

Theme 15: A dynamic Earth

Coordinators: Dietmar Müller (dietmar.muller@sydney.edu.au)

Symposia in this theme will address the processes and driving mechanisms that have shaped the distribution of the continents and the formation of ocean basins, island arcs and microcontinents through geological time. Likely symposia include global geodynamics; evolution of the plates and plate tectonic history; exploration geodynamics; the accretion and break-up of super-continents; subduction processes and mechanisms, linking deep earth and surface processes; understanding deep earth structure and rheology; and major impact events and their significance.

Symposia Theme	Symposia Description	Convenors	eMails
1. Plate tectonics, plate-mantle coupling and associated deformation	This Symposium covers a range of topics from advances in models for relative and absolute motions of the major plates on Earth, which largely behave rigidly, and thus conform to classical plate tectonic theory, to plate- mantle interaction and long-term plate deformation. It is focused on advances in amalgamating regional and global data sets for improved constraints on plate tectonic models, as well as on recent advances that allow us to move beyond classical plate tectonics, in terms of including large-scale, long-term plate deformation into regional or global tectonic models. The Symposium also covers Large Igneous Provinces, looking at their origin, timing, and effects, as well as new insights into the driving forces of absolute plate motions.	Maria Seton Giampiero Iaffaldano	maria.seton@sydney.edu.au giampiero.iaffaldano@anu.edu.au

Session Title	Session Description	Convenors	eMails
1.01 Session: Plate kinematic reconstructions	The session will be a forum to present new plate kinematic interpretations in the light of new geological and geophysical data, and associated deformation, for all time periods at regional or global scales. Submissions may include geophysical, geological or geochemical studies pertaining to the tectonic evolution of either/both the oceans and the continents. We particularly welcome submissions that deal with crustal deformation, which occurs in all tectonic settings over both long and short periods of geological time. Keynotes: Douwe van Hinsbergen (NOR, UiO)	Joanne Whittaker Maria Seton Carmen Gaina	jo.whittaker@sydney.edu.au maria.seton@sydney.edu.au carmen.gaina@geo.uio.no
1.02 Lithospheric deformation cycles in a plate tectonic framework	Large-scale episodic changes between compression to extension are common along many active plate margins. Processes driving these episodicities include accretion events, changes in absolute velocity of the overriding or downgoing plates, changes in convergence speed and obliquity, changes in the age of the downgoing plate, subduction of oceanic plateaus, and the time dependence of interaction with the subducting plate and the mantle transition zone. This session invites contributions on geological observations, as well as computer simulations, related to any aspects of mode switches along active plate margins. Keynotes: Jean-Pierre Burg (CHE, ETH Zürich)	Gordon Lister Jonathan Aitchison	gordon.lister@anu.edu.au jonathan.aitchison@sydney.edu.au

1.03 Plate tectonics,
Large Igneous
Provinces and ore
deposits

At present the link between LIPs, plate boundary processes and ore deposits is poorly understood. The formation of LIPS is sometimes associated with plate breakup and triple-junction formation, but the relative timing of LIP emplacement and the onset of breakup is often contentious. This results in a debate as to whether mantle plume head arrivals at the surface drive continental or even oceanic plate breakup, or whether rifting precedes LIP emplacement. An important known association is that of LIPS with ore deposits, especially Platinum Group Elements (PGEs). Prominent examples are the Noril'sk deposits (of the 250 Ma Siberian Trap event) which produce most of the world's palladium and the 2060 Ma Bushveld intrusion which is the largest known mafic-ultramafic intrusion and is the world's most important producer of platinum and chrome. Archean komatiites are also an important source of Ni. This session invites presentations on all topics related to plate tectonics, LIPS and ore deposits

Keynotes: Franco Pirajno (AUS, WA Geo Survey)

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1.04 Force balance
in the coupled
mantle-lithosphere
system

Advances in deep-Earth imaging, mineral physics and geodynamical modelling, are making the interaction between plate tectonics and the Earth's mantle dynamics increasingly obvious. However, there is still considerable work ahead to quantify this interdependence in terms of explicit budgets of forces driving and resisting plate motions, and their patterns of variations in time and space. Lithosphere kinematics is well reconstructed from observations of past ocean-floor spreading, particularly over the past 200 Myrs or so. Furthermore, geodetic techniques as the Global Positioning System are mapping present-day continental kinematics with unprecedented accuracy. These datasets represent a unique probe into the dynamics of plates, because any change in plate motion must have its root at changes in the driving forces. This session invites contributions assessing the relative importance of forces at work upon the coupled mantle-lithosphere system from models as well as field observations. Examples include, but are not limited to, the prediction of plate velocities, changes in the state of stress and deformation of the lithosphere, tectonic processes occurring at plate boundaries and their influence on the seismic potential of faults

Keynotes: Tim Stern (NZL, VUW)
Mike Sandiford (AUS, Univ. of Melbourne)

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1.05 Paleostress
models and
observations

Summary: Fluctuating intraplate stresses through time have a major impact on regional subsidence, uplift and fault reactivation in sedimentary basins. Even though the world's present day stress field is now fairly well

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understood, little is known about paleo-intraplate stresses, even though they are expected to have fluctuated considerably. Australia is of particular interest in that its past absolute plate motions, plate boundary configurations and plate-mantle interaction have changed considerably through time. This session invites presentations on geological observations constraining paleo-stress fields, as well as on inverse and forward approaches for modelling intraplate stresses and basin deformation through geological time for all tectonic plates.

Keynotes: Olivier Lacombe (FRA, Université Pierre and Marie Curie-Paris 6, Paris)

1.06 Slab Windows, Gaps and Tears

Summary: Subducting slabs divide the Earth into regional tectonic environments with distinctive thermal, chemical and physical characteristics. Relative to the mantle beneath the subducting slabs, the mantle above the slabs is typically colder and wetter, and host to recently subducted materials. Breaches in an otherwise continuous subduction zone may occur at sites of ridge subduction, thermal erosion and tearing of the downgoing slab. These disruptions include slab windows, gaps and tears, and trigger regional changes to mantle flow patterns, behavior of the subducting plates, and characteristics of the overlying lithosphere. Specific features associated with breaches in the subducting slabs include variations in seismicity of the slabs, adjustments to the seismic velocity structure of the mantle, changes in the volume, geochemistry, location and eruptive behaviour of volcanoes, increased heat flow and anomalous magmatism within forearc regions, extensional or transcurrent faulting, and the development of gold-rich epithermal deposits in the overriding plate. This symposium will investigate all aspects of slab breaches, including plate kinematics, volcanism, tomographic imaging, mantle flow as indicated by shear wave splitting, crustal deformation, heat flow, thermal modelling and studies of mineral occurrences.

Keynotes: Ray Russo (USA, Univ. of Florida)

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Symposia Theme	Symposia Description	Convenors
2. Large asteroid impacts and crustal evolution	The regional to global effects of large asteroid impacts, including seismic, tectonic and atmospheric effects, are highlighted by studies of the Vredefort, Sudbury, Chicxulub, Morokweng, Popigai, Chesapeake Bay, Acraman and Woodleigh structures and impact ejecta units, with implications for early crustal evolution and the mass extinction and radiation of species.	Andrew Glikson Don Lowe Victor Gostin Peter Haines

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Symposia Theme	Symposia Description	Convenors
3. Evolution and dynamics of the Indo-Australian	The aim of the Symposium is to be a multi-disciplinary approach to examining the evolution and geodynamics of the Indo-	Myra Keep Wouter Schellart

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Plate	Australian Plate. We aim to bring together researchers from around the world working on all aspects of the Indo-Australian Plate including those working on geographic regions from the Himalayas-Tibet, the Sunda-Banda Arc, all the way over to New Zealand.
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Session Title	Session Description	Convenors
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Symposia Theme	Symposia Description	Convenors
4. Linking deep earth to plate tectonic and surface processes	Recent advances in linked plate kinematic-geodynamic models, coupled with advances in using a diversity of geological and geophysical data to constrain model boundary conditions and outputs, have resulted in a growing interest in exploring the contribution that mantle convection makes to changing surface topography, driving associated erosion, sedimentation and transgressive-regressive cycles. Intriguing questions include: What are the time-dependence, spatial patterns and magnitudes of these phenomena? Small-scale convection in the upper mantle has recently been highlighted as a potential driving force of oscillations basin uplift and subsidence, but the question arises what the minimum amplitude of mantle-driven vertical surface motion is in order to leave a signal in the geological record that we can observe. Which sorts of data are best suited for extracting these signals from the geological record? Which subtle expressions of these processes in relatively flat-lying continental areas or in sedimentary basins do we need to measure to advance the observational aspects of this rapidly evolving research field?	Dietmar Müller dietmar.muller@sydney.edu.au Mike Gurnis gurnis@caltech.edu

Session Title	Session Description	Convenors
4.01 Time-dependent surface expressions of mantle convection	It has long been recognized that plate tectonics processes and sea level change shape the surface of the Earth. However, there is increasing evidence that mantle dynamics significantly contribute to the Earth's topography. This dynamic topography occurs over time scales ranging from several tens of million years over major subduction zones and hotspots to less than a million year for smaller scale mantle flow. Its regional amplitude is typically greater than several tens of meters, reaching approximately one kilometre, while its global average must be zero. The study of dynamic topography can be used to constrain the evolution of mantle flow through time by combining numerical models and geological observations. To this avail, the dynamic	Jean Braun jean.braun@ujf-grenoble.fr Nicolas Flament nicolas.flament@sydney.edu.au

topography signal must be isolated from plate tectonics signals in the geological record, and sophisticated time-dependent mantle flow models must be developed. This session welcomes contributions related to the surface expression of mantle dynamics at all scales both from a geological and from a geodynamical perspective.

Keynotes: Alessandro Forte (CAN,
Université du
Québec à
Montréal)
Mike Gurnis (USA, Caltech)

4.02 Mantle influence on basin subsidence, architecture and infill

Deep Earth dynamics and transient topography have a profound influence on the evolution of sedimentary basins. Induced dynamic topography, either by mantle plumes or mantle convection controls the medium- to long wavelength topography of the whole source to sink system contributing to basin infill, subsidence and uplift. This session will aim at exploring the effects and the magnitudes of such transient topography on the evolution of sedimentary basins and their associated resources. We are inviting contributions from geodynamic and regional scale basin modelling, as well as from field observations to better quantify the spatio-temporal patterns of dynamic topography, its implications on the vertical motions and changes in the sedimentary architecture of basins.

Keynotes: Nicky White (GBR, Cambridge)
Peter Burgess (GBR, RHUL)
Huw Davies (UK, Cardiff)
Kenni Petersen (DNK, Univ. of Aarhus)

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4.03 Using the deep earth to anchor absolute reference frames

Absolute reference frames are essential for determining the positions of the continents through time. The need for an accurate absolute reference frame has become increasingly important as we move towards a standard framework for global plate motions and as we unravel the connection between internal Earth dynamics and geological processes recorded at the surface of the Earth such as long-term sea-level fluctuations and changes in plate motions. Traditional methodologies such as the age progression of hotspot trails, palaeomagnetic data and true polar wander are being supplemented by novel methodologies, which tie the past history of subduction recorded through seismic tomography to the duration of subduction at the surface. In this session, we would like to bring together experts from all fields and methodologies and those focused on both the African and Pacific domains. Focus areas may include but not limited to, the dating and geochemistry of hotspot trails, true polar wander, hotspot motions, subduction reference frameworks and the application of geodynamic modeling in the context of absolute reference frames.

Keynotes: Trond Torsvik (NOR, UiO)
Paul Wessel (USA, UH)
Hans-Peter Bunge (GER, LMU)

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4.04 Testing global and regional kinematic-geodynamic models

Geological and geophysical data are often insufficient to distinguish between alternative relative plate motion models and plate boundary shapes through time. Locations and geometries of convergent plate boundaries are a major uncertainty in plate kinematic models, given that we need to recreate now subducted ocean floor and unravel the evolution and destruction of back-arc basins that no longer exist today. Where major deformation of an overriding plate has occurred this deformation history also needs to be taken into account. The history of mid-ocean ridge evolution is equally uncertain, as we need to consider alternative possible scenarios for mid-ocean ridge evolution, associated emplacement of large igneous provinces, and the ultimate subduction of such features. Once plate models get coupled to mantle convection models, uncertainties in the rheology of the mantle adds another set of variables. This session is aimed at attracting contributions that use a diversity of modelling approaches and observations to distinguish between alternative kinematic-geodynamic models. These approaches may utilise plate kinematic models, geodynamic models, mantle tomography and geological/geophysical data from the overriding plate.

Keynotes: Wim Spakman (NLD, Utrecht)
Claudio Facenna (ITA, Univ. Rome)

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4.05 Top-down or bottom-up drivers of major plate reorganisations

Sharp changes in plate motion typified by the Hawaiian-Emperor bend have been attributed to both convective processes affecting the pattern of global mantle flow and to the dynamic of the subducting lithosphere. What is the relative importance of probable causes including the creation or annihilation of subduction boundaries, ridge subduction and mantle avalanches? Are the different time-scales and cycles suggested by the evolution of plate motions linked to different phenomena? Is plate tectonics a self-driven far-from-equilibrium self-organising system over a passive mantle? This session welcomes contributions related to understanding the mechanisms of global plate reorganisations and their implications for plate-mantle coupling dynamics.

Keynotes: Clint Conrad (USA, UH)
John Tarduno (USA, Rochester)

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4.06 Landscape evolution: Understanding continental uplift, subsidence, tilting and geomorphology in a mantle context

In the last two decades the field of long-term landscape evolution has progressed substantially, stimulated by the emergence of new computational capabilities to explore the links between mantle, tectonic and surface processes. The numerical modelling of landscape evolution has been developed around the formulation of bedrock river and slope processes, and has mostly focused on mountainous regions. The most recent

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generation of coupled numerical models highlights our increasing ability to model the evolution of continental interiors, in terms of uplift, subsidence, and associated landscape evolution away from mountain chains. This session invites contributions on any aspect of landscape evolution in a plate tectonic context, including driving forces of continental uplift, subsidence, and continental tilting, with a special emphasis on the long-term evolution of coastlines.

Keynotes: Jean Braun (FRA, Grenoble)

4.07 Next generation global data sets for earth modelling

Next generation global and regional geodynamic models can offer high spatio-temporal resolution. However, coherent and detailed observational data sets which can match the model resolution and hence help to ground through these models are largely not yet available. The community has become aware of this problem and national and international initiatives have been launched to generate regional or global scale datasets based evolving data infrastructures. Some disciplines such as seismology have been at the forefront for such activities whereas others are in the process of developing global community datasets. In this session we aim to gather multidisciplinary contributions on community initiatives for large scale data sets for spatio-temporal Earth modelling in particular, but not exclusively from domains such as crustal/lithospheric structure and composition, potential field data, paleogeography and stratigraphic databases, ptT datasets for metamorphic rocks, seismic tomography, thermochronology, paleo-altimetry, basin evolution, or paleo-stress.

Keynotes: Steve Grand (USA, UT Austin)
Gabi Laske (USA, SIO)
Shanan Peters (USA, Wisconsin)

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Symposia Theme

Symposia Description

Convenors

5. Orogens and orogenesis: accretionary, cordilleran and collisional processes, products

This Symposium is dedicated to all orogenic styles (cordillera, accretionary, collisional) and all orogenic processes from subduction (oceanic and continental), to accretion, to collision growth and collapse. It welcomes contribution from field geologists (sedimentology, structural geology, metamorphic petrology, geochemistry, geochronology and thermochronology), to geophysicists (seismologists, geodynamicists, physical and numerical modelling etc.). This symposium is organized around the six following sessions:

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Session Title

Session Description

Convenors

5.01 Subduction Dynamics, Slab and Overriding Plate Deformation

Subduction of oceanic lithosphere drives plate tectonics. This session aims at recent progresses on the dynamic of subduction, including - but are not limited to - subduction initiation; slab bending, buckling, folding and

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break-off; mantle-wedge dynamics; and their consequences on surface and near surface dynamics, including the opening of backarcs and marginal basins, formation of ophiolites of continental fragments.

Keynotes: Taras Gerya (CHE, ETH Zürich)
Louis Moresi (AUS, Monash Univ.)
David Stegman (USA, SIO)

5.02 The Formation of Cordilleran Orogens

This session focuses on the buildup and evolution of Cordillera Orogens. It covers kinematic, dynamic, tectonic and metamorphic aspects and examine processes including, but not limited to, back-arc extension, cordillera plateau dynamics, and seismologic aspects.

Keynotes: Laurent Husson (FRA, Rennes)
Fabio Capitanio (AUS, Monash Univ.)

Christian Teysier teyssier@umn.edu
Ray Russo rrusso@ufl.edu

5.03 Continental Subduction and Collisional Processes

This session focuses on the drag of continental margins into subduction zones and collisional processes that follow including exhumation processes. This session examines thermal, mechanical and environmental consequences of continental subduction and collisional orogens.

Keynotes: Brad Hacker (USA, UC Santa Barbara)
Aral Okay (TUR, Istanbul Technical Univ.)

Donna Whitney dwhitney@umn.edu
Magali Billen mibillen@ucdavis.edu

5.04 Gravitational collapse and associated magmatism

Volume forces play a determinant role on the evolution of mountain belts and orogenic plateaux. This role peaks when plateau stage is reached. This session will look at deep to surface expression of gravitational collapse including: partial melting and magmatism, metamorphic core complexes, lower crustal flow, faulting, stress and strain distribution.

Keynotes: Olivier Vanderhaeghe (FRA, Univ. of Nancy)
Roberto Weinberg (AUS, Monash Univ.)

Patrice Rey patrice.rey@sydney.edu.au
Gideon Rosenbaum g.rosenbaum@uq.edu.au

5.05 The Formation of Accretionary Orogens

Accretionary orogens involves the sequential addition of island arcs, ocean crust, continental fragments and sedimentary terranes to continental landmasses. The processes and styles of accretion, terrane amalgamation and collision used to describe these orogens have been largely adapted from the observation of modern and recent relationships around the Pacific Ocean, as well as places like the West Indies and American Cordillera. This session is dedicated to all aspects of accretionary orogens.

Keynotes: Ian Metcalfe (AUS, Univ. of New England)
Nick Mortimer (NZL, GNS)
Graciano Yumul (PHL, Dept. of Science and Technology)
Ron Harris (USA, Brigham Young

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Univ.)

5.06 Lessons from
the Tasmanides of
eastern Australia

The Tasmanides of eastern Australia formed from the convergent margin interaction with the palaeo-Pacific plate that added one third to the continent of Australia between ~520 to ~230 Ma. There was never a terminal continent-continent collision. This session will examine the processes involved in the formation of one of the best-preserved accretionary collages in the world, as well as their resultant geometries.
Keynotes: Richard Glen (AUS, Geological Survey NSW)
Ian Withnall (AUS, GSQ) - TBC

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