Blue Mountains Area Tour

This one-day geological tour to the GBMA will provide the opportunity for participants to observe and understand the geology and the variety of landforms that underpin a truly significant geotourism experience, and to highlight the role of volcanic activity within this geological setting. These include the following.

- High and low-level river terraces on the Cumberland Plain.
- The Hawkesbury River near its tidal limit some 140 km from its mouth in the Tasman Sea.
- Dipping strata from the Wianamatta Group and Hawkesbury Sandstone on the Lapstone Structural Complex (LSC).
- **At the Blue Mountains Botanic Garden at Mount Tomah, columnar basalt (20.1-14.5 Ma), distant views onto the LSC and the opportunity to observe Australian cool temperate rainforest, including the world-famous Wollemi pine.**
- At Blackheath and Katoomba, deep valleys featuring sheer cliffs of Narrabeen Group sandstones above forested slopes through the Illawarra Coal Measures and the underlying marine sediments of the Shoalhaven Group. These valleys with their hard sandstone layers overlying the soft layers of the coal measures and Shoalhaven Group are eroding back into the main plateau of the Blue Mountains. They exhibit numerous geomorphological features such as hanging valleys, rock pinnacles, and waterfalls.
- At Glenbrook and Lapstone, an antecedent stream (Glenbrook Creek) flowing into the high ground of the LSC.

This tour is a key element of the GEOFEST 2024 Sydney Workshop which is being hosted by the Australian Geoscience Council (AGC), the Indonesian Geoparks Network, and The University of Sydney, and co-hosted by generous sponsorship from various AGC societies (The Australasian Institute of Mining and Metallurgy and its Sydney Branch, the Australian Institute of Geoscientists, and the Geological Society of Australia), as well as the Sydney Mineral Exploration Discussion Group. Departing from and returning to The University of Sydney, the tour also provides an educational experience for participating students.

Tour Leader: Geoscientist and Blue Mountains specialist, Dr Peter Hatherly assisted by his professional colleagues, Ian Brown and Angus M Robinson.

Front Cover Photo. *View into the upper Grose Valley, with the heath-covered Lockleys Pylon on the right and (slightly obscured) the Govetts Creek-Grose River junction and Blue Gum Forest on the left. Triassic sandstone cliffs form the rim of the valley. On the horizon, Cenozoic basalts provide a cap to Mount Hay. Image courtesy of Ian Brown*

The Greater Blue Mountains Area was inscribed on the World Heritage List in 2000. It was one of 15 World Heritage places included in the National Heritage List on 21 May 2007.

Outstanding Universal Value - A Brief Synthesis

The Greater Blue Mountains Area (GBMA) is a deeply incised sandstone tableland that encompasses 1.03 million hectares of eucalypt-dominated landscape just inland from Sydney, Australia's largest city, in south-eastern Australia. Spread across eight adjacent conservation reserves, it constitutes one of the largest and most intact tracts of protected bushland in Australia. It also supports an exceptional representation of the taxonomic, physiognomic, and ecological diversity that eucalypts have developed: an outstanding illustration of the evolution of plant life. Several rare and endemic taxa, including relict flora such as the Wollemi pine, also occur here. Ongoing research continues to reveal the rich scientific value of the area as more species are discovered.

The geology and geomorphology of the property, which includes 300 m cliffs, slot canyons and waterfalls, provides the physical conditions and visual backdrop to support these outstanding biological values. The property includes large areas of accessible wilderness near 4.5 million people. Its exceptional biodiversity values are complemented by numerous others, including indigenous and post-European-settlement cultural values, geodiversity, water production, wilderness, recreation and natural beauty.

Criterion (ix): The Greater Blue Mountains include outstanding and representative examples in a relatively small area of the evolution and adaptation of the genus Eucalyptus and eucalypt-dominated vegetation on the Australian continent. The site contains a wide and balanced representation of eucalypt habitats including wet and dry sclerophyll forests and mallee heathlands, as well as localised swamps, wetlands and grassland. It is a centre of diversification for the Australian scleromorphic flora, including significant aspects of eucalypt evolution and radiation. Representative examples of the dynamic processes in its eucalypt-dominated ecosystems cover the full range of interactions between eucalypts, understorey, fauna, environment and fire. The site includes primitive species of outstanding significance to the evolution of Earth's plant life, such as the highly restricted Wollemi pine (Wollemia nobilis) and the Blue Mountains pine (Pherosphaera fitzgeraldii). These are examples of ancient, relict species with Gondwanan affinities that have survived past climatic changes and demonstrate the highly unusual juxtaposition of Gondwanan taxa with the diverse scleromorphic flora.

Criterion (x): The site includes an outstanding diversity of habitats and plant communities that support its globally significant species and ecosystem diversity (152 plant families, 484 genera and c. 1,500 species). A significant proportion of the Australian continent's biodiversity, especially its scleromorphic flora, occur in the area. Plant families represented by exceptionally high levels of species diversity here include Myrtaceae (150 species), Fabaceae (149 species), and Proteaeceae (77 species). Eucalypts (Eucalyptus, Angophora and Corymbia, all in the family Myrtaceae) which dominate the Australian continent are well represented by more than 90 species (13% of the global total). The genus Acacia (in the family Fabaceae) is represented by 64 species. The site includes primitive and relictual species with Gondwanan affinities (Wollemia, Pherosphaera, Lomatia, Dracophyllum, Acrophyllum, Podocarpus and Atkinsonia) and supports many plants of conservation significance including 114 endemic species and 177 threatened species.

The diverse plant communities and habitats support more than 400 vertebrate taxa (of which 40 are threatened), comprising some 52 mammal, 63 reptile, over 30 frog and about one third (265 species) of Australia's bird species. Charismatic vertebrates such as the platypus and echidna occur in the area. Although invertebrates are still poorly known, the area supports an estimated 120 butterfly and 4,000 moth species, and a rich cave invertebrate fauna (67 taxa).

Various Eucalypt species commonly observed along the ridge lines between the Grose and Jamison Valleys. Scribbly gum (*E. racemosa*) to the left and Black Ash (*E. sieberi*) to the right. Image courtesy of Ian Brown

Geological Background Highlighting Evidence of Volcanic Activity Within the Sydney Basin

At 50-100 km to the west of Sydney and beyond the Cumberland Plain, the Blue Mountains lie on the eastern flank of Australia's Great Dividing Range. This range has a length of 3,500 km and forms a watershed between river systems draining eastwards to the Coral and Tasman Seas and river systems draining westwards into the interior of Australia. The Great Dividing Range was initially uplifted 120-80 Ma as a rift shoulder associated with the breakup of Gondwana. In the Blue Mountains, rocks of the Permo-Triassic Sydney Basin overlie older Palaeozoic rocks of the Lachlan Orogen.

During the Late Carboniferous and Early Permian, the Sydney Basin developed as an extensional rift which became a foreland basin later in the Permian and Triassic. With an estimated maximum thickness of 4 km of rift volcanics and another 4 km of sediments, the Sydney Basin is about 250 km long and averages 100 km in width. Significant coal deposits formed in the late Permian and coal mining is currently underway to the south, west and north of Sydney where the basin thins and coals either outcrop or lie at depth suitable for underground mining. In the GBMA, coal was once extracted at Katoomba for local consumption purposes and is currently mined on its western margins, underlying the Gardens of Stone Conservation Area.

The world-wide Permian-Triassic extinction event marked the end of coal formation and the start of the deposition of a thick sequence of Triassic sandstones, siltstones and claystones of the Narrabeen Group and then the Hawkesbury Sandstone. The Hawkesbury Sandstone is quartz rich and typically about 200 m in thickness. It forms the spectacular cliff-lines around Sydney Harbour and is the building stone for many old buildings in Sydney, including the University of Sydney.

Overlying the Hawkesbury Sandstone are the shales and siltstones of the Triassic Wianamatta Group. Both the Wianamatta Group and Hawksbury Sandstone outcrop in the Sydney region. The Wianamatta Group lies at the top of the Sydney Basin sequence and its original thickness is not known. Not is it known whether any Jurassic strata have been present. Coal vitrinite and gas content studies suggest that there has been 1-2 km of denudation in the Sydney area since uplift in the Cretaceous.

Considering its essentially and dominantly sedimentary nature, the Sydney Basin hosts a remarkably diverse range of igneous rocks, both intrusive and extrusive. Jurassic and Cenozoic volcanic and intrusive activity in the Sydney Basin is strongly biased towards alkali basalt and differentiates such as microsyenite. Early Middle Jurassic activity has been identified in the Ku-ring-gai GeoRegion, an area just north of Sydney in which one of the world's best exposed diatreme complexes is located.

After the uplift of the Great Dividing Range, there has been widespread volcanic activity across eastern Australia. With ages ranging from 60 Ma to 10 Ma and no dominant spatial or temporal patterns, reasons for this intraplate volcanism are still the subject of research.

It appears that the origins are due to lithosphere/mantle interactions which have also created dynamic topography which has led to further uplift. However, the Cenozoic basalt flows at Mount Tomah and the nearby Mount Wilson, Mount Banks, and Mount Hay locations are regarded as important landform features of the Sydney Basin within the confines of the GBMA.

Since about 10 Ma, the Australian Plate has been subjected to a compressive stress field. In the east of the country this is due to ridge push from the south and compression at the boundaries with the Pacific Plate in the east and north. This compression has resulted in neotectonic uplift and associated seismicity in several locations in New South Wales, Victoria and South Australia. In the Blue Mountains, the eastern front to the range is a prominent escarpment known as the Lapstone Structural Complex (LSC). The LSC is due to this compression. Pre-existing rivers form antecedent valleys and river gravels have been stranded on the crest of the escarpment.

The Blue Mountains form a major part of the catchment for the Wollondilly-Nepean-Hawkesbury River system. Known as the Hawkesbury River where it flows into the Tasman Sea 35 km to the north of Sydney, this river flows across the Cumberland Plain after it exits the mountains near Glenbrook. Here, alluvial gravels occur at heights of 170 m above current river levels. These elevated gravels are thought to be of late Pliocene age.

Points of interest

a. <u>Sydney to the Cumberland Plain and the Hawkesbury River at Richmond</u>

Heading west from Sydney, most suburbs are located on either the flat-lying Hawkesbury Sandstone or the shales of the overlying Wianamatta Group. Road cuttings, where not vegetated or shotcreted provide the opportunity to observe these rock types. South of the harbour, streams are close to sea level. To the north, where the land is more elevated, sharp valleys are cut into Hawkesbury Sandstone.

About 30 minutes after our departure from The University of Sydney, we leave the expressways, and the coach takes us along Richmond Road. Here, shales outcrop, and the land was previously used for agriculture. These areas are now being used for housing developments to help cater for Sydney's growing population.

The housing developments reach as far as South Creek. South Creek (also known as Wianamatta Creek) flows northwards into the Hawkesbury River. The elevation at Richmond Road is less than 10 m and the land is obviously flood prone. It provides a corridor for power lines servicing Sydney.

Beyond South Creek, the ground surface flattens and Richmond Road crosses elevated terraces (elevation of about 20 m) which are paleo flood plains of the Hawkesbury River and thought to be of late Cenozoic age. The 10 m thick Londonderry Clay is at the ground surface. It overlies the coarse Rickabys Creek Gravel which is of similar thickness. The terraces overlie the shales of the Wianamatta Group.

In places, the road passes through nature reserves featuring Cumberland Plain woodland. Prior to European settlement in the early 1800's, woodland such as this was present throughout this area.

About 12 km after South Creek, Richmond Road leaves the high terraces and enters rich agricultural land lying on more recent floodplains. The road crosses Rickabys Creek where the elevation is less than 10 m, and the land is again flood prone. Beyond this there is a slight rise to a terrace and the town of Richmond (elevation 20 m).

Between Rickabys Creek and Richmond, there are good views to the west of the sharp escarpment of the LSC about 15 km further on. To the southwest (left side of coach), the line of the escarpment is broken by the valley of the east-flowing Grose River. Our excursion circumnavigates the Grose River and here we are seeing where it leaves the Blue Mountains prior to joining the Hawkesbury River just to the south of Richmond. The Grose River and several other streams exiting the mountains are antecedent and pre-date the development of the LSC.

Immediately after Richmond, the road drops off the Richmond terrace onto a low-lying Holocene flood plain. At the end of the plain, the road crosses the Hawksbury River on a low-level bridge which is frequently flooded. Here, the Hawkesbury River is at sea level, despite being some 140 km from its mouth in the Tasman Sea. Tidal changes of about 0.5 m are experienced at this point. The actual tidal limit is just a few km to the south.

The road climbs the west bank of the Hawkesbury River and enters the town of North Richmond.

b. <u>North Richmond to Blue Mountains Botanic Garden, Mount Tomah</u>

Beyond North Richmond our road (now known as the Bells Line of Road) is above the flood plains and the terraces of the Hawkesbury River and lies on the shales of the Wianamatta Group. These shales can be seen in road cuttings to either side of the coach. The road ascends the foothills leading to the LSC. This impressive structure can be seen ahead of the coach and to either side.

In this part of the Blue Mountains, the underlying structure of the LSC is likely to be a fault-propagation fold where an underlying west-dipping thrust is approaching the ground surface. An anticline has formed above the fault. As we will see, on the western side of the LSC there are steep, west-dipping beds. Again, we are close to the boundary between the Wianamatta Group and the Hawkesbury Sandstone. There is a strong topographic expression of the geological structure.

west *east*

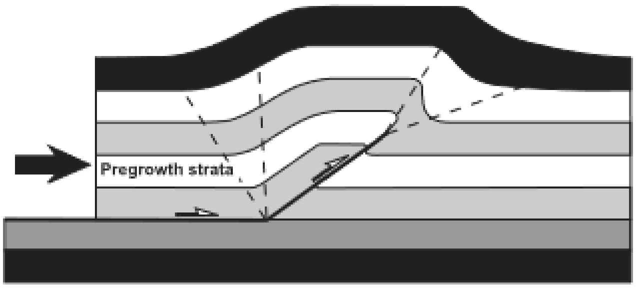


Diagram from McClay, et al., AAPG Memoir 94, 1-19.

After crossing Little Wheeny Creek, Bells Line of Road begins the steep climb up the east face of the LSC. In the first instance, shales are present (note the weedy vegetation) but higher up we enter sandstone. The vegetation changes to typical open bushland and dipping beds of sandstone can be observed in the road cuttings.

At Kurrajong Heights the crest of the LSC is at about 600 m. Shales are again present and the land has been cleared for housing and farms. As it was during the ascent of the LSC, there are good views eastward onto the Cumberland Plain and low hills (Hawkesbury Sandstone) further to the north.

The road then descends a tight valley through the underlying sandstone. At the point where the road exits the valley, steeply dipping sandstone beds can be briefly observed to the left of the coach at a location known as Cut Rock. These beds form the western side of the LSC. The road has descended about 130 m and here, this western side of the LSC is referred to as the Kurrajong Fault.

Ahead, there are sharp hills on the horizon. These hills define a line of Cenozoic basalts (20.1-14.5 Ma). The basalts originally flowed down a NE trending valley, but erosion has caused topographic inversion with the basalts now forming a ridge line. Mount Tomah forms one of these landforms.

The ridge that Bells Line of Road follows beyond Cut Rock, eventually leads to the western side of the Blue Mountains. To the south there is the valley of the Grose River and to the north there is the valley of the Colo River. In the first instance shales of the Wianamatta Group are outcropping. The shales combine with the cooler temperatures at these higher elevations to provide good conditions for growing fruit. Numerous orchids and roadside stalls selling fruit will be seen. Road cuttings will mostly show the presence of shale.

20 km beyond Cut Rock, the road climbs 200 m to Mount Tomah (elevation 1,000 m). We have seen the last of the shales and the underlying Hawkesbury Sandstone has both thinned and been eroded away. Beyond Mount Tomah, the sandstones of the Narrabeen Group represent the main outcrops.

The basalt at Mount Tomah has a maximum thickness of at least 110 m. Weathering has given rise to rich soils on which cool temperate rainforest naturally occurs. The Blue Mountains Botanic Garden at Mount Tomah occupies 28 ha and contains a combination of formal gardens and rainforest. We visit the gardens for morning tea and some brief tours.

c. **STOP 1: BLUE MOUNTAINS BOTANIC GARDEN, MOUNT TOMAH**

Much of the Blue Mountains lie within the Blue Mountains World Heritage Area (1 million ha). Down the stairs within the Visitor Centre, there are excellent displays and interpretative material on the World Heritage Area. This includes a film (15 minutes duration). Wait for the spectacular conclusion!

The walls and gardens adjacent to the pathway leading to the Visitors Centre utilise blocks of columnar basalt. Some of this basalt comes from Mount Tomah but most of it has been brought in from other sites. Soil profiles developed from the basalt have enabled the development of a showcase of local and imported cool climate plants and alpine rainforest.

From the viewing deck of the Visitor Centre where we will enjoy morning tea/coffee, there are splendid views to the north and east from where we have travelled. On the northern horizon, the ridges are the inverted topography of the basalt caps. These get progressively lower as they swing towards the east. The last two caps have been cleared for agriculture (Mount Tootie). Further to the east, the LSC marks the end of the Blue Mountains. To the left, towards the northern end of the LSC, there is an obvious break in the ridge line. This is the antecedent gorge of Wheeny Creek. During the uplift of the LSC, this creek was able to maintain its easterly course by cutting through the rising ground. Further to the south, the antecedent gorge of the Grose River can also be seen. Unfortunately, the viewing angle is not optimal.

For a good 10-minute walk to see cool temperate rainforest and plantings of the iconic Wollemi pine, take the path at the north (left) of the viewing platform. This path curves leftwards past some buildings and across a lawn. Cross the road beyond the lawn and follow the sign for the Darug Walk. At the bottom of the stairs there is a branch to the left for the Gondwana Walk. Take this path. Along it there are some excellent signs explaining the development of the Australian flora and fauna following the break-up of Gondwana some 120 Ma. There are also groves of Wollemi pine. This tree was discovered in 1994 growing in a remote canyon in the northern Blue Mountains. The tree belongs to the 200-million-year-old Araucariacea Family, and it is present in the fossil record from 90 Ma. Relatives include Kauri, Hoop and Monkey Puzzle pines. There are less than 100 mature trees in the wild and they have no genetic diversity. Since the discovery there has been a successful campaign to cultivate these trees. The trees here are plantings. Wollemi pines are now growing in botanic gardens and other gardens around the world.

At the end of the Gondwana Walk you will see the car park and Visitor Centre. To read the signage and properly view the rainforest and Wollemi Pines, allow 20 minutes for this walk.

Another 10-minute walk allows you to see some basalt in-situ and columnar jointing. From the entrance to the Visitors Centre on the car park side, turn left and follow the road below the formal garden past a water tank on the right and a sign concerning rhododendrons on the left. There is a picnic area. Take the path at the rear on the righthand side and you will soon see the basalt outcrop. Return the way you have come.

d. Mount Tomah to Blackheath

After leaving Mount Tomah, the Bells Line of Road descends steeply off the basalt cap and swings around another basalt cap (Mount Bell) before continuing in a general westward direction. Along this section of the road, you will see burnt eucalypt forest. This area was badly burnt in the huge bushfires of the summer of 2019/20. These fires burnt approximately 80% of the World Heritage Area. The years since have been very wet, and floods have caused a great deal of erosion.

About 9 km from Mount Tomah, there is a turnoff to the left to **Mount Banks which is another basalt cap**. Soon after, on the lefthand side of the coach you will see wonderful views into the cliff-lined Grose Valley. This valley extends below the base of the sandstones of the Narrabeen Group and into the Illawarra Coal Measures. These rocks are much less resistant to weathering and erosion. The Grose River, once it reached the level of the Coal Measures, has rapidly eroded these weaker strata. This has undermined the sandstones. Collapse along vertical joint systems has created the spectacular cliff lines.

12 km further on, we leave the Bells Line of Road and drive south along the Darling Causeway to join the Great Western Highway at Mount Victoria. Along the Darling Causeway, you will see to the right, cleared agricultural land in the broad valley of the Coxs River. The Coxs River eventually flows into the Hawkesbury River and the rocks in this valley are from the Palaeozoic basement rocks to the Sydney Basin. The land has been cleared because it is more suitable for farming. On the horizon is the Great Dividing Range.

The railway line on the lefthand side of the road is the main western railway line. This railway line goes as far as Perth, Western Australia. The bushland to both sides of the Darling Causeway was all shockingly burnt in 2019/20. Some recovery is underway, but many trees have been killed.

Once the Darling Causeway reaches Mount Victoria, we join the Great Western Highway and turn left. This highway is the main road across the Blue Mountains, and we will follow it back to Sydney. It is a short distance to Blackheath where we will turn left and visit Govetts Leap Lookout (elevation 1,000 m).

e. **<u>STOP 2: GOVETTS LEAP LOOKOUT</u>**

At Govetts Leap lookout there are splendid views into one of the two arms of the cliff-bound Grose Valley. The cliffs are the sandstones of the Triassic Narrabeen Group. There are two major sandstones separated by a claystone band (Mount York Claystone) which forms a vegetated ledge midway down the cliff face. The vegetated hillsides below the cliffs are within the Permian Illawarra Coal Measures and the underlying marine sediments of the Shoalhaven Group. In addition to coal, the coal measure sequence includes claystones, siltstones and some sandstones. These and the basal marine sediments are much less resistant to weathering and erosion and through their erosion, the valley is actively opening. The Narrabeen Group sandstones get undermined and cliff collapses occur along vertical joint systems. Large sandstone blocks from the cliffs sometimes tumble to the base of the streams hundreds of metres below.

To the right of the lookout, there is the spectacular 180 m high Govetts Leap (Bridal Veil Falls). The stream leading to the waterfall is in a shallow valley and it is very clear that the waterfall is a huge knickpoint whereby the coupled erosional processes on the cliffs and the valley below are progressively causing this knickpoint to make its way upstream. The upstream valley can be thought of as a hanging valley. In time, these erosional processes will lead to the consumption of the plateau on which Blackheath and other towns in the upper Blue Mountains are located.

Standing out from the cliff face to the left of the lookout, the prominent pinnacle is Pulpit Rock. This pinnacle has been left standing while the cliffs around it have collapsed. The famous Three Sisters at Katoomba represent a similar set of pinnacles.

On the horizon to the right (southern side) of the Grose Valley, **the domed mountain is Mount Hay. This mountain has a basalt cap (inverted topography) similar to that on Mount Tomah. The basalt is of the same age as Mount Tomah and the other basalt caps, all of which are located on the northern (left hand) side of the Grose Valley. It is thought these basalts were all connected at the time of their formation (youngest age 14.5 Ma). It therefore follows that this is the maximum age of the current Grose Valley.** Over this time there has been at least 700 m of vertical incision. Presumably coupled knickpoint retreat and the rapid erosion of the Illawarra Coal Measures and Shoalhaven Group have played significant roles.

We will enjoy a short walk through the bushland to visit the George Phillips Lookout where Ian Brown, a noted Blue Mountains geomorphologist, ecologist and photographer, will interpret flora characteristics of this bushland setting.

f. <u>Blackheath to Echo Point, Katoomba</u>

From Blackheath to Katoomba (about 10 km), the Great Western Highway runs along the plateau separating the Grose Valley to the north and deep valleys to the south where the Coxs River flows. There are occasional views into the southern valleys, especially at Medlow Bath.

Katoomba is the main town of the Blue Mountains, and we stop here for lunch at the Blue Mountains Cultural Centre (1020 m elevation).

g. STOP 3: BLUE MOUNTAINS CULTURAL CENTRE

The Blue Mountains Cultural Centre at Katoomba also features a variety of A/V displays about many aspects of the natural and cultural heritage of the Greater Blue Mountains Area.

From the upstairs balcony of the Cultural Centre, there are magnificent views to the south across Katoomba and the valleys beyond. Katoomba itself is located on the remnant plateau lying between these valleys and the Grose Valley to the north. The processes observed at Govetts Leap are also actively eroding into the plateau at Katoomba. In this case, the main valley is Jamison Valley and the stream draining it flows into the Coxs River. The cliffs to the right of the valley form the Narrow Neck Peninsula, so named because valley forming processes operating from both sides have almost completely cut through this south trending remnant of the plateau. In places the peninsula on top of the precipitous cliffs is only a few tens of metres wide.

Directly to the south, the mountain on the far side of Jamison Valley is Mount Solitary. Here, the erosional processes have cut through the sandstone plateau connecting Mount Solitary to Narrow Neck Peninsula. Mount Solitary now stands as an isolated mesa with a low ridge containing remnants of the plateau connecting it to Narrow Neck Peninsula.

With good visibility, isolated mountains can be seen on the far horizon. Most of these have basalt caps like those observed around the Grose Valley and Mount Tomah. This entire area forms the southern part of the Blue Mountains World Heritage Area.

h. STOP 4: ECHO POINT

After lunch, we take a short drive to Echo Point to see the most famous view of the Blue Mountains. From Echo Point, the view is mainly of the Jamison Valley with Mount Solitary directly to the south and the cliffs of Narrow Neck to the west (right). These cliffs are all sandstones from the Narrabeen Group. As it was at Govetts Leap, there is a vegetated ledge halfway down the cliff faces where there are claystone bands from the Mount York Claystone. Beneath the cliff lines lie the Illawarra Coal Measures and underlying marine strata. The same cliff and valley forming processes described for Govetts Leap are in operation here. There are several waterfalls which tumble over the cliffs from the hanging valleys of the plateau.

Immediately to the left is the wonderful view of the Three Sisters. The reason for their name is obvious. They are remnant pinnacles, and the Mount York Claystone is located midway down the cliff face. There are numerous walking tracks available for the many tourists who visit this area. Some descend into the valley and around the base of the cliffs. In recent years there have been some fatalities caused by rock falls. Management of the geotechnical risks associated with these very popular trails has become a major issue for the authorities concerned. However, we will traverse along an easy pathway to briefly visit the Three Sisters. Passing through the archway, next to the Echo Point Visitor Centre, and you'll soon be surrounded by soaring eucalypt forest, banksia flora, and bird calls. As we walk along the gently sloping path for 400 m to Oreades lookout, Ian Brown will be our specialist ecological guide. Marvel also at the views of the Three Sisters' weather-eroded sandstone turrets, and the hazy 'blue' Jamison Valley stretching to Mount Solitary.

From here, steps lead a further 50 m to Lady Game lookout, for a closer view of this remarkable rock formation. A short but very steep set of stairs at the top of the Giant Stairway leads to Honeymoon Bridge, which connects to the first sister.

The Three Sisters landscape highlights Aboriginal connections with Country through the telling of one of three different cultural stories about how this landscape was created during the Dreamtime.

i. Katoomba to Glenbrook/Lapstone

We now follow the Great Western Highway for about 40 km as it makes its way eastwards, down through the towns of the Blue Mountains. In the first instance the outcropping sandstones are from the Narrabeen Group and there will be occasional views to the right (south) into Jamison Valley and to the left (north) of the **basalt covered peaks of Mount Banks, Mount Hay, and Mount Tomah**. The highway then starts to traverse the Hawkesbury Sandstone and the views will be mainly of the towns and bushlands of the lower Blue Mountains.

j. STOP 5: GLENBROOK AND LAPSTONE

Glenbrook (elevation 200 m) is located immediately to the west of the LSC. Our stop is at Chalmers Lookout which is on the crest of the LSC and looks westward, just a short walk from the coach.

From this lookout, on a clear day, there is a good view of the lower Blue Mountains towards the plateau of the upper mountains which lies on the horizon. On the horizon to the right, Mount Hay can be seen. Below, the land drops steeply. Glenbrook is to the right and Glenbrook Creek is in the valley lower down. The steep hillside below us is the Glenbrook Fault, but as with the Kurrajong Fault at Cut Rock on the Bells Line of Road, the fault is represented by a narrow band of steeply dipping sandstone.

It can be seen that Glenbrook Creek is an antecedent stream because it flows directly into the elevated ground of the LSC. A relatively young age for the LSC can also be inferred because Glenbrook Creek, where it passes through the LSC, is in a narrow 180 m deep cliff-lined gorge of Hawkesbury Sandstone. There has been insufficient time for the valley to broaden into the form it has in the upstream reaches of Glenbrook Creek seen to the west.

On returning to the coach, and to see more of Glenbrook Gorge and the Cumberland Plain to the east, we can simply take a very short walk of some 50 m to another lookout where we can discern the valley of the Nepean River just as it is about to exit the Blue Mountains and onto the Hawkesbury–Nepean Valley flood plain. The Coxs River which drains the southern side of the upper Blue Mountains flows into the Nepean River via Lake Burragorang and Warragamba Dam, Sydney's main water supply. The Hawkesbury–Nepean Valley is one of the most complex floodplains in Australia. The unique landscape and large existing population in the Hawkesbury-Nepean Valley make this part of Western Sydney one of the highest flood risk areas in Australia.

k. Glenbrook and Lapstone to Sydney

It is now time to return to Sydney via Lapstone. Our coach rejoins the Great Western Highway on the eastern face of the LSC. The sandstone beds of Hawkesbury Sandstone are steeply dipping and at the junction with the highway, there are large rock bolts in the cutting to the left which have been installed to stabilise the strata.

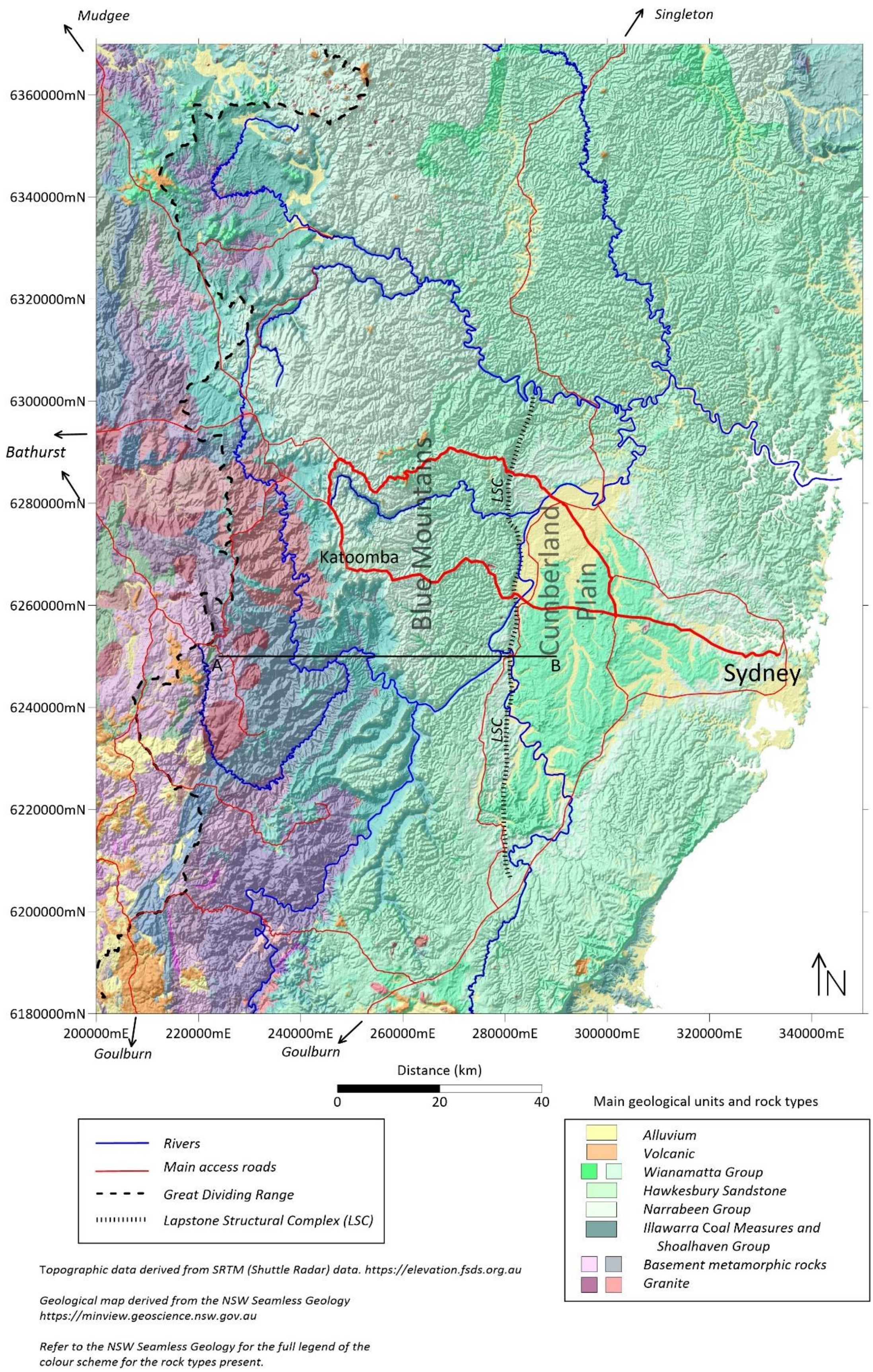
At the base of the LSC, the highway curves to the right and onto the Cumberland Plain. In the road cutting at this point, thinly bedded sandstones and siltstones of the Mittagong Formation can be observed. This is the basal unit of the Wianamatta Group. Minor structures associated with the flexure of the LSC can also be seen.

Once on the plain, the highway becomes an expressway. To the right of the bridge crossing the Nepean River, the gorge marking the exit of the river from the mountains can be seen. The river is at an elevation of less than 10 m and at this point it has been dammed by a weir a few km downstream (left hand side). Once across the river, the expressway crosses elevated terraces and then enters gently undulating hillsides where shales of the Wianamatta Group outcrop. South Creek and its flood plain are crossed at 11 km from the bridge over the Nepean River. Just as was the case on Richmond Road, the region east of South Creek is part of the densely urbanised suburbs of Sydney.

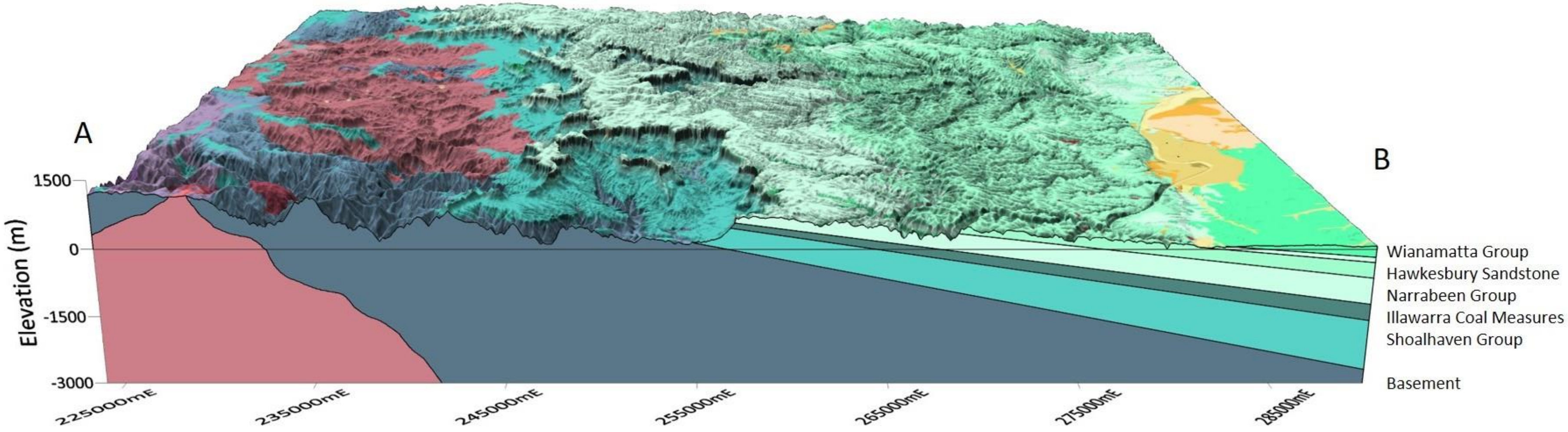
Further reading

Hatherly, P. and Brown, I. 2022. The Blue Mountains: exploring landscapes shaped by the underlying rocks, uplift and erosion. Windy Cliff Press, Mount Victoria, New South Wales 196 pp.

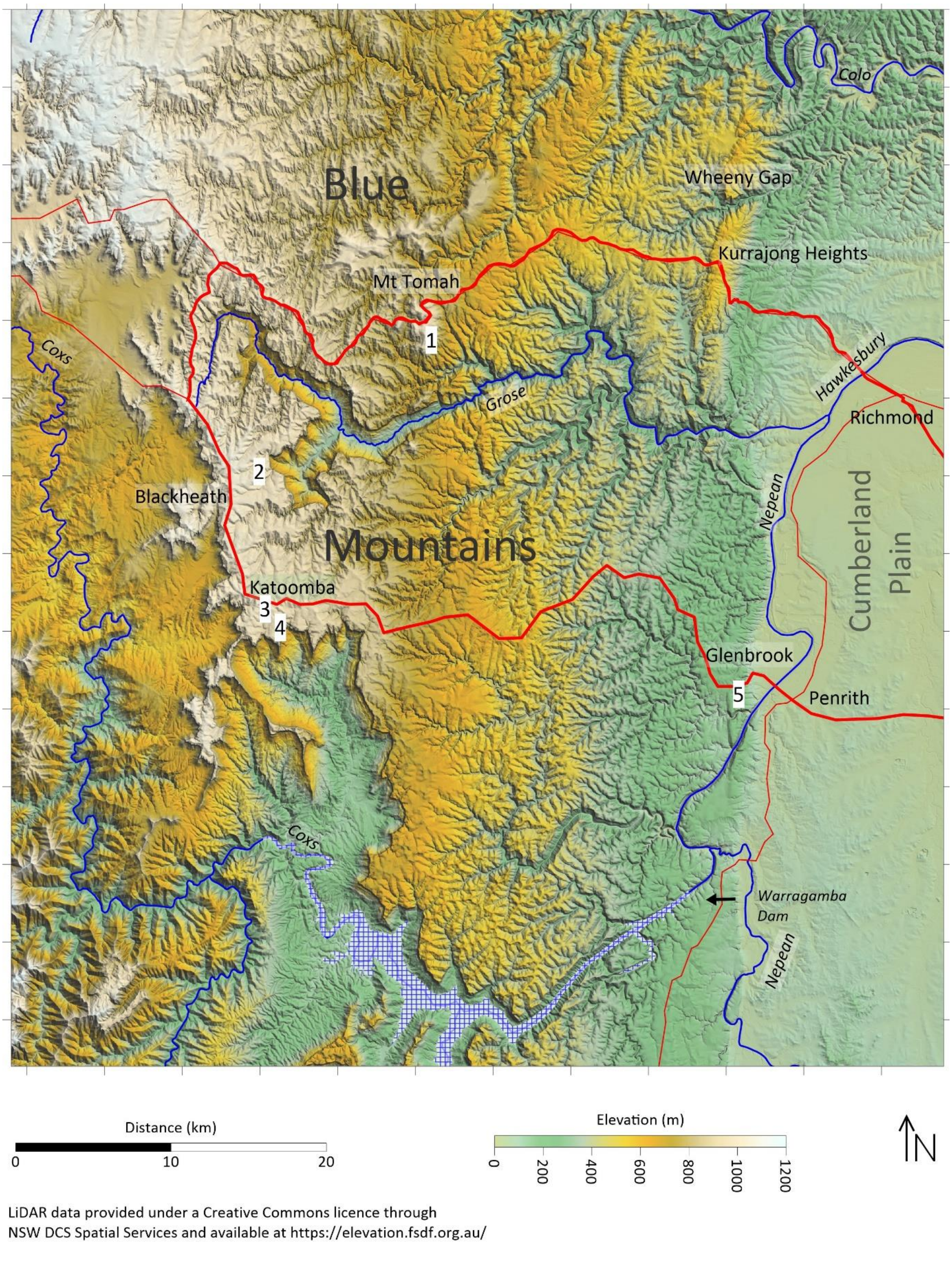
Pickett, J.W. and Alder, J.D. 1997. Layers of time: the Blue Mountains and their geology. New South Wales Department of Mineral Resources, Sydney 34 pp.



Geological map of the Sydney area and Blue Mountains. The route of the excursion is shown by the thick red line.



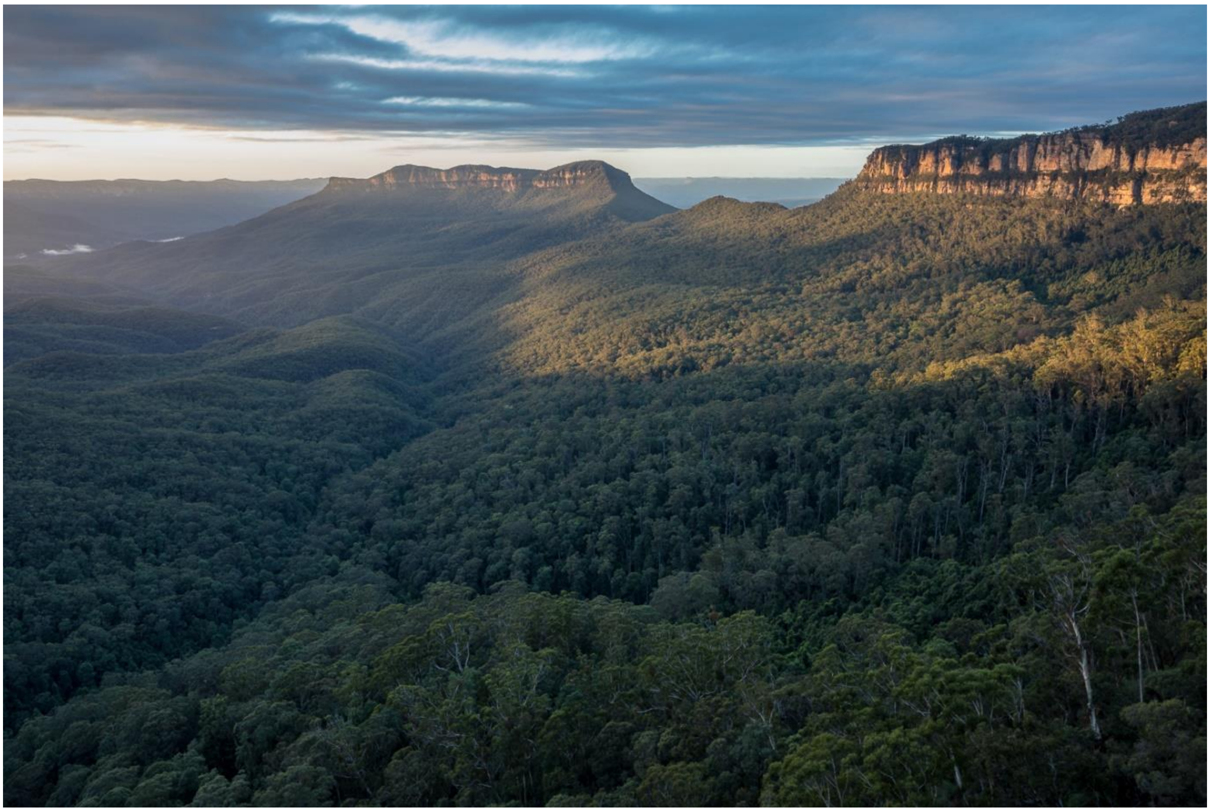
A cross section through the Blue Mountains showing the eastward dip and thickening of the main units of the Sydney Basin



Topographic map of the Blue Mountains showing the route of the excursion (thick red line), stops, major towns and other features of interest.

Mount Tomah Botanic Gardens looking east and displaying use of basalt blocks forming part of the garden landscaping. Image courtesy of Angus M Robinson

The Three Sisters viewed from below Echo Point. Image courtesy of Angus M Robinson



Mount Solitary viewed across the head of Jamison Valley from Narrow Neck Peninsula near Katoomba. The remnant sandstone blocks of Ruined Castle rise between, with the Southern Highlands on the horizon. The slopes below the Triassic sandstone cliffs are composed of weaker Permian sediments, and basement rocks of the Lachlan Orogen are exposed in the depths of the valley. Image courtesy of Ian Brown

GeoFest Sydney 2024

Kiama - Bombo: Eastern Australian volcanism, geoheritage and geotourism

SYDNEY WORKSHOP AND FIELD TRIPS / 18 - 19 July 2024

FIELD TRIP ORGANISERS

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Sponsors and Supporters of GeoFest Workshop

Sponsors of Kiama-Bombo Field Trip

NSW Division

Field trip notes acknowledgement
These notes are adapted from a previous Deep Carbon Observatory field trip and other notes - with contributors including Sabin Zahirovic, Kelsie Dadd, Chris Fergusson, Dietmar Muller, Adriana Dutkiewicz, and Sara Moron.


The 5th
Geotourism Festival
& International
Conference
Ijen - Rinjani - Sydney
July 2024


GEOFEST 2024
SYDNEY WORKSHOP
18th and 19th July 2024
Sydney, Australia
Post conference event of the 5th
Geotourism Festival & International Conference
An Australian – Indonesian collaborative project
"Volcano as a World Class
Sustainable Geotourism Destination"

Kiama - Bombo Field Trip

Friday 19 JULY

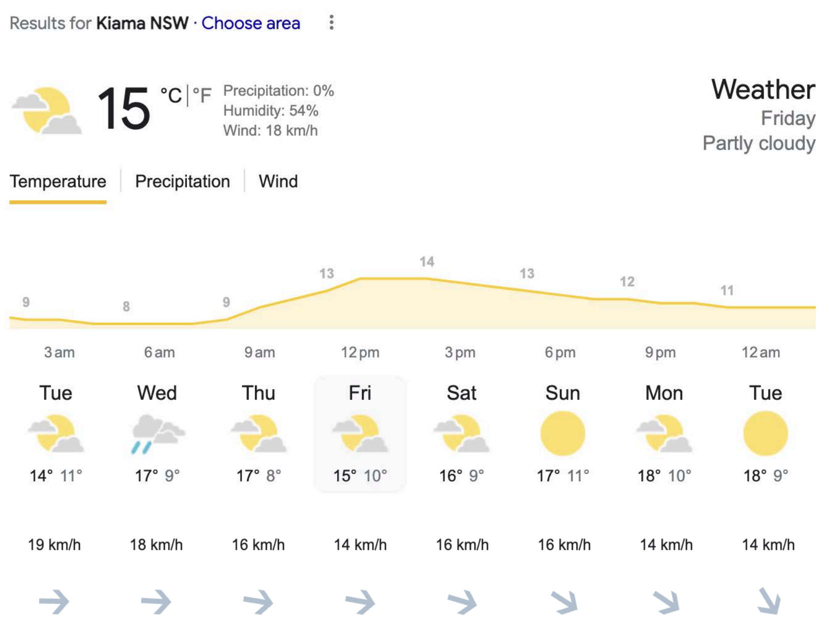
Field trip safety overview

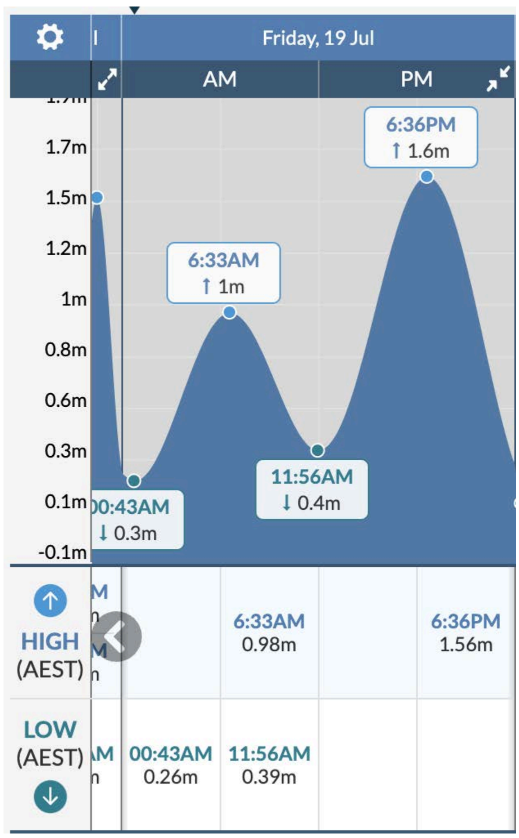
On Friday, 19 July 2024, about 20 participants will board two mini-buses in front of the Chau Chak Wing Museum on the University of Sydney Campus at 7:30-8 am. Others will meet us at the field trip locations. The bus will be loaded with first aid equipment and some emergency bottled water.

Safety is paramount. We will stay in one group, and no participants should ever be alone in the field (especially near water). Please listen out to announcements, and particularly the safety briefing at the first stop. If you have any concerns, let the field trip organisers (such as Sabin) know immediately. Please look out for your own safety, as well as the safety of those around you. Although the field areas are not remote, there is a requirement of moderate physical fitness, especially in terms of navigating the terrain on/around the beaches and headlands. Make sure you have weather-appropriate clothing, including hats and sunscreen, and jacket and scarf as it can get windy.

We will make several stops during the day for toilet breaks, and we will be on our way back to the University of Sydney from the last stop at around 4 pm. Given that this is peak hour, we hope to be back by 6 pm, but in an extreme case of road closures and accidents, we may arrive as late as 7 or 8 pm. Ensure that you have enough water, medication, clothing, and other materials for the duration of the field trip. Please read all of the information below carefully.

Weather and Tide Forecast for Kiama





Field trip safety rules

- No field work will be done after sunset or in very low light (after 5:07 pm)
- Sturdy closed footwear suitable for field conditions (rocky and potentially slippery terrain) is essential
- Broad-brimmed hat, sunglasses, sunscreen, and raincoat/rainpants (if raining) are essential
- Bring any personal medication with you, including painkillers and antihistamines/epi-pens
- No geological hammers are to be used for both safety and heritage/conservation reasons (bring a hand lens!)
- We will stay in one large group - no participant is to be alone (especially near water) in the field
- Drink plenty of water and keep yourself and other team members safe at all times
- Do not enter the water at the field sites, as this is not part of the field trip
- Report any incident (illness, accident, etc.) to workshop organisers immediately, or at least within 24 hours (this is a legal requirement)
- Adhere to the precautions in the table below, as well as exercise safety and common sense in all other scenarios

Potential Hazard	**Description**	**Precautions**
Tripping	Tripping on rocks and other uneven ground, or even entering/leaving bus.	Be aware of your environment at all times. Must wear sturdy/closed footwear appropriate for field work, such as hiking shoes/boots with good grip.
Slipping	Slipping on wet surfaces, including rocks covered in algae at low tide.	Do not step on surfaces covered with algae, and avoid stepping on wet surfaces. If raining, take extra precautions. Footwear with good grip is essential.
Dehydration	Not drinking enough water.	Ensure you have a bottle of water with you. Drink water regularly. We will make several toilet stops throughout the day.
Manual handling	Lifting heavy or bulky gear, including packed food or drink packs. Lifting rocks.	Ask others for help, and exercise safe lifting procedure (lift with legs, not your back, etc.). Do not lift rocks larger than a closed fist!
Exposure - sun, wind, water, temperature	Sunburn is guaranteed if not wearing sunscreen, and temperatures and wind likely to make it very cold on the exposed beaches and headlands.	Make sure you apply and reapply sunscreen, and wear a broad brimmed hat and sunglasses. Wear warm clothing (layers), bring a raincoat, and preferably a change into dry clothes.
Road/vehicle accident	There is always a small risk of road accidents. Crossing the road is a bigger threat to safety.	Ensure you wear the seat belt during transit on the bus. Cross any road very carefully, especially where visibility is limited. This is especially the case for international participants. Exercise caution in car parks and on roads.
Allergic reaction	Bee stings and other environmental conditions, or inadvertent contamination of food.	Carry epi-pen and/or antihistamines if you have any allergies. Check your food before consuming, in case there was an obvious mix-up.
Rock falls	Edges of cliffs may break off, or rocks may tumble down cliffs to outcrops.	Do not stand near the edge of cliffs, and visually inspect any outcrop or cliff face for rocks that may be easily dislodged.
Falling	Falling off rocks or even the edge of a	Tripping and falling off an outcrop or even coastal cliff is

	rock cliff.	potentially extremely dangerous. People have died on the NSW coast by attempting to take "selfies". Please exercise extreme caution, and stay away from cliff edges.
Lightning	Thunderstorms that can sweep through very quickly.	Lightning strikes can be fatal, and the risk is higher in exposed areas such as beaches and headlands. Field trip activities will be cancelled in the case of a severe storm or lightning storm, and attendees will be required to return to the bus.
Dangerous animals - marine life, snakes, spiders	Snakes may be sunbathing on rocks, while spiders may be hiding underneath rocks. Blue-ringed Octopus in rock pools can also be deadly. Ant, bee, and other insects may sting.	Approach all outcrops slowly, and be aware of your environment. Make noise as snakes will prefer to escape. Try not to overturn rocks bigger than a closed fist. Avoid interaction with Blue-ringed Octopus at all cost, do not approach or handle, under any circumstances. Be aware of any insects that may be around or on rocks.
Bushfires	Bush fires can start during dry and warm weather, or even during lightning strikes. Occasionally, back-burning, accidental fires, or intentional fires may be lit.	Smoking is discouraged on the field trip. Do not light any fires. If any smoke or fire is visible, alert others, and evacuate the field area safely.
Rogue waves	Some waves can be much higher than others - called "significant waves". These can surprise people on headlands, and in extreme cases can wash people off the headland.	Keep your distance from the water, and keep an eye on the water conditions - including waves. Under no circumstance should attendees walk off on their own out of sight from other field trip participants.
Tsunami	Very unlikely, but remotely possible - can be triggered by distal earthquake or proximal submarine landslide.	If water recedes suddenly or is unusually low, alert others, and proceed to higher ground.
Others ?	Alert Sabin (sabin.zahirovic@sydney.edu.au) to any other potential safety issues.	

Image: Blue-ringed Octopus (Animal Planet) - these live in/around rock pools, stay away from them!

Emergencies, incident reporting, and nearest hospitals

In any emergency, call 000 immediately.

Wollongong Hospital (closer to field sites, with Emergency Dept)
Loftus Street
Wollongong
NSW 2500
Ph: (02) 4222 5000

Royal Prince Alfred Hospital (closer to workshop site, with Emergency Dept)
50 Missenden Rd
Camperdown NSW 2050
Ph: (02) 9515 6111

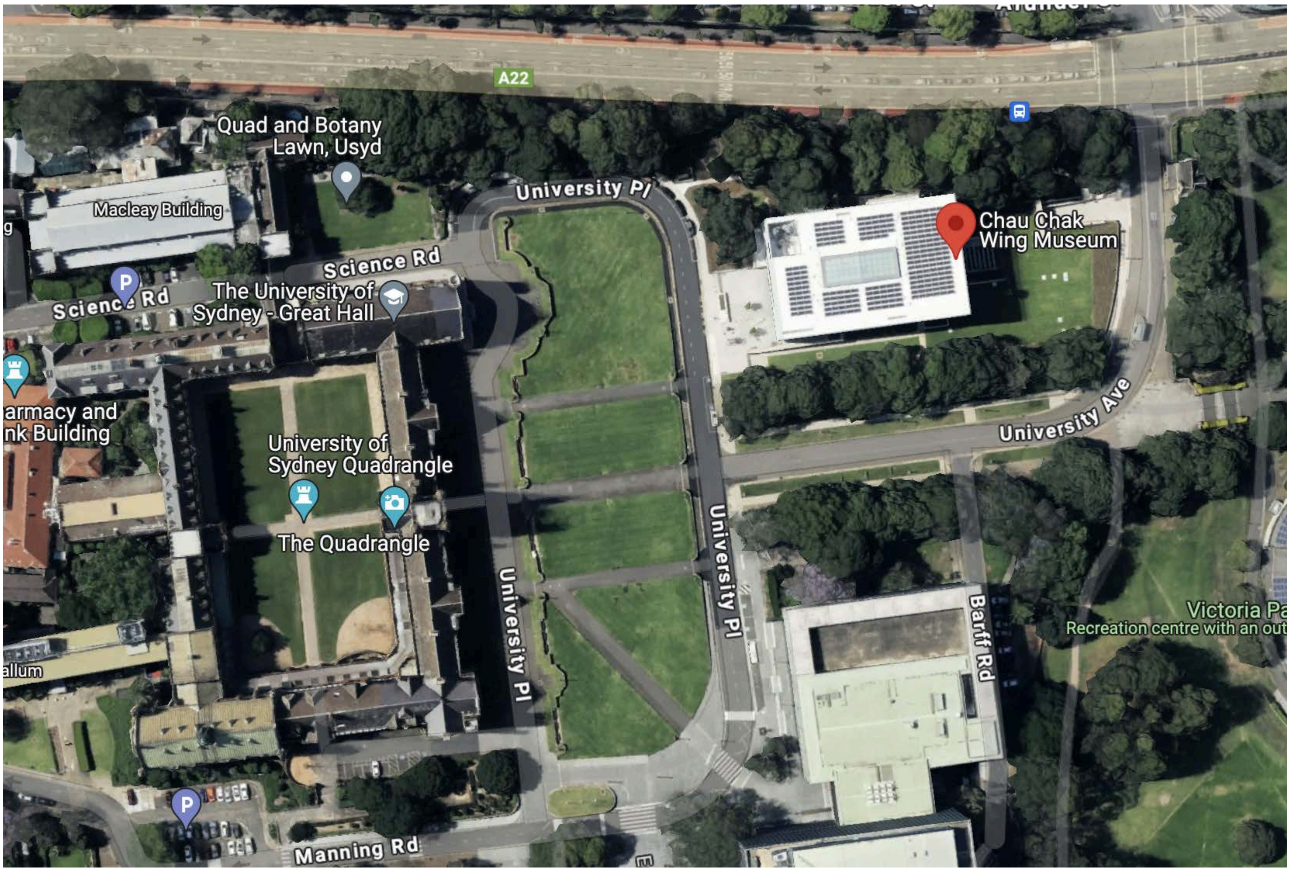
Note: Bulli District Hospital DOES NOT have an Emergency Department.

MEETING SPOT

Morning meeting spot for Mini Bus transport at 7:30 am on Friday - University of Sydney

Chau Chak Wing Museum
21 University Place
Camperdown NSW 2050

https://maps.app.goo.gl/U5wwJVSrFvuofjAx8



APPROXIMATE ITINERARY

7:30 to 8 am
Meet at Chau Chak Wing Museum at Sydney Uni

9 to 9:20 am
Stanwell Tops Lookout (and toilet stop, morning snack), Chris Fergusson to meet us there.

9:30 am
Sea Cliff Bridge stop (Permo-Triassic boundary)

10:50 am to 1.30 pm
Bombo Headland Geological Site (plus lunch – toilets at Bombo Beach at quarry start point)

1:40 pm
Kiama Blowhole

2:20 pm
Little Kiama Blowhole (optional)

3 pm
Geology and GeoTourism discussion (and time buffer)

3:30 pm
Drive back to Sydney

Acknowledgement of Country

We acknowledge the Dharawal people, the traditional owners and custodians of the land on which we are meeting. We recognise and respect their cultural heritage and beliefs and we pay our respects to their Elders, past, present and future.

The Dharawal people lived in the coastal areas of Sydney between Broken Bay/Pittwater, west to Berowra Waters, south to Parramatta and Liverpool and extending into the Illawarra and Shoalhaven districts. The traditional language of this tribe was also known as Dharawal. Many rock platforms in the Illawarra region have grinding grooves that are assumed to have been formed during the making and sharpening of ground-edged hatchets. The abrasive qualities of sandstone were excellent for sharpening tools. Grinding grooves are also present on the driplines of rock shelters and on sandstone blocks. Some sites have anthropogenic channels that redirect water seepage onto areas where hatchets were ground (Stokes, 2015). There are numerous midden and quarry sites in the region, as well as stone arrangements and engravings. The Bass Point campsites may be the oldest dated coastal campsites in NSW, with occupation going back 17,000 years (Josephine Flood, 1990, The Riches of Ancient Australia, p. 286).

The following are possible meanings to local names we will encounter on this field trip (http://www.kiama.nsw.gov.au/library/explore-kiama/aboriginal-kiama):

Bombo - from Thumbon (renowned head man)

Bong Bong - big swamp

Gerringong - fearful noises on beach

Elanora - home by the sea

Illawarra - from the aboriginal words Elourera or Allowrie, meaning high place near the sea

Kembla - from Djembla (wallaby)

Kiama - name of the father spirit of Eastern NSW (Kiahma or Baiame); or fish caught from rocks or where the seas roar

Warrigal - wild dog

Wollongong - from Wollonyuh or Wollonga, meaning sound of the sea or hard ground near water

We could paste lots of text that nobody will read... OR, we could write a few things hopefully that you might remember from the field trip. Thanks for coming along - we hope you enjoy your day with us!

PHANEROZOIC EASTERN AUSTRALIA

The Gondwana mega-continent was assembled by 530 Ma during the Kuunga Orogeny where Australia and East Antarctica joined the rest of the continental fragments. (You could try to debate Sabin as to why Gondwana ought to be a supercontinent, rather than a mere 'megacontinent'.) Australia spent much of the Phanerozoic as the eastern boundary of Gondwana, with final breakup between Australia and Antarctica occurring from about 130 Ma with very slow seafloor spreading. However, the connection between Antarctica and the Australian and South American continents persisted until about ~35-30 Ma, where the final "land bridges" were breached by plate tectonic processes. These opened a continuous oceanic gateway in the Southern Ocean, enabling a very strong Antarctic Circumpolar Current to be established. This current deflects the warm equatorial waters before they reach Antarctica, leading to the thermal isolation of Antarctica, and amplification of the icehouse climate conditions in the Cenozoic. The ice sheets on Antarctica are now about 3 km thick (and sea levels would be ~80 m higher at present if all ice sheets in the world were to melt).

But back to deep time, the Phanerozoic tectonic evolution of eastern Australia remains contentious. Just ask Chris Fergusson, Kelsie Dadd, and others who have been involved in trying to decipher the tectonic history - and check in with Addison Tu as he embarks on an adventure to propose a numerical model for the geological and paleogeographic evolution of the region. Importantly, it's worth remembering the broader significance of this geological detective work - the past arrangement of continents, terranes, and ocean basins has had a fundamental control on oceanic circulation and climate (just as Jonathon Leonard today!), influenced biogeographic dispersal (e.g., the Wallace Line), and generated the economic resources that we will need to help us decarbonise our economy. The complex history of subduction, (back-arc) rifting, terrane accretions, and a combination of these processes has shaped the landscape you will encounter today.

For much of the Phanerozoic, oceanic crust was being consumed along eastern Australia (and Gondwana). Much of this crust belonged to an ancient ocean basin called the Panthalassa (or paleo Pacific, or proto Pacific) Ocean. There is a complex mosaic of suture zones and terranes, often demarcated by ophiolite belts. Many of the rocks you will see today, and around Sydney during your stay, are representative of the Sydney Basin, with typical ages of Permian and Triassic. Importantly, you might even glimpse the Permo-Triassic Boundary itself (252 Ma), which represents the most significant mass extinction in the geological record where up to 95% of marine species and 75% terrestrial species went extinct. It's the closest Earth came to losing the biosphere... Much of these processes are ascribed to the distant Siberian Traps volcanism, however, recent (unpublished) research is re-evaluating the role of massive volcanism in eastern Australia in contributing to this cataclysm.

The Hawkesbury Sandstone, the signature rock of the Sydney region, was deposited during the Anisian stage of the Middle Triassic epoch which lasted from 247.2 to 242 Ma, soon after the end Permian Mass Extinction. It marks a dramatic shift in deposition from organic rich shales and coal seams of the Permian, to the (barren) Triassic sandstones of the Sydney Basin. Interestingly, zircon age spectra and previous work by John Veevers suggests that these sandstones were sourced from the Ross Orogen in Antarctica, highlighting the spatial scale of the mega-rivers (akin to the Amazon) transporting tremendous amounts of sediments across Gondwana.

Although Australia's present topography is mild at best (our highest peak is ~2.2 km), the geological evidence suggests that just a hundred million years ago the eastern active margin may have hosted an Andean-style cordillera, with crustal thicknesses of ~60 km, which would suggest elevations of 6 km! As the subduction zone was jammed by the collision of the Hikurangi Plateau at ~100 Ma, the cordillera collapsed, rifted to open the Tasman Sea. So consider that 100 million years ago, instead of looking out to the ocean, you would have seen a tremendous ice-capped mountain range instead...

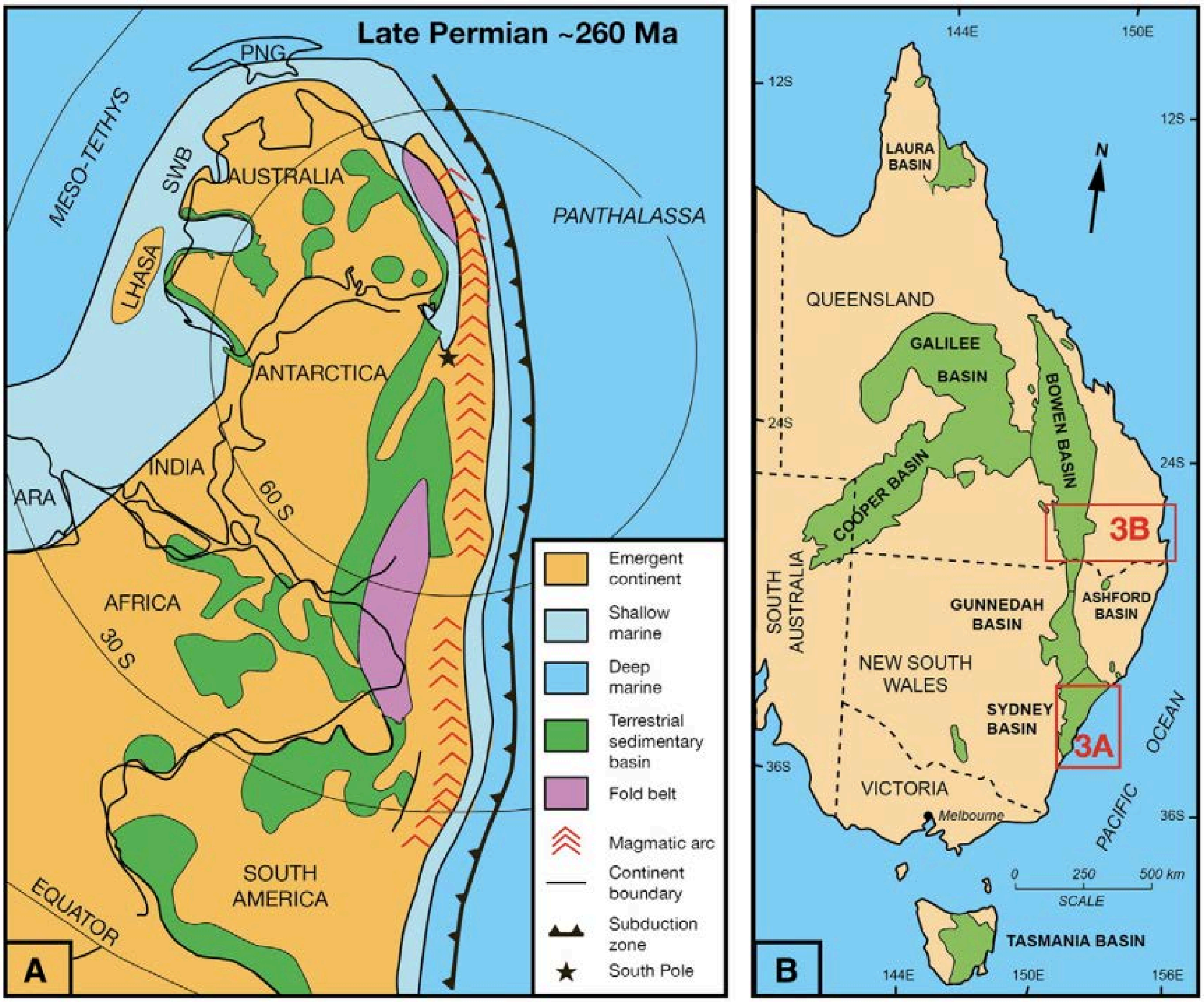


Figure 1. A: Late Permian (260 Ma) paleogeographic reconstruction showing the location of Australia at the eastern convergent margin of Gondwanaland. ARA= Arabia, PNG= Papua NewGuinea, SWB = SouthWest Borneo. B: Locations of Permian sedimentary basins (green) of eastern Australia (from Metcalfe et al., 2015)

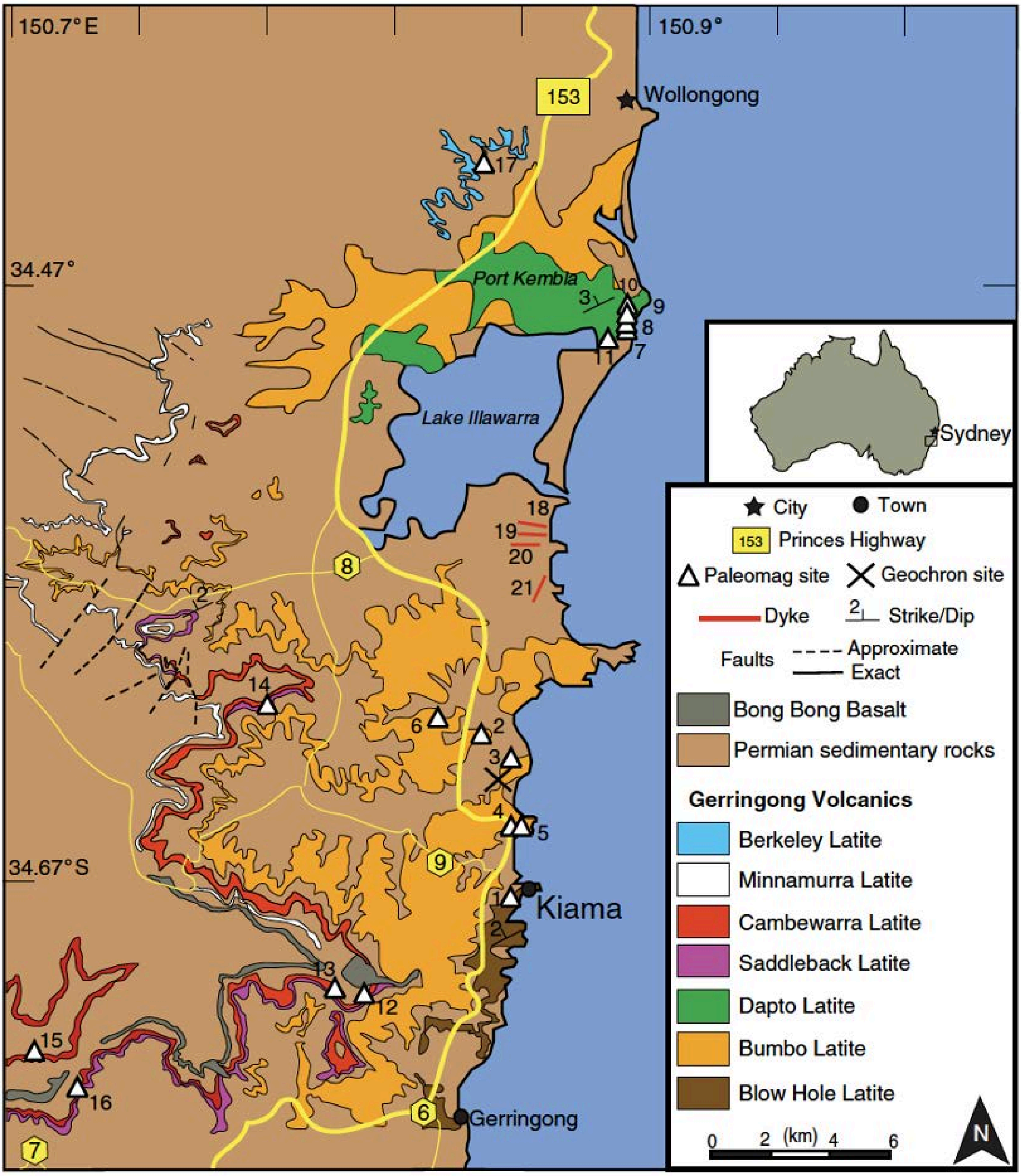


Figure 2. Geologic map of the Kiama region showing the surface and sub-surface distribution of Early –Late Permian volcanic and sedimentary rocks of the Shoalhaven Group (from Belica et al., 2017). Note Triassic and younger units are not shown.

BOMBO QUARRY - OUR GIANT'S CAUSEWAY

The Bombo Quarry site is a significant geoheritage site, being listed on the NSW State Heritage Register in 1999. It served as a source of building material since 1880 for the construction of the jetty, and even as a road base for Sydney. (Most Sydneysiders do not realise that the rocks beneath their all-important railway sleepers are usually andesites and other volcanic rocks sourced from the region.) The outcrop across the entire headland is known as the Bumbo Latite, which is a mafic volcanic rock that is ~265 Ma in age (Permian). You will see a range of volcanic textures, including dykes and (mantle) xenoliths. The description of the site within the NSW State Heritage Register states:

> *Two units of the Late Permian Gerringong volcanic facies are exposed on Bombo Headland. The Kiama Sandstone member forms a narrow wave-cut platform and adjacent vertical cliff face around the south-eastern extremity of the quarry. To the north the sandstone dips below sea level and is overlain by about 20m of porphyritic basalt, termed Bombo Latite member. The contact between the two units is well-exposed in the cliff section at the eastern end of the section of the two points comprising the headland. The red-brown colour (due to oxidisation of haematite) of the sandstone contrasts markedly with the grey-black latite, which displays spectacular columnar jointing elsewhere in the quarry. Isolated columns 5-5 meters in height stand adjacent to the coast between the north and south parts of the quarry; just to the north the sea wall exposes cross sections of the columns 1-2.5 metres in diameter, resulting in a 'Giants Causeway' appearance.*

Figure 3. Bombo Quarry ca. early 1900s. Image source: http://www.kiama.nsw.gov.au/

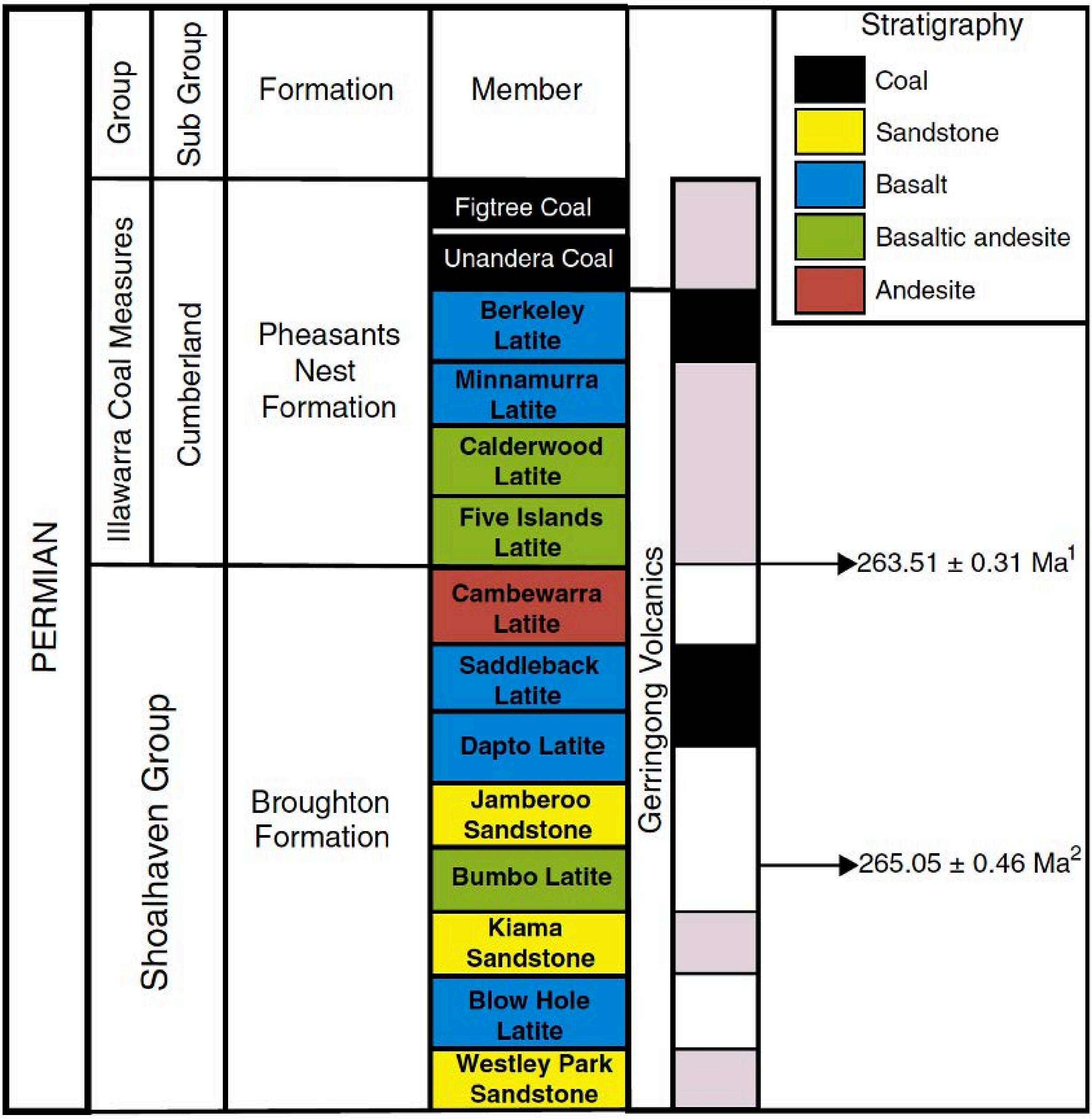


Figure 4. Lithostratigraphy for the southern Sydney Basin. Black= normal polarity; White= reverse polarity; Grey = Indeterminate. From Belica et al. (2017). See Belica et al. (2017) for detail on radiometric ages

Figure 5. Satellite view of Bombo (Google Maps) and the geological map (NSW MinView).

The Bombo Quarry site has been made famous globally in music video clips, movies, and TV shows. See if you can figure out who those young people are in the photo below, and the link to a popular kids movie and TV franchise. Hint: This is not an old photo of Sabin, Kelsie, Chris, and co...

KIAMA BLOWHOLE

The blowhole in Kiama is a famous geotourism destination for locals and visitors. It is most spectacular on sunny days with choppy seas, with the waves creating an almighty splash and 'boom', with rainbows and great views onto the Tasman Sea (and Pacific Ocean). It is a very popular destination for Sydneysiders, and you might see a lot of Sydney-based families visiting today (given that we are still on school holidays). The volcanic rock here is called the Blow Hole Latite Member, which is thought to be slightly older than the Bumbo Latite.

The most significant aspect of the rocks here in Kiama is that they represent something truly astonishing. These rocks record the LONGEST ever period of magnetic stability on our planet. The "Kiaman Superchron" (named after Kiama) represents more than 50 million years of stable REVERSED magnetic polarity. In other words, the North and South poles were flipped compared to the present. Many might have heard of the Cretaceous Normal Superchron, which lasted for about 40 million years, but the Kiaman Superchron holds the geological world record, and is the "type locality" for this part of the global geomagnetic polarity reversal timescale. Importantly, we still do not know exactly what sets the pace of the magnetic reversals on our planet, and we look to future generations of Earth Science students to solve these and many other mysteries! We are working very hard at the University of Sydney to build a numerical "time machine", which will hopefully help us understand our planet's past and future evolution.

Figure 6. Satellite view of Kiama Blow Hole (Google Maps) and the geological map (NSW MinView).

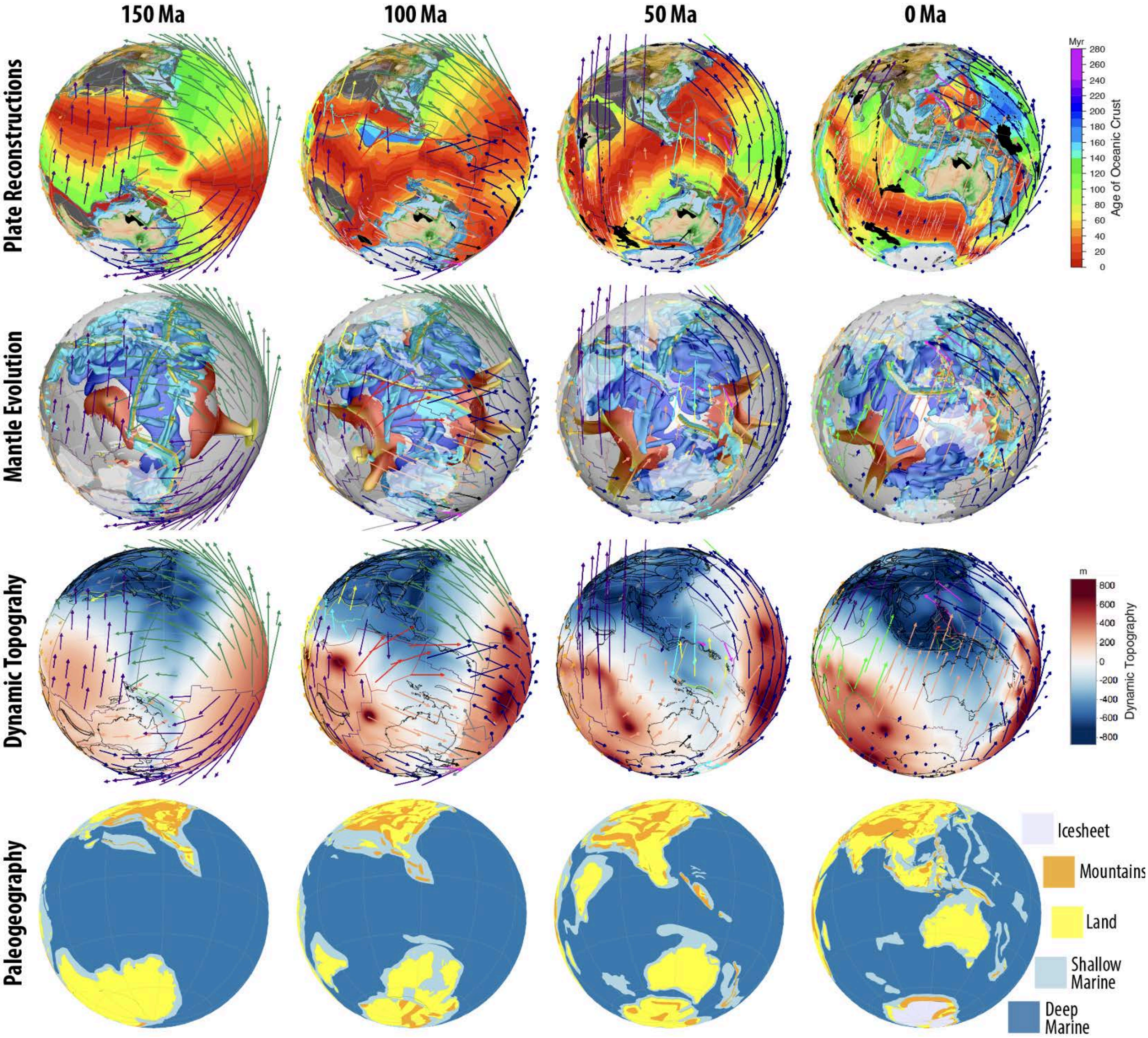


Figure 7. Global plate tectonic reconstructions since the Jurassic in GPlates (www.gplates.org) from Zahirovic et al. (2016) with an Orthographic view of the Australian (Tethyan-Pacific) region. The plate motions (top row) from GPlates are used as surface boundary conditions for mantle convection models (second row), which help us estimate the dynamic topography (third row) acting on continental and oceanic basins resulting from mantle flow. This model highlights the mantle evolution resulting from Pangea breakup, with Australia overriding different mantle flow domains – leading to tilting of the continent on geological timescales, and the resulting paleogeography (bottom row).

AUSTRALIA'S "YOUNG" VOLCANICS

Australia's mainland does not have actively-erupting volcanoes. HOWEVER, that does not mean they are extinct. The Atherton Volcanic Field in far north Queensland was erupting only 5,000 years ago, meaning that these volcanoes are classified as dormant - and much of the recent volcanic history on the mainland is captured in the oral history of the First Nations peoples. (Big Ben on Heard Island, an Australian territory in the Indian Ocean near the Kerguelen Plateau, has actively erupting volcanoes.)

As the Australian tectonic plate and continent traveled northwards in the last 100 million years, several volcanic "age-progressive" chains were produced - including the Cosgrove Track on-land, and two offshore tracks (Tasmantid and Lord Howe Seamount chains). The mantle plume that fed these volcanic processes has waned, and a broad thermal anomaly is observed in seismic tomographic imaging of the mantle between Tasmania and Victoria.

However, much of the volcanism along eastern Australia that is less than 3 million years old remains a mystery. These are not age progressive, and are clearly not associated with either subduction or plate boundary volcanic activity. Models of edge-driven convection have been proposed, but these remain complicated given Australia's northward motion, when the lithospheric step is also a north-south feature. Again, another project for our future Earth Scientists to work on!

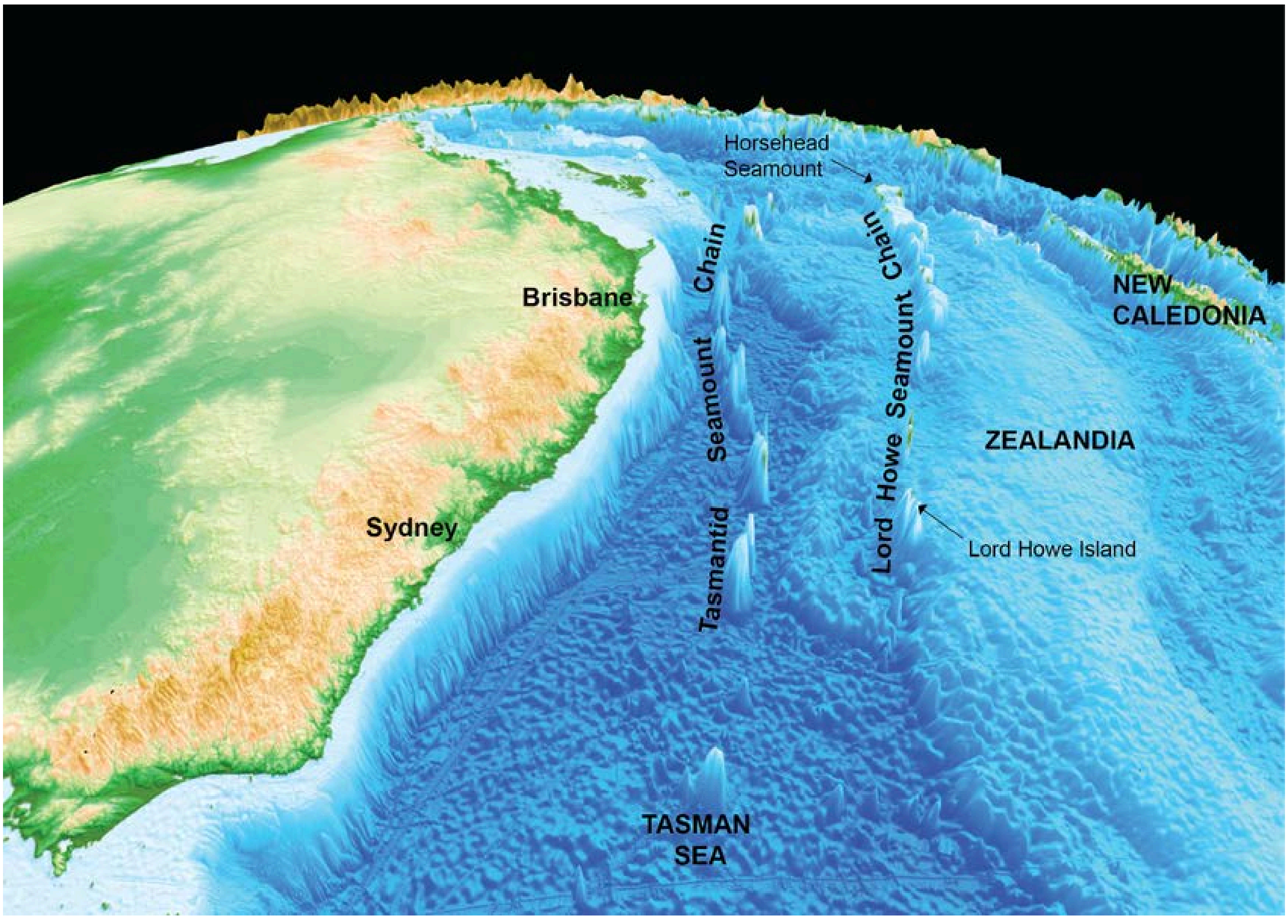


Figure 8. Offshore age progressive seamount chains. Source: Maria Seton

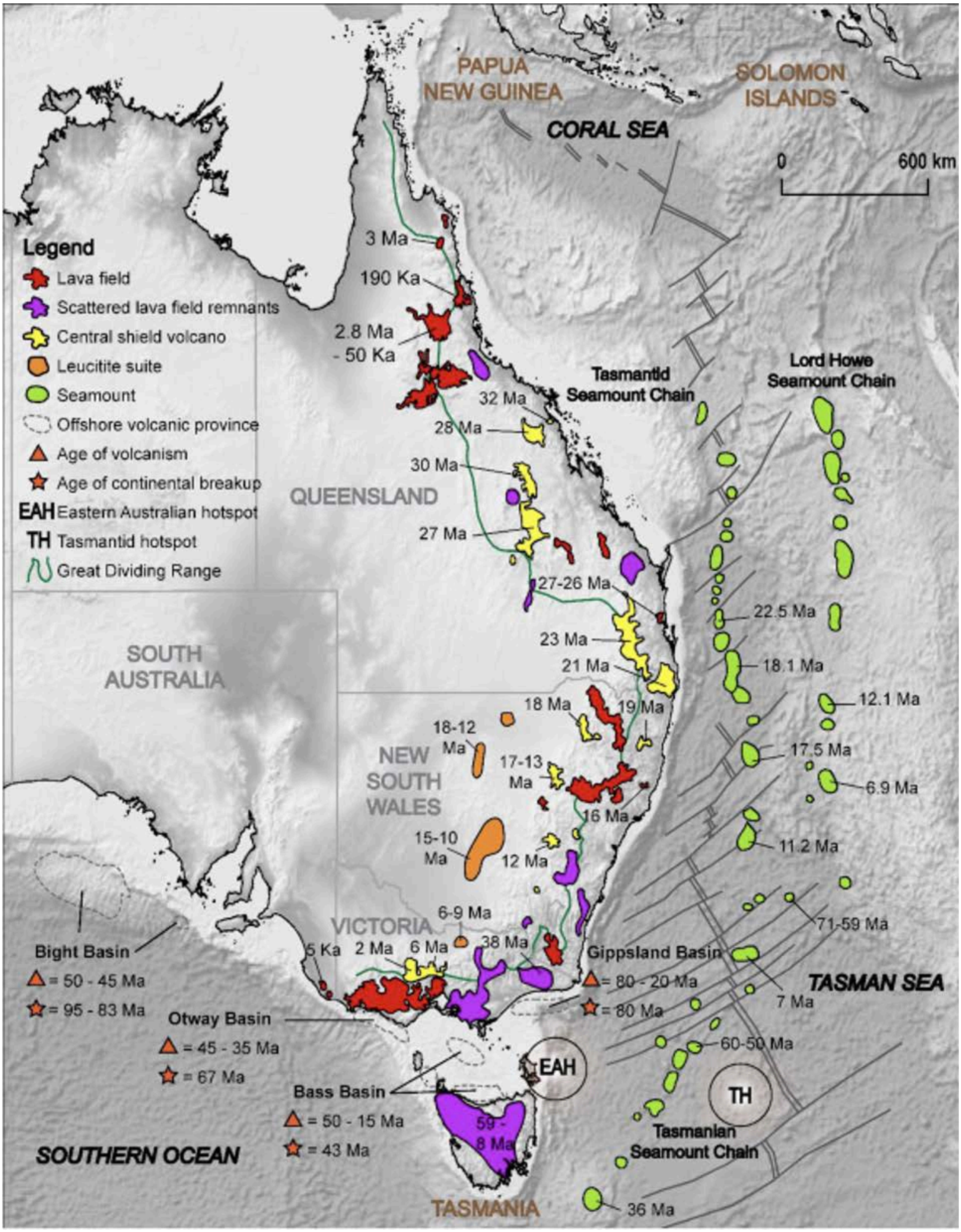


Figure 9. Onshore and offshore Cenozoic volcanism. Source: Meeuws et al. (2016)

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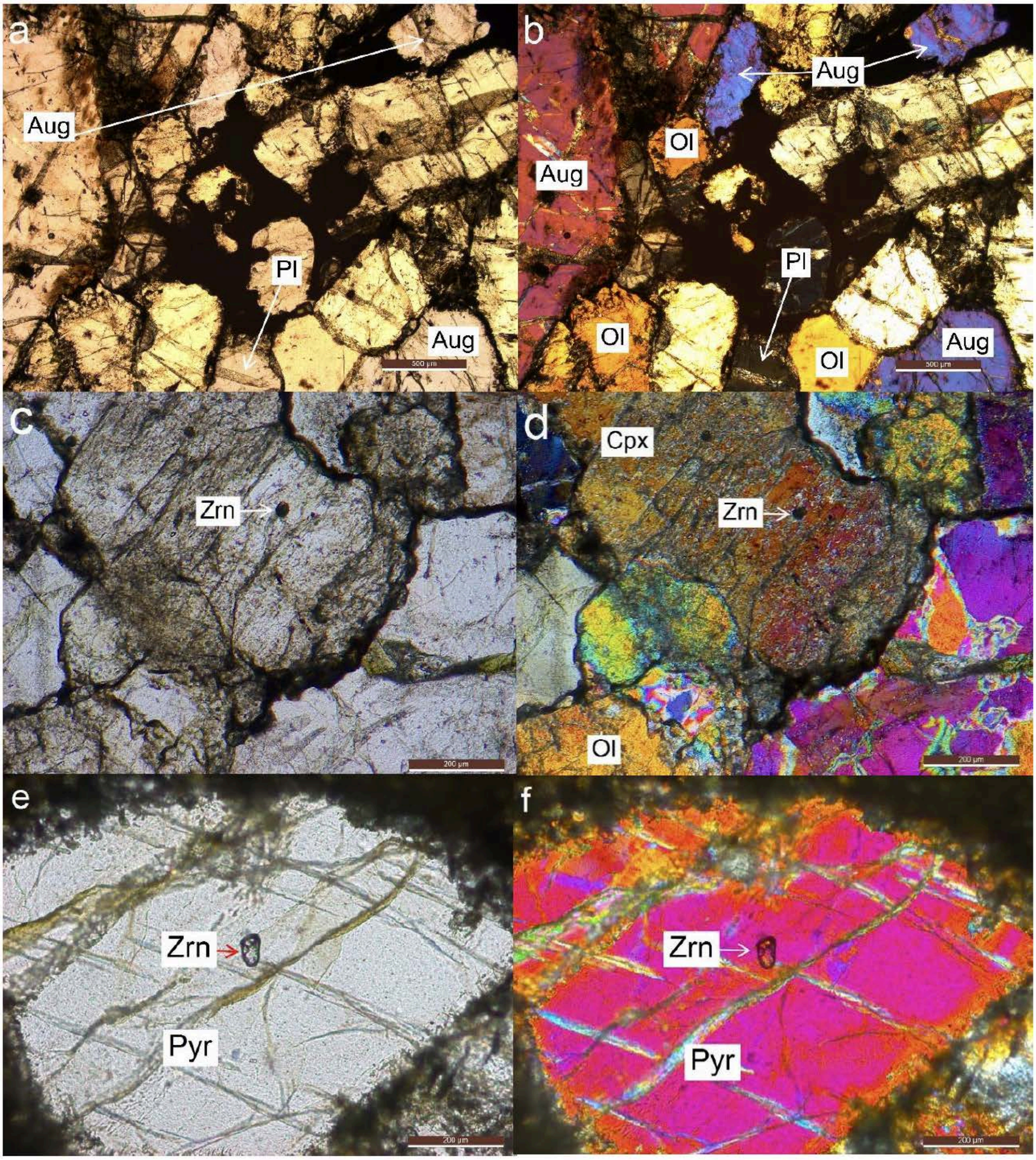

Figure 3.8: **16BHB3_3** exhibits a mafic gabbro xenolith double thickness thin section. **(a) PPL** and **(b) XPL** exhibit dominant augite, olivine and < 10% plagioclase. NOTE: Fe (Ti) oxides are interstitial between silicate phases caused by late crystallisation. **16BHA4_10** exhibits peridotite xenolith double thickness thin section. **(c) PPL** and **(d) XPL** exhibit a clear zircon within dominant clinopyroxene. **16BHB3_5** exhibits a zircon in pyroxene grain of a gabbro xenolith double thickness thin section. **(e) PPL** and **(f) XPL** exhibit a clear zircon in pyroxene of a gabbro inclusion.

The 2016 Honours Thesis by Courtney J Alcorn is a fantastic read if you wanted to get into the details of the xenolith dykes at Bombo - with a wonderful geological summary, some stunning rock thin sections, and really a fantastic piece of geological detective-work.
https://ro.uow.edu.au/thsci/128/

The 5th Geotourism Festival & International Conference
Ijen - Rinjani - Sydney
July 2024

Wildlife Tourism Workshop, Saturday 20th July 2024

Wildlife Tourism in Australia and Indonesia and its relationship to Geotourism

Led by Dr Ronda Green, President of Wildlife Tourism Australia, with specialised knowledge of wildlife in the Asia Pacific region. Ronda is chair of the Biodiversity Working Group within IUCN's Tourism and Protected Areas Group. Indonesia and Australia are both amongst the world's highest-ranking countries in terms of biodiversity and endemism. The two countries mostly harbour quite different fauna and flora, but also share quite a few taxonomic groups such as fruit bats, marsupials, monotremes, cassowaries, megapodes, bowerbirds, birds of paradise, cuckoos, crocodiles, and monitor lizards.

The session will discuss these shared groups and some of the endemic creatures of both countries. Some of the species will also be considered in relation to their dependence on kinds of soils or landscapes, and in some cases their own influence on soils. Finally, the session discusses some ideas on incorporating wildlife interpretation into geotourism displays and activities.

Other speakers include Jatna Supriatna, Professor of Conservation Biology, University of Indonesia, will be talking on "The primates of Indonesia".

Julien Louys, Professor of Palaeontology, Griffith University will present on the topic of "Australasian Exchanges and Extinctions: why is Australia, New Guinea and Wallacea so alike and yet so different?"

Dr Simin Maleknia of Tetratherix Medical will be discussing forensic investigations into illegal wildlife trafficking in Australia and Indonesia.

Roundtable discussions will be addressing various other topics which include:

- Arousing tourist awareness of and interest in lesser-known creatures in volcanic landscape?
- Diverse ways of presenting local wildlife to tourists: animals commonly seen; animals present but rare or cryptic; and animals of past eras.
- Ways of interpreting wildlife in geotourism: examples and ideas.
- The potential and techniques for including wildlife in geotourism.