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Presenting author and presentation title

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Geology and Microtectonics of the Boundary Region of Jajarkot Klippe and Karnali Klippe, Jajarkot District, Western Nepal.

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Jajarkot Klippe and Karnali Klippes are adjacent in western Nepal and represent the variation in stratigraphy and metamorphism. Previous researchers included the area between these two klippe or individual klippe in their regional geological mapping. However, discrepancies exist among them regarding the boundaries of each klippe and the underlying autochthons. Most of the previous studies are focused on field-based data and not on laboratory data and microtectonic analysis is sparse in western Nepal. An attempt is made to carry out the microtectonic analysis in each tectonic unit and to correlate the microtectonic analysis with the regional and local geological structures and stratigraphy. The study area is selected in such a way that it touches the western part of the Jajarkot Klippe and the eastern part of the Karnali Klippe in the area between Bakharka of the Surkhet district and the Saureni of the Jajarkot district. About 2 months of fieldwork was carried out, and the systematic oriented sampling was taken, followed by the preparation of thin sections in the laboratory. The microfold trending toward the E-W direction can be correlated with the outcrop scale fold and the regional scale syncline and anticline fold. The pre-tectonic and syn-tectonic garnet is observed in the different tectonic units. The shear sense indicator shows top to the south sense of shearing with few exceptions i.e. top to the north sense of shearing in shear zone developed within Jajarkot Klippe. The quartz grain microstructural analysis shows the similar nature of recrystallization of both klippe, while the low-temperature recrystallization was observed in the autochthonous unit.

Time-Aware 3D Modelling of Polydeformed Terranes: A LoopStructural Application to the structures of Bermagui, NSW

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Despite advances in computational modelling, constructing reproducible 3D geological models of complexly deformed terranes remains challenging. Sparse or scale-limited observations often leave geological geometries under-constrained, requiring substantial interpretation and introducing modeller bias. LoopStructural was developed to address these limitations by incorporating all available structural data and accepted geological concepts within a time-aware modelling workflow. LoopStructural uses structural frames-local coordinate systems comprising three mutually perpendicular scalar fields-to represent faults, folds and intrusions. These fields are fitted to geological observations and combined according to the relative timing of deformation events. For folds, the frame axes approximate the principal shortening, extension and intermediate strain directions. Fold geometries are quantified using s-plots, which describe the rotation of a folded surface relative to its axial foliation and fit this variation with a Fourier series. The approach was applied to the Narooma Accretionary Complex at Bermagui, NSW. Ordovician turbidites record four principal deformation events: D1 produced bedding-parallel thrust imbrication and S1 foliation parallel to bedding; D2 generated tight to isoclinal F2 folds and S2 crenulation or dissolution foliation; D3 formed tight, recumbent F3 folds of the S2 foliation and a shallowly dipping S3 foliation; and D4 gently refolded S3 into open, upright F4 folds. Data were recently collected by Honours students in Bermagui Heads and Point Dickinson. Time-aware modelling capture the progressive overprinting of these structures and quantifies the geometry of the different fold generation. F4 splots are consistent with gentle, symmetrical folding while F3 and F2 folds are very tight to isoclinal. The resulting model demonstrates that LoopStructural can integrate field observations, structural interpretations and multiple deformation events within a consistent 3D framework. Structural frames also provide geologically conformable curvilinear coordinates for spatial and geostatistical analysis. This approach supports more reproducible, adaptable and updateable subsurface orebody models and help in reducing drilling, energy consumption, water use and the overall environmental footprint of mining.

Refining the age of Tasmanian Neoproterozoic Snowball Earth stratigraphy

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Globally, Neoproterozoic diamictite and corresponding ‘cap carbonate’ units formed by Snowball Earth style glaciations depict periods of extreme climatic variability and turmoil. These units typically correlate to either the earlier ‘Sturtian’ glaciation, or the later ‘Marinoan’ glaciation, although a third, younger glacial event termed the ‘Gaskiers’ also can often be seen in Neoproterozoic strata. Understanding these units provides not only useful chronostratigraphic markers in the regions they are found, but also helps us better understand earth’s climatic extremes and the formation of modern climate systems. Such events may also be linked to the formation of large-scale sediment-hosted Cu-Co deposits, as seen in the African Copperbelt.

Whilst it is known that North-West Tasmania contains some of these crucial Neoproterozoic diamictites, recent research has provided conflicting age constrains to the lower of the two, termed the ‘Julius River Member’. Constraining the age of this unit has significant impacts on Western Tasmanian stratigraphy, and would allow for further research into both understanding ‘Snowball Earth’ deposits and the formation of sediment-hosted Cu-Co deposits.

As such this project provides new geochronological data, helping to constrain the age of the Julius River Member and nearby units. Our findings help refine stratigraphy across the Western Tasmanian Terrane, and creates further questions surrounding stratigraphic correlations and tectonic reconstructions of the region.

The tectonic trigger & revised setting for haematitic iron oxide copper gold (HIOCG) deposits in South Australia with significant outcomes for ore genesis & discovery

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A new tectono-stratigraphic model has been progressively developed for the 1590Ma Olympic Metallogenic Event (OME). Data released for the OD Deeps and Oak Dam West discoveries and the coeval Paris-Nankivel epithermal/porphyry system in the parallel belt on the other side of the Gawler Range Volcanic (GRV) massif, were integrated with prior research, plus historic drill logs, core photos and Hylogger data available on the government SARIG server for most of the HIOCG deposits. The study addressed the questions of: 1) What triggered the synchronous development of contrasting deposit styles; 2) Whether there is a connecting mid-GRV stratigraphic marker; 3) Origin of the sediments within the Olympic Dam breccia complex proposed as an absent Olympic Dam Basin; and therefore; 4) How did the requisite vigorous erosion leave multiple deposits preserved at the same unconformity surface? The conclusion was reached that the incorporated sediments were the clastics of the Lower Pandurra Formation along with elements of the GRV. That sequence is now proposed as the missing Olympic Basin. HIOCG deposits formed in the arcuate basin keel coinciding with the combined G2/G7 tectonic structures of Tim O'Driscoll. The much younger Upper Pandurra redefines the Cariewerloo Basin as the true post-OME cover. The model proposes: 1) Localised deposition of the Lower GRV and earliest "Pandurra" PF1 sediments into half-grabens; 2) Wet sediment collapse of the PF2 Red Shale into the deepening structures; 3) Forming a cone-shaped interface of slurried sediment and brecciated granite wallrocks where the mixing of mantle and basinal fluids provided a metal trap; 4) Subaerial exposure of hydrothermal mounds above HIOCG systems with the Red Shale apron extending out as the regional stratigraphic marker of the OME; and 5) Preservation of the OME palaeosurface by rapid deposition of PF3 clastics. The conceptual OME trigger is rebound after the first collision of the NAC and SAC, with cessation of subduction possibly on both sides of the GRV mega-caldera that then collapsed. Deep extensional structures both 1) sourced metals from differently prepared mantles and 2) produced metal traps on the exhumed caldera margins as a) the post-subduction porphyry system at Paris-Nankivel and b) sub-basins as precursors to HIOCG deposition that reached the palaeosurface. The model provides far-seeing geochemical and sedimentological vectors within a new 4-D exploration space.

Where and when do sediment-hosted ore deposits form? Testing tectonic and climatic controls with full-plate reconstructions

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Sediment-hosted copper-cobalt and base metal deposits supply much of the metal required for the energy transition, yet the conditions that control where they form and survive through Earth history are poorly constrained. Evaporites are widely regarded as essential because they generate the saline brines that transport metals and sulphur, and evaporites form preferentially in arid belts at latitudes where evaporation exceeds rainfall. The largest sediment-hosted Cu-Co deposits on Earth, in the Central African Copperbelt, are hosted by Neoproterozoic rocks deposited during one of the most extreme climatic intervals in the geological record. Whether this is coincidence, or whether extreme climate is itself a driver of mineralisation, has not been tested against the tectonic setting in which these basins formed. We combine a global database of sediment-hosted ore deposits with full-plate tectonic reconstructions spanning the last billion years to test the relationships between deposit occurrence, paleolatitude and tectonic setting. Fossil rift margins extracted from the reconstructions are used to quantify the spatial association between deposits and long-lived extensional settings, with emphasis on Neoproterozoic basins. Preliminary results indicate a spatial correlation between sediment-hosted ore deposits and rifted continental margins. Reconstructed paleolatitudes cluster at low to mid latitudes, but the distribution shifts through time. Ongoing work integrating new depositional age constraints from key basins with paleoclimate model outputs will test this interpretation and provide a predictive framework for underexplored sedimentary basins.

Engineering Geoscience for a society increasingly relying on critical infrastructure

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Globally, capital expenditure to support next-generation civil infrastructure is projected to reach USD 106 trillion by 2040 across the transport, energy, digital, social, water, agriculture, and defence sectors. In Australia, the 2025 Infrastructure Market Capacity Report identifies a record AUD 242 billion pipeline of major public infrastructure projects over the five years from FY2024-25 to FY2028-29. Historically, the delivery of large infrastructure programs has been vulnerable to substantial cost overruns and delays. Infrastructure Australia identifies comprehensive investigations and early works packages as essential mechanisms for mitigating these risks. Safe and efficient delivery of this infrastructure pipeline therefore requires the strategic application of engineering geoscience, supported by proportionate investment in early-stage site characterisation, a proven means of reducing schedule slippage and cost variations. In this context, structural geology has a primary control on ground conditions. The tectonic history and subsequent in situ modification of a rock or soil mass establish the baseline physical conditions and geomechanical properties on which civil designs depend. Engineering geoscientists evaluate a site’s structural architecture to develop three-dimensional Engineering Geological Models (EGMs) that evolve throughout the asset life cycle, rather than being used only during design. For example, gross geological structure, in situ stresses, and discontinuity sets can inform tunnel alignment, rock-mass permeability, and excavation-support requirements during the design stage of a tunnel project. The same EGM can then evolve into a framework for ongoing risk assessment of geohazards during the operational stage. By mapping structural geology, geoscientists translate geological uncertainty into quantifiable design and operational parameters, helping to protect capital-intensive infrastructure from costly delays, overruns, and, in the worst case, catastrophic ground failure. This presentation outlines the Australian market context for engineering geoscience and highlights the value of site-specific structural geological knowledge derived from geological mapping, intrusive investigations, and geophysical imaging using selected case studies.

Testing the Role of Tectonic Inheritance in Rift Evolution: Analogue Modelling of the Turkana Depression, East African Rift System

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The Turkana Depression of northern Kenya forms a remarkably broad and segmented sector of the East African Rift System (EARS), where Cenozoic rifting overprints the pre-existing NW-SE Cretaceous-Paleogene Anza and South Sudan rifts. Key unresolved questions include why early Paleogene EARS deformation first localised in Turkana, why the zone of extensional deformation was so wide there, and why rift development was diachronous. Conventional interpretations invoke reactivation of a mechanically weak lithosphere inherited from earlier rifting. Alternatively, the pre-existing older rift structures may have been poorly connected or mechanically strengthened by refractory mantle and lower crust, with subsequent localisation controlled by evolving regional deformation rather than inherited weakness alone. We use scaled brittle-viscous analogue experiments to test how inherited lithospheric architecture and changing extension directions control rift localisation. Experiments vary the connectivity, depth and strength of NW-SE inherited domains representing the Anza-South Sudan rift system under constant orthogonal and progressively rotating extension. Experiments with mechanically weak linear inherited structures show that a fully connected mantle heterogeneity produces an over-localised NW-SE rift, whereas unconnected structures limit strain transfer. Partial lithospheric linkage between separated weak domains promotes strain transfer and broad, segmented N-S deformation, but rifting develops synchronously, inconsistent with the diachronous evolution of Turkana. In contrast, strong unconnected inherited domains focus strain within the intervening weaker region, producing a wide zone of distributed deformation and multiple sub-basins that more closely resemble the broad architecture of Turkana. Experiments with progressive clockwise rotation of the extension direction further evaluate the relative controls of inherited geometry and evolving extension direction on changing fault and basin orientations. These results challenge the assumption that older rifts necessarily act as zones of weakness. Instead, mechanically strong inherited domains may have focused distributed deformation within the Turkana region, while the geometry of rifts and their interaction with evolving extension contributed to the spatial complexity of early EARS rifting.

Paired Rodinian Oroclines Revealed by Indo-Antarctic Aeromagnetic Reconstruction

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We use regional aeromagnetic data on the conjugate margins of India and Antarctica coupled with published geochronology data to constrain their positions during the Rodinia Supercontinent. Our new geological interpretation of the Eastern Ghats Mobile Belt provides new piercing points that can be correlated with the Oygarden Group and Rayner Province in East Antarctica. The reconstruction reveals paired oroclines comprising the eastern Ghats Mobile Belt, Oygarden Group and the Rayner Province. Oroclines wraps the Archean Napier Province and is interpreted to have formed in response to congested subduction as the Napier Province microcontinent accreted to the margin of East Antarctica. The Napier Province and the orocline collided with India during Rodinia amalgamation. This new model suggests that India and Antarctica amalgamated in two stages, and that the EGMB has its vestiges in Antarctica rather than India as commonly depicted in many tectonic models.

Geology of Warangi area in eastern Nepal with special reference to geological structure and strain distribution.

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This study provides detailed insights into the geological and tectonic characteristics of the Warangi area, highlighting its division into three distinct tectonic units: the Higher Himalayan Crystalline, the Lesser Himalayan Sequence, and the Sub-Himalayan. These units are delineated by prominent tectonic features, namely the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT). Within the Lesser Himalayan Sequence, the Dadabajar Group comprises four formations: - Ukhudanda Formation, Mulghat Formation, Okhre Formation, and Patigau Formation. The Mulghat and Patigau Formation consist distinctive quartzite members, recognized as Arubote Quartzite and Majite Quartzite. By analyzing the structures and movements within shear zones, this research gain insights into the tectonic processes that have shaped this complex region. This method allows for a detailed examination of strain patterns, fault interactions, and the relationships between different geological units, ultimately enhancing our understanding of the orogen's formation and evolution. Two ductile deeper-crustal core domain i.e Ukhudanda Formation and Augen gneiss are exposed with in the study area along with upper-crustal brittle faults as the MBT. Lenticular body of mylonitic Augen gneiss is exposed only in the certain horizon and conceal as anastomosed shear zone with in the damaged zone of Mulghat Formation and Okhre Formation. Strain analysis of quartz and feldspar within the study area exhibits a complex pattern in the footwall, contrasting with a predominant pure shear component observed in the hanging wall of the Higher Himalayan Crystallines.

Investigating the Role of Faults and Fractures in Crustal Hydrogen Migration

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Naturally occurring hydrogen gas in the continental crust is emerging as a promising clean energy resource, yet the role of faults and fractures in controlling its migration remains poorly understood. This project investigates the Paralana Fault Zone (PFZ), a 90-km-long fault in the northern Flinders Ranges, South Australia, as a case study for how fault geometry governs hydrogen migration pathways. The PFZ cuts through the radiogenic Mount Painter Inlier, a region with strong potential for geologic hydrogen generation, making it an ideal natural laboratory for this research.

The initial stages of the project focus upon characterising the structure of the PFZ and constraining the extent of its damage zone. Existing studies broadly classify the PFZ as sinistral-transpressive but do not resolve sub-seismic-scale structure, with the fault transitioning from strike-slip dominant motion in the south to a reverse regime further north. Digital elevation model imagery is first used to identify major fault traces via geomorphic indicators such as stratigraphic offset, triangular facets, and offset drainage channels, producing an updated regional fault map to guide field targeting. Fieldwork then investigates outcrop-scale evidence for faulting, combining field observations, fracture set analysis and fracture network topology to constrain the spatial extent of the damage zone, assess the timing of fracture set formation, and evaluate fracture connectivity along the fault.

Preliminary findings include the identification, classification, and temporal analysis of regional-scale fracture sets, alongside initial estimations of the fault damage zone’s extent. Fracture network topology reveals high connectivity between fractures both intra and inter-outcrop, indicating a well-connected fault consistent with a viable pathway for natural hydrogen migration. These early structural interpretations will be integrated with forthcoming geochemical and fluid inclusion data, working towards a full assessment of the PFZ as an active hydrogen migration pathway.

Oral presentation

Deep roots: how continents form, survive, and shape planetary evolution

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From the ancient cores of continents, cratons, to the present day, Earth's lithosphere preserves a record of its own evolution. Using computational simulations of mantle convection, I will show how the structures observed in cratons and younger lithospheres can be reconciled with the geodynamic processes that formed them, and how these structures govern lithospheric stability and survival through geological time. These findings extend beyond Earth, pointing to a fundamental and recurring process of lithospheric growth common to rocky planets, one that may hold the key to understanding critical tectonics' transitions during planetary evolution

Oral presentation

Felsic lithosphere is fundamentally constrained by materials limits so that conservation of volume requires secular thickening is compensated by surface area decrease - a model for Earth evolution and the stagnant lid to plate tectonics transition.

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Recent reviews of published models of felsic continental crustal volume change through time highlight general consensus for continual, if episodic, volume increase from Earth formation to present. End-member models advocate for low volume growth until the Mesoarchean with increasingly rapid growth thereafter, or rapid Eoarchean volume growth with slow subsequent growth. Other models adopt in-between positions. Few models explicitly discuss evolution of continental surface area through time. A shared increase in crustal volume and continental surface area with time is implied by some. Into this mix comes debate about the drivers of the change from stagnant lid Earth to plate tectonic Earth. Here a new way of thinking about Earth evolution is presented, dominated by the idea that felsic continental surface area has systematically decreased since the Archean. This is because felsic continental lithosphere volume has a conservation problem: its volume is fundamentally limited by availability of the raw materials required to form it. As lithospheric thickness progressively increased by secular cooling beyond the point where a thin felsic lithosphere enveloped the Earth, so its surface area was forced to progressively decrease to compensate. The model suggests that early gravitational differentiation drove lighter element pooling near-surface so young hot Earth lithosphere was thin, felsic, uniform, submarine: Stagnant Lid. As secular cooling allowed early felsic lithosphere to grow downward and sustain increasingly thick roots, and as heat flow variability promoted lateral variations in thickness, so exhaustion of felsic lithosphere-forming elements in the asthenosphere crossed a threshold where further secular felsic lithospheric thickening was at the expense of its surface area. Gaps opening in thinner parts of the felsic lithosphere shell filled from below by asthenosphere so fundamentally depleted that 'oceanic lithosphere' was all it could create, from that point onwards. The progressive increase in surface area of oceanic lithosphere afterwards made the change from stagnant lid to plate tectonics inevitable.

Reconciling structure and geochemistry: a case study from the Mount Isa Inlier

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Reconstructing fluid pathways in polydeformed, structurally complex terranes such as the Mount Isa Inlier requires methods capable of resolving spatial variability in fluid-related geochemical signatures at the scale of individual structural domains. Here we apply a new approach that quantifies and spatially interpolates geochemical data to characterise fluid-rock interaction across the entire region. Coupling this interpolation with a mass transfer approach allows the chemical composition of the causative fluid to be quantified within each structural unit, directly linking geochemical variability to the structural framework. Results show that across the study area, several structural domains identified as zones of net mass leaching. Fe speciation is used as a proxy to resolve fluid redox state within individual structural units, revealing a systematic contrast between more oxidised fluid signatures associated with Cu-Pb-Zn-Ag mineralisation at the Mount Isa mine and Hilton/George Fisher deposits, and more reduced signatures associated with uranium mineralisation at the Valhalla, Skal and Odin deposits. These leached, redox-contrasted domains reconcile closely with the previously interpreted main fluid pathway through the region, linking fluid mass loss and redox evolution directly to the distribution of both mineralising systems. This integrated approach combining geochemical interpolation, mass transfer, and Fe-speciation-based redox reconstruction, provides a quantitative, spatially explicit means of reconciling structural and geochemical datasets and testing structural controls on fluid flow within the Mount Isa region, with implications for vectoring toward both Cu-Pb-Zn-Ag and U mineralisation in analogous structurally controlled terranes.

Punctuated dehydration contributes to switching between fast brittle and slow ductile response in blueschist

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The prograde breakdown of hydrous minerals like lawsonite is energy-intensive and releases fluids at depths coincident with extensive slow earthquake phenomena for many subduction geotherms. However, there remains inconsistency between the spatial occurrence and inferred temporal rates of these dehydration reactions relative to the episodic character of slow earthquakes. The example of lawsonite breakdown shows that dehydration reactions will dictate heat consumption, thus buffering the rate of temperature increase for a rock undergoing intervals of metamorphism (<30°C) and delaying each small increment (~1°C) of fluid release. A non-linear behaviour is predicted involving periods of fast fluid release paused by periods of slower heat absorption. Such stepped reaction progress is consistent with natural rock textures of lawsonite breakdown indicating intermittent fluid-present crack propagation and associated step changes in mineral growth. Pulsed fluid flow into rocks of heterogeneous permeability may result in stress build-up enabling crack propagation and slip at different scales. Punctuated dehydration and fluid flow match temporal and spatial predictions of slow slip behaviour.

When UHT Metamorphism Doesn’t Mean Orogenesis: New Insights from the UHT Terrane of the Eastern Ghats Province, India

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The genesis of supercontinents is considered to be associated with convergence of multiple continental nuclei driven by plate tectonic processes, and ultra-high temperature (UHT; T>900°C) metamorphism is assumed to be contemporaneous with such continental convergence in ancient orogens. In the Eastern Ghats Province (EGP) of India, Stenian-Tonian UHT metamorphism has conventionally been related to collisional orogenesis associated with assembly of the supercontinent Rodinia. This study integrates field, microstructural, metamorphic and geochronological data from the celebrated UHT localities of Araku-Anantagiri in the southern EGP to re-evaluate the UHT-orogenesis coupling model proposed for this terrane. An early sapphirine-quartz bearing gneissic foliation (S1), correlated with syn-D1 peak UHT metamorphism (M1; ~1100°C; ~6.6-7.6 kbar; ca. 1130 Ma), is folded into isoclinal recumbent folds across scales during D2, whereas D2 is interpreted to be the major orogenic episode, associated with crustal shortening. Pre- to syn-D2 charnockites (ca. 980-950 Ma) and syn- to post-D2 megacrystic granitoids (~950 Ma) intruded the terrane after a prolonged period of post-UHT, near-isobaric cooling (ca. 1130-980 Ma). Crystallographic Preferred Orientations (CPOs) of sapphirine, cordierite, orthopyroxene and sillimanite coronae on sapphirine testify to post-UHT D2 crustal shortening. Phase equilibria modelling reveals that an up-pressure, down-temperature retrograde P-T trajectory (M2), associated with crustal thickening during D2, followed post-peak temperature isobaric cooling. The major orogenic episode in the EGP (D2) that was associated with crustal shortening and thickening, therefore, occurred ~150 Ma after the UHT peak. Orogenesis, collisional or accretionary, leading to supercontinent formation was therefore not associated with UHT metamorphism in the EGP, stating that UHT metamorphism is not unequivocal evidence of contemporaneous collisional orogenic processes associated with supercontinent assembly.

Mantle kinematics in strike-slip plate boundaries: Interference between plate-driven shear and buoyancy-driven flow

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Strike-slip plate boundaries are commonly viewed as lithospheric-scale shear zones characterized by subhorizontal, plate-boundary-parallel mantle flow and simple-shear strain. However, fault segmentation, bends, and step-overs may generate heterogeneous upper mantle deformation. At releasing step-overs, transtensional thinning drives asthenospheric upwelling and buoyancy-driven flow, introducing a vertical deformation component that interacts with plate-boundary-parallel shear. The resulting finite-strain field is expected to reflect the relative contributions of these competing deformation regimes.

The Sea of Marmara along the North Anatolian Fault Zone provides an ideal natural setting to test this hypothesis, as its segmented fault architecture and complex structure is expected to generate spatially variable mantle deformation. We integrate three independent records of mantle strain: (i) seismic anisotropy calculated from mantle xenoliths extracted from 38-75 km depth; (ii) radial anisotropy derived from full-waveform tomography; and (iii) three-dimensional thermomechanical models of a pull-apart system that track the progressive development of finite-strain ellipsoids during 5.5 Myr of dextral shear.

Our results reveal a vertically stratified pattern of upper mantle deformation. Between 35 and 60 km depth, plate-driven wrench shear dominates, as indicated by positive radial anisotropy resulting from faster horizontally polarized shear-wave velocities. In contrast, between 80 and 100 km depth, buoyancy-driven upwelling generates a dome-shaped mantle flow domain characterized by negative radial anisotropy. The geometry of this domain mirrors segmentation within the overlying fault system, suggesting coupling between crustal and mantle deformation. The dome crest is characterised by prolate strain and fault-parallel stretching, whereas its flanks exhibit oblate strain. Between 60 and 80 km depth, plate-driven shear and buoyancy-driven flow contribute comparably to deformation. This transition is marked by weakening of both xenolith-derived and tomography resolved anisotropy.

Our findings indicate that mantle deformation beneath strike-slip plate boundaries is governed not by a single kinematic driver, but by the interaction of plate-driven shear and buoyancy-driven flow. The resulting mantle fabrics preserve the composite finite-strain field generated by horizontal plate motion and vertical mantle upwelling.

The cryptic crustal core of the East African Orogen: scrutinising the Tsaratanana Complex of north-central Madagascar

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During the amalgamation of central Gondwana, Madagascar lay in a key collision zone between ancestral east Africa and Neoproterozoic India. This collision contributed to the formation of the East African Orogen (EAO): one of the largest mountain ranges of the last billion years, believed to have significantly changed the Earth's climate and ocean chemistry in the Neoproterozoic. Specifically, central Madagascar is interpreted as the deep crustal root of the EAO, providing a rare window into the formation of the Himalayan-scale collisional system.

In north-central Madagascar, three greenstone belts of the Mesoarchean Tsaratanana Complex structurally overlie the Neoarchean Antananarivo Domain basement, yet the tectonic relationship between the two units remains contested. Debate exists around whether the Tsaratanana has affinity to Africa or India, and whether it is authochthonous and a part of the Antananarivo Domain, or whether it is thrust upon the Antananarivo Domain at some time after their formation. If it is allochthonous, the timing of the juxtaposition between the two is unknown. Clarifying the relationship between these tectonic units is integral in clarifying current tectonic models for the amalgamation of Gondwana at the closure of the Proterozoic.

This initial geochronological study focuses on the Andriamena Belt, the central of three greenstone belts, to give an insight into the protolith age and thermal history of the Tsaratanana Complex. Additional samples have been analysed from between the Andriamena Belt and the westernmost Maevatanana Belt, collected along a transect of the Antananarivo Domain that has undergone extensive reworking. We present new U-Pb dating of zircons to scrutinise the similarities and differences in age across the Tsaratanana Complex and Antananarivo Domain. From here, we examine the proposed tectonic affinities of each unit, based on the timing and distribution of metamorphism and magmatism.

What epigenetic mineral deposits really look like

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Since the 1960s theoretical ore-deposit models have diminished understanding of deposit geometry by relying on highly schematised cartoons. The concurrent decline of structural geology as a primary investigative method has reinforced this problem. Our research uses company drilling data to examine the true three-dimensional geometry and timing of epigenetic mineral deposits. At Mount Isa, bedding-parallel sphalerite mineralisation terminates against transecting calcite veins, producing asymmetric patterns at outcrop and hand-specimen scale. Perkins (1997) recognised the epigenetic implications of this relationship, challenging the accepted syngenetic interpretation. At deposit scale, Pb-Zn mineralisation occurs preferentially on one side of the Mount Isa fold axial plane, indicating that mineralisation post-dates folding. We termed such features Perkins Discontinuities (Cowan and Hobbs 2025). They include fractures, low-displacement faults, veins, dykes and intrusions that create asymmetric mineralisation patterns unrelated to measurable fault displacement. Comparable deposit-scale grade and alteration asymmetries are common in epigenetic gold deposits. We interpret them as the result of minor permeability contrasts across fractures. Where these discontinuities transect folded host rocks, mineralisation must post-date most ductile strain. Several SEDEX and VMS deposits conventionally classified as syngenetic contain post-fold Perkins Discontinuities, including Sturgeon Lake, Horne, Rio Tinto, Neves-Corvo, Hellyer and Currawong. Our drilling-based studies of gold and sulfide deposits suggest that post-fold mineralisation may be the normal expression of epigenetic ore formation. Deposit geometry may therefore record fluid migration along pre-existing fabrics, rather than syngenetic stratigraphic deposition or syn-deformational mineralisation. The resulting alteration patterns can resemble Liesegang banding seen at small scales with the banding abruptly terminating laterally by hairline fractures acting as Perkins Discontinuities. A comparable example of post-consolidation ferruginous alteration is displayed in the Natural History Museum specimen known as “Ruin Marble”. Cowan, E.J. & Hobbs, B.E. (2025) Australian Journal of Earth Sciences, 72, 660-700. Perkins, W.G. (1997) Ore Geology Reviews, 12, 61-110.

Coupled dissolution-precipitation (CDP) replacement in metamorphic and mineralised systems: challenges for geochronology

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Geochronology underpins our understanding of the timing and duration of geological processes. However, increasing evidence suggests that coupled dissolution-precipitation (CDP) replacement can significantly modify isotopic systems and generate complex age datasets that do not faithfully record geological events. This presentation synthesises experimental and natural examples demonstrating the profound influence of CDP replacement on geochronological interpretations.

High-pressure melt-zircon reaction experiments (Asimus et al., 2024) show that brief exposure of zircon to natural silicate melts (0.9 GPa, 1100-1180 °C) produces dissolution textures, micro-porosity, and partial replacement within hours to days. These microstructural changes are accompanied by redistribution of U and Pb, generating near-concordant U-Pb age arrays spanning more than 100 million years. Similar features occur in zircon from granulite-facies terranes, including the Pembroke Granulite of New Zealand (Daczko et al., 2024) and the Mawson Charnockite Plutonic Complex of East Antarctica (Gazi et al., 2026), where melt-mediated replacement produced disrupted zoning, porous reaction domains, altered trace-element signatures, and age arrays extending over tens to hundreds of millions of years. In these cases, apparent age spectra exaggerate the duration of metamorphic events or falsely imply prolonged zircon growth histories.

Our new unpublished research demonstrates that the implications of CDP replacement extend beyond zircon (above) and monazite (Varga et al., 2020) in metamorphic systems into economic geology. At the Dugald River Zn-Pb-Ag deposit, Queensland, ultra-high-resolution microstructural characterisation combined with U-Pb, Rb-Sr, and Lu-Hf geochronology reveals that mineral porosity is a critical control on isotopic fidelity. Porous minerals interpreted to have undergone fluid-mediated replacement yield ambiguous ages due to partial isotopic resetting and post-replacement element mobility, whereas low-porosity minerals provide robust constraints on the age of mineralisation at c. 1490 Ma.

Collectively, these studies show that microstructural evidence for coupled dissolution-precipitation replacement must be assessed before interpreting geochronological data. Failure to recognise replacement-related porosity and chemical modification can lead to misleading conclusions regarding the timing, duration, and evolution of both metamorphic and mineralised systems.

Architecture of the Entia Gneiss Dome: A Fold Interference Structure Formed During the Intracratonic Alice Springs Orogeny, Central Australia

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The Entia dome of the intracratonic Palaeozoic Alice Springs Orogen (ASO), exposes high grade gneisses and migmatites of the orogen's mid crust in a ~30km wide monoclinic double-dome configuration. Detailed structural mapping reveals its internal architecture is characterised by fold interference between four folding events. The two oldest folding events (F1and F2) define a type III interference pattern of coaxial refolding and exhibit axial planar leucosomes, indicating association with melting. The two late events whose relative timing was not established, are referred to as F3^ and F3>, and these occurred at lower metamorphic grade. F3> and F3^ interfere to form a type I pattern of dome and basins, and together they overprint a strong top-to-SW mylonitic fabric, and the two early melt-present folding events (F1+ F2). Informed by structural context, timing of the documented deformation episodes was investigated by U-Pb geochronology of samples across the dome by LA-ICPMS. U-Pb dating of zircon and titanite in F2 axial planar leucosomes constrains timing of F2 (which predates doming) to 335-345 Ma. Titanite U-Pb dating across the dome reveals a spatial gradient of dates: ca. 315 Ma in the core to ca. 350 Ma in the margins. The spatial gradient in titanite dates is interpreted to relate to the last two folding events F3^ and F3> which create the first order dome architecture: either by folding of rocks as they rise through flat isotherms or by folded isotherms flattening through a folded structure.

Spatial U-Pb Titanite and Zircon geochronology of the Entia Gneiss Dome: a Fold Interference Structure in the Intracratonic Alice Springs Orogen

Datta, C.[1]; Weinberg, R.F.[1]; Cruden, A.R.[1]

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Multi-scale structural controls of mineral systems and mineralised volumes

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Conjecture exists as to what ‘multi-scale’ genuinely means for mineral systems and whether the industry practises it. The term ‘multi-scale’ should frame a down-scaling hierarchy from global-/craton-scale to camp-/deposit- and orebody scales where metals precipitate.

The unifying thread across every level is permeability, particularly its transient nature and the factors that control its generation and maintenance within active faults, shear zones and fracture networks under evolving fluid-pressure gradients.

At the lithosphere- and belt-scale, the most prospective corridors are the longest, deepest fault zones at lithospheric domain boundaries, including cryptic structures.

At the deposit-scale, some of the features responsible for ore localisation and formation of ore shoots include linear structures such as fold hinges, boudin necklines, structural and lithological intersections, fault jogs and movement-parallel permeability. Commonly, multiple controls, and multiple shoot orientations, coexist in a single deposit.

At all scales, a recurring control is the kinematic flip or tectonic switch, and examples are provided for several deposits. Each of these deposits shows major gold deposition following a modest reorientation of far-field stress, commonly only 10-20°, and reactivation of pre-existing architecture.

A critical element in establishing the structural controls is the formulation of a geological history that provides overprinting relationships between the age of deposition of mineralisation and other geological elements, particularly structures. The implications of resolving the geological history and constraining the age of hydrothermal mineral deposition within this are given, using examples of structurally controlled mineral deposits.

Multiple factors, including geological and human/personality and logistical ones, compromise informed multi-scale mineral system analysis. Many of our models, especially 3D models, are built on inference without factual constraints - this can lead to expensive mistakes and woeful misinterpretation of our mineral systems.

My conclusion is that the term ‘multi-scale’ is too often a label rather than a practice, with core-, hand-specimen- and development-scale observations, lineations and kinematics chronically under-collected, and 3D models built without them. Rigorous overprinting studies, mapping and kinematic integration remain the decisive advantage.

A numerical perspective on the mechanisms driving continental intra-plate volcanism, with an application to eastern Australia

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Compared with oceanic hotspot tracks, volcanic provinces within Earth's continents generally exhibit more intricate surface characteristics, including the spatio-temporal distributions and geochemical signatures of erupted lavas. These complex surface patterns relate to dynamic interactions in the mantle’s uppermost convective layer, where decompression melting occurs. To improve our understanding of the mechanisms controlling the onset and extent of melting, we model the generation of intra-plate continental magmatism within and around a thick lithospheric block using 2-D and 3-D numerical simulations of upper-mantle convection. We examine scenarios that may include plate motion and a plume to assess their impact on the spatio-temporal distribution and intensity of magmatism. Our findings demonstrate the critical role of lithospheric architecture and motion in determining the location and volume of continental magmatic provinces. Building on these results from simplified lithospheric structures, we investigate the dynamics of the Cosgrove track of eastern Australia, a compelling example of recent, intricate continental volcanic activity. We present preliminary results from the interaction between an upper-mantle upwelling and a 3-D analogue of the Australian continent. These results indicate that melting triggered by buoyancy- and shear-driven upwellings, modulated by the Australian lithospheric architecture, combine to explain the observed volcanic record.

Quantifying Sulphide Mineralisation Processes Using Sulphide Orientation Analysis

England, T[1,2,3]; Daczko. N[1]; Dyriw. N[2]; Hu. S[3]

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Precipitation, replacement, and deformation are commonly invoked to explain sulphide textures and paragenetic histories in ore deposits. These interpretations are typically based on field relationships, hand-specimen observations, and conventional petrography, with process identification relying largely on qualitative assessment of mineral textures. Although electron backscatter diffraction (EBSD) provides quantitative information on crystallographic orientation and microstructure, its application to sulphide minerals and economic geology remains relatively under-explored.

Here, we combine high-resolution backscattered electron (BSE) imaging and conventional petrography with EBSD to investigate sphalerite-hosted textures from the Dugald River Zn-Pb-Ag-Cu deposit, NW Queensland. Detailed BSE and thin-section characterisation are first used to establish mineralogical and microstructural relationships and develop textural interpretations of precipitation, replacement, and deformation. These interpretations are then tested using EBSD-derived crystallographic orientation, grain reference orientation deviation (GROD), and misorientation data. The results reveal varying degrees of internal lattice distortion, subgrain development, crystallographic preferred orientation, and other microstructural features that are difficult or impossible to resolve using conventional petrography alone. Integrating these observations provides a quantitative framework for distinguishing and evaluating sulphide mineralisation processes and their relative timing. Our study demonstrates the potential of EBSD, when combined with high-resolution textural characterisation, to provide a more rigorous basis for interpreting ore-forming processes and offers a pathway for testing established microstructural models in economic geology.

Lachlan Orogen subduction zones in New South Wales

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The Cambrian to early Silurian tectonic history of the Lachlan Orogen is notable for its complexity and multiple hypothesis generation. In many ways the Lachlan Orocline championed by Ross Cayley has simplified our interpretations but still leaves unanswered the issue of double inward-dipping subduction (as argued by David Gray and David Foster) across the late Cambrian - early Silurian Macquarie Arc (cf. Luzon in the Philippines). In the Cambrian a Delamerian active continental margin developed resulting in a subduction complex in the eastern Teltawongee Group in the Koonenberry Belt and a much narrower equivalent in the western Stawell Zone. East of this subduction zone, in the late Cambrian marginal sea oceanic crust formed basement to the widespread Ordovician turbidites which developed as fans either side of the long-lived (circa 70 million years) Macquarie Arc. In NSW the Wagga-Omeo and Girilambone zones form a Benambran fold-thrust belt along the western side of the Macquarie Arc and must have been in the forearc of a west-dipping subduction zone (i.e. subduction complex) as has been hypothesized by Erwin Scheibner. The late Cambrian to Middle Ordovician subduction zone arrangement of the Macquarie Arc remains problematic but the western subduction zone built a subduction complex in the eastern Girilambone Zone in the Late Ordovician. Whereas subduction to the east of the Macquarie Arc subduction may not have initiated until the latest Ordovician to form the Narooma Accretionary Complex. In the early to middle Silurian the Macquarie Arc igneous activity migrated westward into the Girilambone Zone (Alaskan-style intrusions) and then changed into silicic igneous activity with abundant granites forming two linear belts considered related to the double inward-dipping subduction zones. Subsequently the western subduction zone became inactive as the Narooma subduction zone migrated eastwards in the late Silurian.

Poster presentation

Mélange and mud diapirs: early Paleozoic Bogolo Formation, New South Wales South Coast

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The Ordovician to lower Silurian(?) Bogolo Formation is well exposed in coastal headlands in the Narooma Zone of the eastern Lachlan Orogen on the NSW South Coast around Batemans Bay and Narooma. It is a classic example of a tectonic mélange with a block-in matrix structure and has fragments of quartz sandstone, chert and greenstone in a clay-rich fine-grained matrix and lacks internal layering. The Bogolo Formation is strongly deformed with composite foliations and a strong stretching lineation in the drawn-out fragments within the foliation. It is associated with the upper Cambrian to Ordovician Narooma Chert, the Kianga Basalt, and the Ordovician Adaminaby Group turbidites. Most contacts of the Bogolo Formation to adjacent units are faulted. The Narooma Chert and Adaminaby Group show ample evidence of fold shortening of the order of up to 60-70% and much faulting. Discussion abounds on the origin of mélanges with the three most common explanations being: (1) sedimentary deposits (i.e. olistostromes which are sedimentary mélanges), (2) formation by faulting and shearing usually during imbricate faulting, and (3) an intrusive origin as mud diapirs. The intrusive origin was championed by Tony Barber who made the author aware of this mechanism in 1985. The Bogolo Formation has been interpreted as olistostromes by others but with the increasing awareness of mud diapirism in various settings it is considered that this is the most likely origin of the Bogolo Formation. Given the scarcity of exposed contacts a sedimentary origin for at least some of the unit cannot be completely ruled out as mud diapirs extruded at the surface do result in the formation of olistostromes. A mud diapir origin of the Bogolo Formation requires reassessment of a major thrust fault in the succession that was previously interpreted as an out-of-sequence thrust.

Precursors of the New England Orogen deciphered by zircon isotope-trace element compositions

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The New England Orogen in eastern Australia is an example of an accretionary orogen that was active for a long period without experiencing major collisions. From the Devonian to the Triassic, a series of magmatic arcs, forearc/backarc basins, and accretionary complexes developed along the continental margin. However, little is known about the pre-Devonian geological history of this margin, because of limited outcrops, tectono-metamorphic overprints, and extensive cover of sedimentary basins. To obtain information on the pre-Devonian history of the New England Orogen we apply a time-integrated detrital zircon isotope-trace element dataset as a tool to track a diverse array of crustal-scale processes, which range from inferring parent-rock composition, crystallisation temperature, crustal thickness, and tectonic setting. We report new Lu-Hf isotopic data from Devonian-Carboniferous rocks and complement the new data with a compilation of previously published detrital zircon ages, isotopic, and trace element data. The combined dataset allows us to assess the variation in magmatic arc composition, trench advance-retreat dynamics, and continental growth evolution of the precursors of the New England Orogen during the late Neoproterozoic and early Paleozoic. We compare the results with available data from the Lachlan and Thompson orogens, thus covering the entire eastern Australian margin. Through a multi-proxy geochemical-isotopic approach, we recognise differences in magma sources and slab dynamics temporally and spatially, recognising and categorising a series of petrogenetic differences across the orogens.

When continental arcs look oceanic: the evolution of the Devonian arc in the New England Orogen, Australia

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Late Silurian to Middle Devonian volcanic and volcaniclastic rocks in the New England Orogen (Calliope, Gamilaroi and Silverwood provinces) record subduction-related magmatism and sedimentation. Their tectonic affinity remains debated, with interpretations ranging from intra-oceanic island arcs to continental-margin arcs. Previous studies relied mainly on biostratigraphy, petrography, and whole-rock geochemistry. An intra-oceanic origin was proposed based on predominantly mafic lithologies and oceanic compositions. Conversely, a continental arc affinity was suggested from silicic volcanic rocks, rare detrital muscovite, and detrital zircon ages matching older eastern Gondwana components. New U-Pb zircon and apatite geochronology, integrated with stratigraphic, provenance, and trace-element data from the Calliope and Silverwood provinces, constrains the timing and tectonic evolution of these rocks. Results indicate that arc-related magmatism and sedimentation are younger than previously recognised (Late Devonian to earliest Carboniferous). Discrepancies between fossil-based and radiometric ages reflect reworking of older fossil-bearing material into younger volcaniclastic successions; fossil assemblages may thus record sediment source ages rather than depositional ages. Geochemical data reveal a complex tectonic signature. Devonian volcanic and volcaniclastic rocks contain continental detritus and inherited zircon, yet whole-rock and trace-element compositions commonly resemble intra-oceanic arcs. Late Devonian zircon trace elements from the Calliope and Silverwood provinces display low U/Yb ratios comparable to MORB sources. These results demonstrate that low zircon U/Yb, widely used in tectonic discrimination diagrams, cannot universally distinguish intra-oceanic from continental arcs. We interpret the late Devonian arc assemblages of the New England Orogen as a hybrid continental-oceanic arc developed on attenuated or hyperextended continental crust. Reduced crustal thickness limited magma-crust interaction, allowing the arc to acquire oceanic geochemical characteristics while retaining continental inheritance. This highlights how arc systems are a continuum controlled by crustal thickness, extension/contraction, magma-crust interaction, and tectonic reorganisation, rather than two distinct end-members.

Leeuwin-Northcliffe block (Australia-Antarctica) records eastern extent of high-grade Kuunga orogenesis

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The assembly of Gondwana included the Kuunga orogenic system (also known as the Pinjarra Orogen) in Western Australia and East Antarctica, which remains poorly understood due to lack of exposure. Here, we investigate felsic orthogneisses from the Redgate Domain of the Leeuwin Inlier in Western Australia, and Cape Harrisson and Possession Rocks in East Antarctica to compare their crustal affinity and tectonic history. We synthesise field relationships, petrographic analysis, zircon U-Pb and Lu-Hf analysis, and apatite and garnet Lu-Hf dating to elucidate a shared evolution from emplacement to high-temperature melt-present deformation during orogenesis. In both new and legacy datasets from all locations, complex zircon U-Pb and Lu-Hf isotope systems complicate the interpretation and correlation of c. 1100 Ma protolith ages and c. 550-500 Ma crustal reworking signatures. We relate this disturbance to isotopic mobility during zircon coupled dissolution-precipitation replacement during melt-present deformation as indicated by field relationships and zircon microstructures. Garnet Lu-Hf dates form dispersed isochrons with the youngest ages ranging from c. 555 to 525 Ma, suggesting all samples experienced coeval peak metamorphism during the Kuunga Orogeny. Apatite Lu-Hf dating yield simple, unimodal isochrons with ages overlapping at c. 520 Ma, indicating cooling below ~700 °C and the end of deformation. Based on these data, we define a new crustal block in East Antarctica, the ‘Northcliffe Block’ that is a correlative of the Leeuwin Inlier in Western Australia. Some garnet grains record Lu-Hf dates between c. 750 and 675 Ma, hinting at earlier metamorphic event(s) and coinciding with emplacement of widespread c. 780-660 Ma protoliths to orthogneisses in the Leeuwin Inlier interpreted to have intruded during rifting. Based on global plate models reconstructions, we speculate that the Leeuwin-Northcliffe Inliers are allochthonous and were accreted onto the margin of Australo-Antarctica following the closure of the Mawson Ocean during Gondwana amalgamation in the Neoproterozoic.

Toward constraining the timing of India-Madagascar rifting from the Indian margin

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The Late Cretaceous separation of India and Madagascar was accompanied by widespread magmatism along both continental margins and ultimately led to the opening of the Mascarene Basin. In Madagascar, the timing of this magmatism is relatively well constrained by robust geochronology, with several ages between ~92 and 89 Ma. In contrast, the magmatic record on the Indian margin remains poorly constrained. Many published ages from southwestern India are imprecise (>2% uncertainty), are based on whole-rock analyses rather than mineral separates, or were acquired using heterogeneous references. This leaves the timing of magmatism on the Indian margin insufficiently resolved to robustly constrain India-Madagascar rifting. Here, we reassess the timing of Indo-Madagascan magmatism on the Indian margin using zircon U-Pb and plagioclase 40Ar/39Ar geochronology from Late Cretaceous igneous rocks exposed along southwestern India. Zircon U-Pb dating of felsic volcanic rocks from the St Mary's Islands yields an age of 91.03 ± 0.96 Ma, consistent with previous high-precision geochronology, confirming magmatic activity on the Indian margin at ~91 Ma. Farther south, rocks from the Ezhimala Complex in Kerala yield a zircon U-Pb age of 89.66 ± 0.90 Ma, extending the well-constrained Indian record of Indo-Madagascan magmatism to ~90 Ma. These new ages substantially improve the temporal framework for the Indian side of the Indo-Madagascan magmatic province and allow direct comparison with the better-resolved Madagascan record. Six additional plagioclase 40Ar/39Ar datasets from Indo-Madagascan samples are currently being generated. Whilst not all geochronological results are in hand, we aim to determine whether magmatism along the Indian and Madagascan margins was synchronous and to better constrain the timing and duration of magmatic activity associated with India-Madagascar rifting.

Megathrusts and duplexes, or imbricate fans? Structural architecture of the eastern Amadeus Basin

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The northeastern Amadeus Basin, in the Northern Territory, preserves a fold-and-thrust system developed in Tonian-Devonian (850-360 Ma) sedimentary rocks. Deformation in this region occurred during the Petermann (630-470 Ma) and Alice Springs (450-300 Ma) orogenies. Previous workers interpreted the structural system as a megathrust and hinterland-dipping duplex that accommodated ~50 km of horizontal shortening during the Alice Springs Orogeny. This model is geometrically plausible and consistent with the published geological map and balanced cross-section, but much of the inferred structure is concealed by erosion or Quaternary cover.

To test this interpretation, fieldwork examined whether the mapped structure preserves the expected characteristics of a hinterland-dipping duplex, which includes fault-bounded horses, floor and roof thrusts, and progressively steeper ramps and bedding towards the hinterland. However, we were unable to find evidence for fault-bounded horses or a roof thrust. Instead, we observed a series of subparallel thrusts, with each thrust separating folds of broadly similar geometries.

We propose an alternative imbricate-fan interpretation that better accounts for these field observations. Balanced cross-section forward modelling demonstrates that this model is geometrically viable and requires 25 km of horizontal shortening, substantially less deformation than required by the megathrust and duplex model. Both models are thin-skinned and influenced by laterally extensive salt horizons, but they predict markedly different fault geometries, displacement magnitudes, and subsurface architectures.

These results demonstrate that regional geological maps may incorporate substantial structural interpretation where fault zones are eroded or concealed. Balanced cross-sections, forward modelling, and targeted fieldwork are therefore required to discriminate between geometrically viable end-member models. Although exposure is incomplete, the imbricate-fan interpretation best explains the available field evidence and requires approximately 50% less shortening of the cover sequence than the megathrust model. This indicates that deformation in central Australia during the Devonian-Carboniferous Alice Springs Orogeny was substantially less intense than previously proposed. The new interpretation revises our understanding of the tectonic evolution and structural architecture of the Amadeus Basin.

Probing the lithosphere: Multilevel structural mapping for tectonics and mineral exploration integrating enhanced geophysical data

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Conventional use of magnetic and gravity data focuses on enhancing near-surface geological features. Considerably more information can, however, be obtained with the potential to reshape geological understanding and to generate new exploration targets. This talk will highlight instances of regional shear zones and faults that change significantly in orientation at specific crustal levels. Furthermore, it will unveil structural patterns in the deep crust and subcontinental lithospheric mantle (SCLM) suggestive of mantle upwelling and dripping related to mafic-ultramafic and carbonatite intrusions.

Examples drawn from the Superior, Yilgarn, and West African cratons and younger terrains show: - Structures and geological domains at different depths, imaged by extracting different wavelength components, a technique which also provides less noisy images of upper crustal features compared to vertical derivatives. Aeromagnetic anomalies may also change from highs to lows, or vice-versa, at different depths in AMCG complexes. - Preservation of discrete faults in the deepest crust of Archaean and Proterozoic terrains at a high angle to overlying structures, requiring a mid-crustal décollement and two brittle-ductile transitions, i.e. a ‘millefeuille’ strength profile. - In central Türkiye, elliptical ‘holes’ in SCLM gravity images overly mantle drips imaged by seismic tomography. Elsewhere, concentric or pentaskelion ‘spoke-line’ patterns in gravity and magnetic data characterise mantle upwelling.

All elements of a mineral system are portrayed by integration of geophysical datasets in the Archaean Superior Province: ‘traps’ in the upper crust, fault-fracture ‘plumbing systems’, and a transverse suture and refertilised domains in SCLM. MT isosurfaces show N-S conductive SCLM domains from which finger- and mushroom-shaped conductive zones rise obliquely through SCLM gravity discontinuities; Au deposits occur above these zones or their flanks. Aeromagnetic images of the mid-lower crust show that parallel N-S faults intersect concentric features above mantle upwellings on a proto-craton margin. Results provide evidence for Archaean formation and preservation of an autochthonous Mesoarchaean SCLM terrane boundary, reactivated as a transfer zone during Neoarchaean rifting, and younger SCLM and deep crustal structures formed during extension and mantle upwelling; their regional extent and timing are incompatible with previous plate tectonic accretionary models.

Predictive Lithospheric Structure Targeting for Giant Ore Discoveries

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Understanding translithospheric faults (TLFs) is crucial as they pose major seismic hazards while also concentrating much of the world's natural resource wealth. Despite TLFs forming a key architectural component of most tectonic systems on Earth, their 4D architecture and evolution remain poorly constrained by deep-penetrating geophysical imaging and current mapping practices. Indeed, most TLFs are blind to conventional seismic reflection surveys. And 2D lineament maps as proxies for TLF maps are generally inadequate for driving new discoveries because most lack key structural details (dip, depth, kinematics, timing), have unnaturally straight lines with high false positive rates, unsupported by quantitative analyses or field validation. More scale-integrated, multi-disciplinary studies and mapping practices are needed.

The importance of TLFs for selectively targeting giant Ni, Cu, Zn and Au ore deposits and camps was recently assessed through a series of global subprovince to district-scale structure case studies. Results show that intersections between primary strike-parallel TLFs, especially those linked to lithospheric domain boundaries, and more cryptic secondary transverse lithospheric faults can be powerful predictors for buried giant discoveries, where 90% of large porphyry Cu (Au,Mo) deposits and 82% of large magmatic Ni-Cu (PGE) deposits occur ≤5 km and ≤25 km from the largest secondary transverse TLF intersections, respectively. Similarly, 90% of large sediment-hosted stratabound Cu and Zn deposits <20 km from buried basement sutures. The lateral spread is explained by diversion of fluids up steep, rheologically weak, 2nd/3rd order hangingwall shortcut faults. Jogs and relays may be important deposit-scale structural controls, but they are not the primary camp-scale structural control for most giant ore systems.

Giant deposits appear more orderly distributed than small deposits. Some ore camps show semi-regular along-strike periodicity inherited from older self-organized fault system architecture. The localisation of giant ore deposits is explained with new mineral and structural system models that invoke bottom-up self-organization, transient crust-mantle coupling, fluid-induced failure, and growth amplification through feedback loops.

The Cambrian Waratah Ophiolite; structure, tectonics and implications for the Selwyn Block hidden microcontinent

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In the Middle Cambrian, the Waratah Ophiolite was obducted onto a stable Bass Strait platform of quartz-rich Proterozoic continental crust. This occurred ~50km north of the present Tasmanian coast which was the site of a dextral continental transform. The ophiolite comprised MORB-like Maitland Beach volcanics in the south juxtaposed, across an oceanic transform, with arc-related Walkerville South volcanics in the north, both tightly folded and reverse-faulted then overthrust by mantle rocks. There was no cleavage and metamorphism was up to lower-greenschist grade. In contrast to the nearby thick, Late Cambrian sedimentary-volcanic sequences in the Tasmanian Dundas-Fossey Troughs, the Waratah Ophiolite was eroded and only received a 0-3m veneer of Tasmanian detritus in the Early Ordovician. Subsidence led to deposition of thin, shallow-water dolomitic marls and reefal Early Devonian carbonates, both associated with strong listvenitisation of the mantle serpentinites. In the Silurian to Early Devonian, the 3km-wide Waratah wrench fault, near the eastern margin of Vandieland, was activated sinistrally creating the >400m wide Waratah fault and the >170m wide Bell Point Fault, with pervasive sinistral strike-slip and buckling of the ophiolite between them. The wrench fault displaced a slice of the platform-ophiolite, the Waratah Platform, ~150km to the north where the leading edge was uplifted and eroded providing quartzose and ophiolitic sediment at Boola and Dolodrook. It is possible that the Middle Cambrian Tyennan orogeny developed east of the Bass Strait Platform and that the Waratah and other sinistral wrench faults transported fragments of it north into the Tabberabbera zone accounting for quartz-rich sediment at Glen Creek. The Bass Strait platform records no overlying Palaeozoic sediment and it continues north to the Victorian coast and beneath Cape Otway, where it is dated at 1570 Ma. The Selwyn block to the north comprises dense oceanic material overlain by 10-15km thick, deep-water turbidites.

Poster presentation

The Influence of Stress on Metamorphic Reactions

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Deformation clearly influences metamorphic reactions, but does it merely change how rapidly equilibrium is approached, or can it change the equilibrium state itself? The simplest interpretation is kinetic. Deformation generates defects, grain boundaries, fractures and pathways for mass transfer, allowing reactions to proceed more rapidly without changing the final equilibrium assemblage. Local traction at mineral interfaces may also determine where dissolution and precipitation occur. These effects influence reaction rate and localisation, but do not necessarily alter bulk equilibrium. A second effect arises when stress is included as a mechanical-work correction to an otherwise conventional, scalar-pressure Gibbs calculation. Differential stress can then displace a metamorphic reaction boundary. For geologically reasonable stresses and small reaction strains, however, the predicted movement of most pressure-temperature boundaries is modest. Larché-Cahn thermodynamics provides a more general and potentially much larger effect. In a stressed solid solution, the relevant chemical or diffusion potentials depend upon the coupling between stress and compositional strain. Where this coupling is significant, different elastic strain and stress states can produce substantial differences in chemical potential, mineral composition and phase stability. Rocks at essentially the same temperature, regional pressure and bulk composition may therefore support different equilibrium or quasi-equilibrium assemblages because they occupy different mechanical states. These effects are not mutually exclusive, but they make different geological predictions. If deformation acts only kinetically, weakly and strongly deformed domains should principally record different degrees of progress towards the same equilibrium state. Larché-Cahn equilibrium selection instead predicts reproducible fabric-specific mineral compositions, phase proportions and assemblages, potentially separated by sharp transitions at particular deformation states. The influence of stress on metamorphism therefore extends from kinetic acceleration and interface localisation, through small shifts of conventional Gibbs equilibria, to potentially large changes in mineral stability through stress-composition coupling. Metamorphic mineral maps may consequently record deformation state as well as pressure-temperature history.

Metamorphic Differentiation as a Coupled Configurational-Chemical Instability

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Why should an initially compositionally homogeneous but mechanically anisotropic rock spontaneously divide into mineralogically distinct domains? Differentiated crenulation cleavages, quartz-rich and mica-rich bands, and metamorphic reaction zones demonstrate that metamorphism can generate remarkable spatial organisation from comparatively homogeneous protoliths. Diffusion, pressure solution and reaction redistribute material once gradients exist, but do not answer the more fundamental questions: why does differentiation begin, and why are particular spatial configurations selected? We propose that the answer lies in coupling mechanical instability to chemical thermodynamics. Biot showed that homogeneous deformation of an anisotropic material can lose stability under homogeneous external conditions and develop a patterned deformation mode. Biot's analysis identifies the onset of instability; its nonlinear continuation may produce two or more mechanically stable configurations, represented by alternative minima in a multi-welled configurational free-energy landscape. Where bulk deformation and compatibility constraints must be satisfied, configurational coexistence and a common-tangent construction can select the coexisting states and their relative proportions. Larché-Cahn thermodynamics supplies the coupling to chemistry. Where stress couples to compositional strain, the heterogeneous stress fields generated by localisation produce gradients in diffusion potential that drive reaction and mass transfer. In a quartz-mica rock, for example, differentiation need not require migration of both minerals. Silica may be transferred from one mechanically selected domain to another by dissolution, transport and precipitation, simultaneously producing a relatively mica-rich source domain and a quartz-rich sink. The resulting chemical differentiation modifies strength, anisotropy and deformation, feeding back upon the original instability. Metamorphic differentiation can therefore be viewed as mechanical instability followed by configurational coexistence, stress-generated chemical-potential gradients, reaction and mass transfer, and continuing feedback between chemistry and deformation. Differentiated rocks may preserve thermodynamically selected spatial configurations rather than merely heterogeneous strain or variable reaction progress.

Poster presentation

Paleothermal structure of the Australian continental lithosphere

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The thickness of continental lithosphere influences the long-term evolution of landscapes and sedimentary basins, controlling the location of seismic and volcanic hazards and the distribution of natural resources including critical minerals and strategic materials. While geophysical methods provide a means to map present-day lithospheric architecture, placing quantitative constraints on its past evolution remains an important goal in observational geodynamics. Here, we assemble an inventory of ~12,000 major and minor oxide analyses of mantle xenoliths and xenocrysts (AusXenos) from 66 sites across the Australian continent, providing coverage from the Archean to the Phanerozoic that rivals more extensively studied regions in North America and southern Africa. We apply thermobarometric techniques to obtain 2072 pressure-temperature constraints and use these to calibrate a Bayesian inference scheme (GeoFit) that constrains the steady-state paleogeotherm at each site, thereby inferring properties such as depth of the lithosphere-asthenosphere boundary (LAB) and its uncertainty. Cratonic regions generally return mechanical LAB depths of 160-200 km and thermal LAB depths of 200-300 km, while Phanerozoic regions such as the Tasmanides return values of 60-80 km and 80-100 km, respectively. In places such as the Kimberley Craton, we observe consistently thick lithosphere despite eruption ages spanning more than one billion years, while we find potential evidence for ~20 km of Late Jurassic-to-Eocene thinning beneath parts of the Eastern Highlands that generated ~400 m of isostatic surface uplift. Our results map the first-order pattern of Australian LAB variations through space and time and provide constraints against which geophysics-informed models of present-day lithospheric architecture can be benchmarked.

Oral presentation

Rift history of the Proterozoic Isa Superbasin and its relationship to base metal mineralisation

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A series of world-class sediment-hosted mineral systems are located in the Carpentaria Zinc Belt of northern Australia. Despite over a century of mining, the first-order geodynamic setting of these Proterozoic basins remains highly debated and hampers efforts to expand exploration into frontier regions, particularly those areas overlain by younger cover. Here, we combine field observations, seismic reflection profiles, and borehole data to reconstruct the depocentre of Isa Superbasin stratigraphy in the vicinity of the Lawn Hill Platform. We perform backstripping analysis to extract its subsidence history and undertake rift modelling to constrain the timing and intensity of extension. Our results support a link between active extension and formation of sediment-hosted mineral systems, while IOCG emplacement post-dates rifting events. The analysis provides insights into the paleothermal structure of the basin and its prospectivity for various resource systems. This study demonstrates a novel framework for assessing prospective time periods for mineralisation in frontier basins by using their respective subsidence histories.

Where are the Proterozoic Wide Rifts ?

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A hotter, weaker Precambrian lithosphere should have been a factory for wide, sweeping continental rifts. Yet, in the literature, these rifts are virtually absent. We use coupled 2D and 3D thermo-mechanical and landscape evolution models to reconstruct these ghost rifts: broad, low-relief ridges and shallow, disconnected basins, often buried beneath a thin layer of sedimentary cover deposited during conductive cooling of the lithosphere. We show how a crustal flow, keeping the Moho flat, created a mosaic of shallow sediment traps prone to the accumulation of evaporite-carbonate-shale-volcanic associations, that shaped the chemistry of the environment. These hidden, largely endorheic basins governed the redox environments that cycled metals into sediment-hosted deposits, and by trapping sediment inland they starved the ocean of nutrients, plausibly contributing to the protracted environmental stasis of the "Boring Billion". The evolution of continental rifting is dynamic. The initial, protracted wide-rift phase eventually gives way to a more localised narrow-rift regime as sustained extension induces lower-crustal cooling and strengthening. We show that the mechanical coupling of the crust and mantle forces a transition from distributed to localised strain, and therefore the transition from wide-rift to narrow-rift that precedes final breakup. A critical interrogation of the geological record suggests that wide-rifts aren't missing from the Precambrian. We suggest they are absent from the literature because they have been interpreted through frameworks built for modern continental rifts margins, largely dominated by the narrow-rift regime.

Identifying structurally significant geological boundaries through contact stability analysis of remotely sensed geophysical data.

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Traditional geological mapping provides the fundamental framework for understanding geological architecture and structural relationships. However, mapping is inherently constrained by surface exposure, and geological contacts may be obscured by sedimentary or regolith cover, weathering, vegetation, or limited outcrop. Consequently, the location, geometry and subsurface extent of geological boundaries can remain uncertain. Geophysical data provide an important means of extending geological interpretation beyond these limitations by measuring contrasts in the physical properties of rocks below the surface. However, geophysical interpretations are non-unique, and the inferred position and significance of geological boundaries may vary between datasets. This can lead to different interpretations that vary based on the interpreter's experience, geological understanding and familiarity with the available datasets.

We present an investigation on whether the spatial persistence of boundaries across multiple integrated geophysical interpretations can be used to quantitatively distinguish geologically meaningful contacts. Magnetic, gravity and radiometric datasets were integrated using k-means clustering, with 396 solutions generated across different numbers of clusters and geophysical dataset weightings. We extracted contacts from each solution and compared them spatially to assess how consistently individual boundaries were reproduced. Boundaries that persist despite substantial changes in the parameters used to integrate the geophysical datasets are interpreted as having stronger geophysical support than contacts that occur only under restricted parameter combinations.

The methodology has initially been applied to mapping igneous plutons and their internal intrusive phases, which provide a useful test case because their interpreted boundaries often differ between geophysical datasets and individual phases can produce overlapping or contrasting responses. Contact stability provides a quantitative way to integrate these responses and identify where multiple datasets consistently support the presence and geometry of geological boundaries.

Rather than replacing geological expertise, this approach provides an additional constraint to guide geophysical interpretation by distinguishing well-supported boundaries from those that remain ambiguous or require further investigation. Although initially applied to intrusive systems, the methodology has broader potential

Multiscale structural controls on Archean gold deposits, Eastern Goldfields, Western Australia

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Changes in the structural style of orogenic gold deposits are typically attributed to progressive deformation and the depth of formation, with ductile shears and higher metamorphic grades associated with greater depths vs more brittle styles of faulting and associated veins forming at shallow crustal depths. However, in many gold camps in the Eastern Goldfields, Western Australia, there also appears to be changes in the structural style of gold deposits over time. Geochronological studies show that gold deposition in the Eastern Goldfields ranges from ca. 2670 Ma to 2635 Ma. Early formed gold deposits (prior to ~2655 Ma) display marked differences to those formed later, suggesting temporally distinct mineralizing events.

The period around ~2655-2650 Ma marks a change in tectonic regimes from craton-wide gravity-driven (granite-up, greenstone-down) tectonics (regional D_1 event), to orogenesis (regional $D_{2\text{-}4}$ events). The controls on gold distribution in deposits formed during gravity-driven tectonics (dominantly extensional kinematics) differ markedly from deposits formed during horizontal compression (orogenic gold deposits). Gravity driven granite-up, greenstone-down tectonics provides a mechanism to form significant gold deposits on extensional shears and to introduce widespread magmatism and associated alteration (± gold) to the upper crust, to be upgraded by later orogenic mineralising events.

At the craton and camp scale an early plumbing system dominated by north-northwest trending basin-controlling structures was likely established during ca. 2730-2670 Ma rifting. This structural framework focuses fluids during multiple hydrothermal circulation events associated with the different tectonic regimes. At the deposit scale, the geometry and kinematics of mineralised structures reflect development during extension dominated tectonics (regional D_1 event) or east-west directed compression during orogenesis (regional $D_{2\text{-}4}$ events).

Mud volcanoes at a subduction zone interface: the curious tale of a complex plumbing system along the Japan Trench

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Mud volcanoes at subduction zones usually within the accretionary prism or forearc basin. In Japan, mud volcanism occurs in the accretionary prism of the Ryukyu Trench in southern Japan but no mobile mud activity has been documented along the Japan Trench. Seismic and sub-bottom profile data from IODP Expedition 386 show mud diapirism and mud volcanism along an ~600 km transect of the Japan Trench. These features occur in basins along the trench axis itself, and not primarily as part of the forearc basin or accretionary complex (although there is also evidence for them here too). We present evidence for mud diapirism and active mud volcanism in the central and northern part of the Japan Trench. These volcanoes can have surface footprints of up to 700m long x 200 m wide, as could be up to 100 m high. Although this is below the resolution of most multi-channel seismic, it is well recorded on the often overlooked site survey sub-bottom profile data.

Diapiric and volcanic activity shows close spatial relationships to flexural faults on the down-going plate, previously used as fluid pathways transporting petit spot magmas to ocean plate. Re-use of these faults by mobile muds indicates a potentially complex plumbing system associated with the subduction of flexural faults. The source layers for mud remobilisation have not yet been determined but anomalous boron isotopic data indicates additional geochemical complexities. In addition, this discovery raises the importance of sub-bottom profile data as a valuable data source for neotectonic activity.

Paleoseismic evidence for neotectonic reactivation of the Bracalba Fault, New England Orogen, Queensland.

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The Bracalba Fault separates Paleozoic Kurwongbah Beds from Mesozoic Landsborough Sandstone in the northern New England Orogen, near Caboolture. Over a distance of 40.3 km this fault is associated with a topographic scarp, denoted the Calboolture scarp, consistent with the neotectonic reactivation of the fault in one or more large surface-rupturing earthquakes. GIS analysis of LiDAR data was used to map in detail surface fault rupture traces. Field validation was used to select sites for detailed geological and geomorphic analyses. Paleoseismic trenching investigations were used to characterize the timing, displacement, and magnitude of the most recent earthquake (MRE) on the fault. On the basis of available evidence, the MRE is estimated to have occurred between 15 to 23 ka. The co-seismic displacement estimated from the strands identified in the trench is 2.4±0.11m with a maximum displacement of 3.1±0.11m. Our favoured interpretation of the data is that the entire mapped extent of the Caboolture scarp (40.3 km) ruptured during the MRE in an earthquake of ~ Mw 6.9. An ongoing research program aims to determine if the Bracalba Fault has been Quaternary-active beyond the extents of the Caboolture scarp, and whether there is connection to the proximal North Pine Fault System, which extends towards Gladstone and is documented to have experienced significant Neogene displacement (e.g. forming the Ngoorin Basin). The study aims to assess the seismic hazard posed by these poorly characterized structures to proximal high consequence infrastructure and urban development corridors.

Spatial and temporal variability in slip and rupture behaviour along the northern Alpine Fault, New Zealand

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The northern Alpine Fault contains major structural complexities that may influence earthquake rupture propagation, segmentation and termination. The Alpine Fault exhibits significant variations in the structural morphology of primary and secondary faults along its length that reflect variations in fault interactions with neighbouring faults, variations in material properties of faulted media, and fault maturity.

Late-Holocene (~1-2 ka) geological slip rates decrease northeastward from ~14 to 6 mm/yr, but whether this gradient persists over longer timescales, and how it relates to single-event displacement (SED), remains uncertain. We integrate lidar geomorphic mapping, OSL and radiocarbon dating, paleoseismic records and displaced-channel measurements to examine Holocene fault behaviour from the northern-central Alpine Fault transition, through Springs Junction and Landslide Creek, to the Alpine-Wairau Bend.

Mid- to early-Holocene geomorphic markers record tens to hundreds of metres of displacement and reveal pronounced along-strike variability. Right-lateral slip rates reach ~20 ± 2 mm/yr near the northern-central transition, decrease to ~13 mm/yr near Springs Junction, and to 7.0 (6.3-8.0) mm/yr at Landslide Creek. At Landslide Creek, five abandoned channels record 11.0-48.5 m of right-lateral displacement. Comparison with the nearby Marble Hill paleoseismic record indicates that these channels do not record all surface-rupturing earthquakes equally. Larger (~6.5 m SED), less frequent (~1.2-1.3 kyr) displacement events appear to be preferentially preserved through channel beheading, whereas smaller (~0.9-1.3 m SED) events may deflect channels without generating new footwall channels, contributing to cumulative displacement but remaining cryptic in the geomorphic record.

Farther northeast, evidence for only three Holocene earthquakes through the Glenroy Valley suggests additional changes in rupture behaviour approaching the Alpine-Wairau Bend. We propose that this bend and associated Alpine-Marlborough fault junctions constitute important structural controls on rupture propagation. Collectively, the results indicate spatial and temporal heterogeneity in slip rate, SED and rupture extent, with implications for fault segmentation and representation of the northern Alpine Fault in seismic-source models.

Primed and folded: Controls of Au mineralization in the Bomboré Shear Belt, Burkina Faso

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The Bomboré deposit records several distinct controls on Au mineralization over a progressive, polyphase deformation history within a Paleoproterozoic (Birimian) greenstone belt of the eastern Baoulé-Mossi domain, West Africa. Located on an apparent left-stepping splay of the Markoye Shear System, its architecture is defined by tightly folded, west-verging, bimodal volcano-sedimentary sequences and lesser intermediate igneous suites, transposed between belt-parallel shears, resulting in a composite S0/S1 fabric that is refolded by deposit-scale F2 folds. Regional metamorphism reached upper greenschist facies, with localised chlorite-epidote-albite ± carbonate and silica-carbonate alteration.

Combined field investigations and 3D-litho-structural modelling identify several structural controls: 1) Widespread low-grade Au (>0.5 g/t) is established by early, sulphide-bearing veins and disseminations in Fe-rich mafic volcanic units, refolded and transposed with S1; 2) Carbonaceous shales of limited extent also acted as reducing traps; 3) Grades localised along sheared contacts between attenuated, folded units of contrasting rheology, such as intermediate porphyry dykes within felsic tuff units and Cr-rich mafic-intermediate volcaniclastic rocks; 4) Belt-bounding and subordinate belt-parallel shear zones host linear grade anomalies, particularly where they intersect favourable units; 5) Centimetre-scale chlorite-sulphide shear zones axial planar to F2 folds in the mafic units may carry a remobilised increment; 6) Folded and apparently thickened fold hinges hosts Zr-rich, quartz-carbonate alteration zones within the broader Fe-rich mafic units. This alteration zone is marked by elevated Au (>2 g/t) in wallrock-hosted sulphides within fracture networks. This zone likely behaved as a rheologically stiffened marker, with higher-grade increments occupying hydraulic breccias, late veins and fractures within the F2 fold hinges. High-grade Au shoots thus, potentially follow F2 plunges.

Bomboré therefore records an early Birimian gold increment, inferred to be Eoeburnean (D1), followed by superimposed Au-events during progressive Eoeburnean to early Eburnean events (D2).

Deformation and petrophysics of the lithospheric mantle beneath Mount Wiridgil, Southeast Australia

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Seismic and magnetotelluric (MT) imaging provide increasingly detailed views of the Australian lithospheric mantle, yet the interpretation of geophysical anomalies and their links to mantle composition and deformation remains challenging. Mantle xenoliths provide direct samples of the upper mantle from which its composition, structure, and petrophysical properties can be quantified, enabling calibration of seismic and magnetotelluric interpretations. The Newer Volcanics Province (NVP) of southeast Australia offers a unique opportunity to establish these links through its extensive suite of mantle xenoliths and exceptional geophysical coverage. This study characterises the composition, equilibration conditions, microstructures, and petrophysical properties of eight spinel-bearing peridotite xenoliths from Mount Wiridgil, NVP. Two-pyroxene geothermometry indicates equilibration at 960-1100 ºC, corresponding to depths of approximately 40-60 km. X-ray computed tomography reveals weak spinel shape fabrics (anisotropy of 1.11-1.58) with geometries that vary from prolate to oblate. Electron backscatter diffraction shows that olivine and orthopyroxene accommodated deformation predominantly through dislocation creep and subordinate grain boundary sliding, while clinopyroxene occurs mainly as finer-grained interstitial grains. Olivine crystallographic preferred orientations are of low to moderate strength (J = 2.0-4.2), and are characterised by orthorhombic symmetry with transitions between axial-[010] and axial-[100] texture types. Together with low differential stresses of 9-15 MPa, these results indicate relatively weak deformation within the shallow lithospheric mantle beneath the Newer Volcanics Province. We use the SAnTex (Singh et al., 2025) and pide (Özaydın et al., 2025) libraries to calculate upper mantle seismic and electromagnetic properties from xenolith-derived crystallographic fabrics, modal compositions, and equilibration conditions. The resulting petrophysical calculations provide a direct link between mantle composition, deformation, and geophysical observables, allowing regional seismic and magnetotelluric models to be interpreted in terms of lithospheric mantle structure and evolution beneath southeast Australia. References: Singh, U. et al., 2025. SAnTex. J. Open Source Softw. 10, 6886. Özaydın, S. et al., 2025. pide. J. Open Source Softw. 10, 7021.

A ~1000 km extensional system linking the Northeast Australia margin to the Coral Sea

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The northeastern Australian margin preserves a long record of extension spanning the breakup of eastern Gondwana and subsequent opening of the Coral Sea, but these events have generally been treated as separate tectonic episodes. In particular, the relationship between Jurassic-Early Cretaceous rifting along the northeastern Australia margin and Paleogene seafloor spreading in the Coral Sea remain poorly constrained, including the origin of the Mellish Trough, previously interpreted as a Paleogene transform system tied to the opening of the Louisiade Triple Junction. Here we integrate legacy seismic reflection profiles, drill site constraints and gravity data across the Queensland Trough, Capricorn Basin, Townsville Trough and Mellish Trough to place these episodes within a tectono-stratigraphic framework. Consistent unconformities, sedimentary geometries and fault architecture link the Townsville and Mellish troughs into a single continuous extensional system ~1000 km long, active from the Jurassic to the Paleogene.

We interpret that the Townsville-Mellish troughs were a connected system through two main rifting phases. An initial Jurassic-Early Cretaceous phase, shared with the Queensland Trough and Capricorn Basin, formed part of a broader back-arc system associated with subduction along the eastern Australia margin. A second phase, restricted to the Townsville-Mellish trough system from ~100 to ~61 Ma, followed a major plate reorganization that ended subduction along most of the margin while it continued further north near Papua New Guinea. This second phase reflects a shift to extension driven by far-field rotational stresses, in a setting comparable to rifting in the East African Rift System. Following this phase, the locus of extension migrated eastward towards the Louisiade Triple Junction, possibly under the influence of the Tasmantid hotspot, culminating in Paleocene-Eocene seafloor spreading.

Our results link previously separate episodes of rifting along the northeastern Australian margin and show that Paleogene opening of the Coral Sea represents the culmination of a long-lived extensional system rather than a discrete tectonic event. This revised framework provides new constraints on the evolution of the northeastern Australian margin and the transition from continental rifting to ocean-basin formation in the southwest Pacific.

Sulfide geochemical fingerprints of deformation: a case study from the Eloise ISCG deposit, Mount Isa, Queensland

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Deformation can modify sulfides via recrystallisation, dissolution-precipitation accompanied by element redistribution and changes in mineral-scale partitioning, potentially preserving chemical fingerprints of structural reworking. We evaluate this possibility in chalcopyrite (Ccp) and pyrrhotite (Po) from the Eloise Iron Sulphide Copper Gold (ISCG) deposit. Located in theEastern Mount Isa Subprovince, the Eloise deposit is hosted in variably altered meta-arkose/arenite, quartz-biotite psammite, schist and amphibolite of the Mount Norna Quartzite, part of the Proterozoic Soldiers Cap Group (~1680-1660 Ma). Mineralisation occurs as several N-trending, steeply dipping lodes (such as the Elrose, Levuka (including Eloise Deeps, Chloe), Middle West lodes), formed within the Levuka Shear Zone, where ductile to brittle deformation, fault reactivation and local structures have influenced ore development. Trace-element data indicate that sulfides record different scales of variability in samples from four orebodies within the deposit. In Ccp, an Ag-Ni-In-Se compositional signature distinguishes the main orebodies, with Eloise Deeps separated from Chloe-Macy-Middle West. In Po, Co-Ni-As variations are more heterogeneous within orebodies. This study aims to assess whether these chemical patterns are linked to deformation and sulfide recrystallisation. First, we use reflected-light microscopy to establish textures and paragenesis, EBSD to characterise crystallographic orientation, misorientation and recrystallisation domains, EPMA to quantify major and minor element variations, and LA-ICP-MS-based trace-element analysis to resolve mineral-scale chemical gradients. The hypothesis is that Ccp and Po respond differently to deformation because of contrasting crystal structures, element-hosting mechanisms and rheological behaviour. Identifying systematic phase-specific responses could provide a mineral-scale tool for recognising structurally modified mineralisation. The study may contribute to assessing the exploration potential of integrated sulfide microstructures, crystallography and trace-element chemistry in a structurally complex mineral system.

Go with the flow: tracing ancient fluid pathways to discover sediment-hosted copper - insights from the Euro-Permian Basin

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Fluids redistribute copper through the subsurface and concentrate it into sediment-hosted deposits. Deep-time simulations of basin fluid flow can identify the long-lived circulation pathways that remobilise copper from low-grade source rocks into high-grade ore. The Southern Permian Basin of Europe is one of the most intensively explored basins on Earth. Here, we leverage its rich record of stratigraphy, permeability and fault architecture to constrain a 3D, time-evolving model of copper transport into the Kupferschiefer. The model spans 300 million years of basin evolution and resolves fluid pathways through aquifers and up faults that connect red-bed source rocks to ore deposits at the redox front. By tracing these pathways backwards from known deposits, we reconstruct where the copper was scavenged from, how much fluid passed through the basin, and how long the deposits took to form. These constraints can guide exploration toward undiscovered deposits that share fluid pathways with known ones. Although calibrated on the Southern Permian Basin, the framework is basin-agnostic and can be applied elsewhere as a vector to ore discovery.

Preliminary insights on structurally controlled gold mineralization in the Archean Youanmi gold deposit, Yilgarn Craton, Western Australia

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The Archean Youanmi gold deposit hosts gold mineralization in shear zones spatially associated with the contact between a sagducting greenstone succession and voluminous granitic intrusions. Gold-hosting shear zones formed in the greenstone succession, which consists of mafic to felsic volcaniclastic rocks interlayered with banded iron-formations (BIFs) and basalt. Petrographic and field observations suggest that competency contrasts from the micro-to-macro scale focused ore fluids and gold mineralization, and that gold-rich horizons are highly localized within meter-scale shear zones. Early Au-bearing quartz veins within the shear zone were boudinaged and recrystallized, which liberated gold to the matrix where it was scavenged by fluids that preferentially migrated along rheological boundaries. Units that are coarsely layered appear to have accommodated higher amounts of strain and are highly mineralized in comparison to the more massive basalts. Preliminary structural data and textural features of the shear zones will be presented to provide insight into how these shear zones have developed over time and relate to high-grade gold mineralization.

Process based simulation of Earth's topography

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In this contribution we present a process based whole-Earth, simulation of palaeotopography and palaeobathymetry spanning the last 1.8 Ga. Mountains are highly dynamic on geological timescales, growing through subduction, terrane accretion and continental collision and eroding as they are exposed to the atmosphere. This interplay shapes atmospheric circulation and is a principal control on dissolved river loads and sediment transport to basins, making the changing elevation of Earth's surface central to understanding the long-term evolution of Earth’s systems. Yet tracing the past location and topography of mountains in a fully spatial and temporal manner is difficult because so little geological information is preserved. To bridge this gap, we use an existing full-plate tectonic model to automatically isolate the tectonic environments associated with mountain building-continental arcs, continental collisions, rifts and large igneous provinces-and simulate their growth and erosion. The growth and erosion in our simulation are governed by parameters derived from the present-day expression of topography on Earth. We compare our predicted present-day (and ‘recent’ times) surface against observations and other palaeogeographic models to demonstrate that our simulation produces similar topography, hypsometry, simulated climate and global riverine fluxes. The model offers a quantitative and tractable basis for palaeoclimate and landscape evolution modelling over the last 1.8 Ga.

From Arc Magmatism to Continental Collision: New Constraints on the Tectonic Evolution of Eastern Madagascar During Gondwana Assembly

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Madagascar occupies a key position within the East African Orogen and preserves an important record of Neoproterozoic tectonic processes associated with Gondwana assembly. However, the tectonic significance of magmatism within eastern Madagascar remains debated, particularly whether Tonian magmatism reflects continental extension or subduction-related processes along the Mozambique Ocean margin. This study integrates new zircon U-Pb geochronology and whole-rock geochemistry from the Antananarivo Domain, Manampotsy Belt, and Masora Domain to constrain the tectonic evolution of eastern Madagascar. Zircon U-Pb data from amphibolitic gneiss in the Antananarivo Domain preserve Neoarchean crustal inheritance, yielding an upper intercept age of 2500.1 ± 5.1 Ma, confirming the presence of ancient continental crust comparable to crustal fragments preserved elsewhere in Madagascar and India. Tonian granitoids from the Manampotsy Belt and Masora Domain yield crystallisation ages of 809.8 ± 1.9 Ma and 805.4 ± 1.3 Ma, respectively, documenting widespread magmatism during development of the Mozambique Ocean margin. Geochemical signatures, including enrichment in large-ion lithophile elements, depletion in Nb-Ta, and volcanic arc to syn-collisional affinities, indicate derivation from a subduction-modified source and support a convergent-margin setting. A lower intercept age of 546.4 ± 2.5 Ma from the Antananarivo Domain records Ediacaran metamorphism associated with the East African Orogen, while a late Ediacaran granite yields an emplacement age of 538.3 ± 2.7 Ma, interpreted as post-collisional magmatism during crustal stabilisation. Together, these data record a transition from Neoarchean crustal inheritance, through Tonian arc magmatism, to Ediacaran-Cambrian collision and post-orogenic magmatism during final Mozambique Ocean closure. The results favour convergent-margin models for eastern Madagascar and highlight its central role in recording the subduction-to-collision history of Gondwana amalgamation.

Evolution, Timing and Source of Magmatism in the Antananarivo Domain, Central Madagascar

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Ediacaran Madagascar lay within the heart of the East African Orogen (EAO), which was a mountain belt that formed during the Ediacaran-Cambrian amalgamation of the supercontinent Gondwana. The EAO is considered by some to have been the largest mountain belt on Earth, with a large orogenic plateau that likely had a major effect on Earth's surface systems. Complex migmatites within central Madagascar preserve evidence of the protolith history and processes active during this orogenesis. Central Madagascar is made of the Antananarivo Domain, which comprises Archaean to Neoproterozoic granulite to upper amphibolite facies paragneiss and orthogneiss. The granitic Archean basement, the Betsiboka Suite, is interleaved with the granulite- and amphibolite-facies paragneiss of the Ambatolampy Group, maximum depositional age of ca. 1700 Ma. This basement was intruded by the emplacement of the granitic Imorona-Itsindro Suite at ca. 850 Ma to 750 Ma, and later by the A-type granitoid Ambalavao Suite, 575-520 Ma. We report rock relationships, new petrological and geochronological data from the Anteanety Quarry to the west of the capital, Antananarivo, that shows these relationships well. Nine lithodemes are identified based on lithology and relative age from cross-cutting relationships. Six of these lithodemes are dated and unravel a detailed snapshot of the processes occurring at midcrustal levels beneath this Ediacaran Malagasy orogenic plateau. The oldest lithodeme consists of Neoarchaean (2510 ± 10 Ma) melanosomes that are interlayered with equigranular grey microgranite that pass laterally into large bodies and yield ages of ca. 790 Ma, making them part of the Imorona-Itsindro Suite. The rocks underwent high-grade metamorphism with estimated peak temperatures of 750-900°C at ca. 570 Ma based on the age of solid-state recrystallised zircon within protolith units. Distinct late leucosomes and cross-cutting dykes yield zircon with ages of ca. 540 Ma. When considering samples from throughout the Antananarivo region, these older Ediacaran protolith-zircons commonly have low aspect ratios, low Th/U ratios, and in CL appear with ghost-rims and bright CL bands picking out reaction fronts. The younger leucosome/dyke zircon populations are identified by their high Th/U ratio and CL character and are envisaged as growing from Th-rich melts, dating the high-temperature part of the cooling path.

Time-Space magmatic evolution of the Delamerian Orogen

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Magmatic arcs generate the majority of the Earth’s new continental crust and host a significant proportion of its metallogenic endowment, representing a vital intersection between our planet's deep and surface reservoirs. In this study, performed at Geoscience Australia as part of the Resourcing Australia’s Prosperity initiative, we undertook an orogen-wide geochronological, geochemical and isotopic survey of the Cambrian Delamerian Orogen. This area represents a relatively under-studied and under-explored magmatic arc, largely obscured by deep cover. The lithospheric architecture of the orogen was set-up during ca. 830-585 Ma rifting associated with break-up of the Rodinia supercontinent, creating an asymmetric margin consisting of the relatively strong, immobile crust of the Curnamona Province in the north, and weak, mobile crust of the Adelade Superbasin and thinned basement Gawler Craton, in the south. It is possible that the Curnamona Province was already in an eastward position relative to the Gawler Craton within Rodinia at ca. 830 Ma, with sediments of the Barossa Complex to the south. If correct, this initial Rodinian architecture would explain the resultant geometry of the rifted margin. Later, during the 515-495 Ma Delamerian arc phase, asymmetric back-arc extension exacerbated this geometry, driving contrasting geochemical affinities between the northern and southern volcanic-arc sections. Post-orogenic 495-460 Ma magmatism was localised to the south of the Curnamona Province, mirroring the position of the earlier back-arc. The final major magmatic period at 430-395 Ma (420 Ma peak), is focused around and to the east of the Curnamona Province, suggesting a control related to the thicker lithosphere. Hence, potentially all four stages of the Delamerian Orogen demonstrate the long-lived, first-order control of a pre-existing (Rodinian) lithospheric architecture on later arc and post-arc magmatism. This emphasises the importance of large-scale crust-lithosphere structure in understanding long-lived geological systems and their associated mineral systems.

Blast it to smithereens; how explosive fragmentation leads to chonolith emplacement

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Some of the world's most valuable orthomagmatic Ni-Cu-Co-PGE sulfide ore deposits are hosted with small, mafic-ultramafic, tubular to ribbon shaped igneous intrusions called chonoliths. Chonoliths cannot be explained by classical magma emplacement mechanisms such as diapirism, stoping or brittle sheet propagation. Clues to explain their emplacement are found within host rock-magma breccias and extensive carbonate alteration that are frequently associated with their margins. Analogous to kimberlite intrusions, which share similar complex geometries and extensive brecciation, this suggests that chonolith emplacement may be driven by explosive, volatile-driven fragmentation - they effectively blast their way through their host rocks.

Here we present the results of analogue laboratory experiments that seek to test the hypothesis that complex magma pathways and intrusion geometries may form due to gas or volatile-driven fragmentation. Experiments are conducted in a 60 x 60 x 3 cm wide transparent acrylic tank, which is filled to varying depths with either low cohesion dry sand or high cohesion compacted kaolin powder. Compressed air, simulating magmatic-hydrothermal volatiles, enters the base of the tank via a 1mm diameter vertical nozzle, and the inlet pressure is varied systematically between 5 and 100 kPa. Structures developed inside the tank are observed and quantified using digital videos and stills.

Up to critical overburden heights and inlet pressures, dynamic explosive vents form in experiments with low cohesion material, resembling near-surface kimberlite pipes and basaltic maar volcanoes. In contrast, over a range of overburden heights and inlet pressures, experiments with cohesive material develop a rich array of intrusive structures, including the formation of thin saucer-shaped sills and complex stair-stepping dyke-sill complexes with abundant breccias. The inclusion of horizontal barriers to gas ascent further enhances this complexity. We will compare our experimental results to well-known chonoliths (e.g., Norilsk, Eagle, Nkomati) and intrusive kimberlites (e.g., Kennady North).

Are the Olepoloko and Cork Faults Connected?

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The Cork Fault has a 50-km-wide dextral shear zone on its southern margin, consistent with along-strike movement of hundreds of kilometres. This fault forms the boundary between the Mesoproterozoic Mount Isa Block and the Thomson Orogen. The southern boundary of the Thomson Orogen is the convex-south Olepoloko Fault. This formed in the (end Ordovician) Benambran Orogeny but was also active in the middle Devonian Tabberabberan Orogeny. The Wonnaminta Zone forms western boundary of the Thomson Orogen, where the sedimentary rocks are dominated by pencil slates.

This begs the question, did the dextral movement along the drive the Thomson Orogen south to form the Olepoloko Fault? The lithosphere of the Thomson has faster wave speeds than the rest of the Tasmanides and its lower crust is dense, suggesting that it was stronger than the Lachlan crust and lithosphere to the south. When driven southwest along the Cork Fault in the Benambran and Tabberabberan, rather than subducting under the Curnamona Craton, the Thomson escaped south, over-riding the Lachlan Orogen.

Towards a Chemical Tomography of the Australian Lithosphere

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Global demand for critical minerals is outstripping the rate of new discoveries, requiring improved tools for identifying mineralisation at depth. Metasomatic alteration of the sub-continental lithospheric mantle is increasingly invoked as a key control on the fertility of critical mineral systems, yet we lack a quantitative and reproducible framework for characterising its geochemical signature. This limits our ability to interpret continent-scale geophysical anomalies, such as those imaged by national magnetotelluric and passive seismic datasets, in terms of mantle composition and mineral potential. Here, we apply λ-shape analysis to rare earth element (REE) patterns in clinopyroxene from mantle xenoliths of the Newer Volcanics Province, southeastern Australia. By decomposing REE patterns into orthogonal polynomial coefficients, λ-shape analysis offers an objective, quantitative alternative to qualitative descriptors and simple elemental ratios, enabling direct comparison across samples, regions, and depths. We show that lessons from partial melting and melt-rock reaction models can be encoded in λ-space, providing reference trajectories that distinguish melt depletion from metasomatic enrichment. Integrating these chemical constraints with national-scale magnetotelluric and passive seismic datasets establishes a quantitative link between mantle geochemistry and geophysical anomalies, enabling chemical tomography of the Australian lithosphere and improving predictive mapping of critical mineral fertility beneath cover.

Oral presentation

3D Neotectonic Fault Framework, Structural Modelling, and Fault Slip Rates of the Eyre Peninsula, South Australia

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We develop a 3D structural model of neotectonic faults in the Eyre Peninsula to investigate fault geometry to 300 m depth and to estimate fault displacements and slip rates. The model spans an area of 5546 km² and includes 657 boreholes, neotectonic fault traces identified from digital elevation models, and geophysical data. To supplement data gaps, we used an iterative workflow including 1018 synthetic control points (pseudo-boreholes). Stratigraphic tops of those points were adjusted using the structural features of the fault blocks nearby and compared to more than 100 fault-perpendicular cross-sections. The structural framework of the area consists of 73 depth-projected fault surfaces. These faults mainly dip to the west (66%) and have dips from 30° to 53°, consistent with seismological and geological constraints on the contemporary stress field. The fault-averaged slip rates range from 10 to 50 m / Myr. Neotectonic faults in the Eyre Peninsula appear to have slower slip rates than faults in the Mt Lofty-Flinders Ranges to the east and faster slip rates than faults in the Nullarbor Plain and Gawler Craton to the west, suggesting sustained variations in strain rate over geological timescales. The model results improve our understanding of the spatial and temporal characteristics of seismically hazardous neotectonic faults in this region, which contains several industrial development projects and was previously considered for nuclear waste storage.

Spatiotemporal mapping of tectonically driven fluid flow

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Regional-scale fluid flow is an inherent consequence of plate tectonics and is essential to forming some of Earth's largest mineral deposits. However, reconstructing the spatiotemporal patterns of paleo-fluid flow is challenging because traditional methods for dating fluid-rock interactions are difficult to apply at regional scales. Here, we outline a new method for regional-scale mapping of paleo-fluid flow using high-throughput Rb-Sr dating via laser ablation mass spectrometry. We apply this method to 100 samples (n = 7229 analyses) from a Mesoproterozoic basin in northwest Tasmania, which yield mixed errorchron dates spanning ca. 160-1093 Ma, reflecting multiple episodes of fluid-mediated resetting of the Rb-Sr system. Finite mixture modelling of this dataset defines clusters of Rb-Sr dates at ca. 1000 Ma, 770 Ma, and 500 Ma. These three events are linked spatially and temporally to structural and stratigraphic elements related to distinct tectonic events in northwest Tasmania. Dating fluid-mediated resetting of the Rb-Sr system offers a novel, rapid, and accessible means of mapping paleo-fluid flow to inform tectonic models and mineral exploration.

Linking crustal-scale architecture to deposit-scale structures: integrating gravity, magnetics and field structural data across the Ora Banda-Davyhurst tenements, Eastern Goldfields

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Crustal-scale shear zones exert a primary control on the distribution of orogenic gold, however, deposits are rarely located directly on the principal shear surface. Ore instead forms where fluid is diverted into subsidiary structures, in which dilatancy and wall-rock reaction facilitate deposition. A persistent difficulty is that deposits distributed along strike within a single belt commonly differ in geometry, host rock and lode orientation, leaving it unclear whether such variation records separate mineralising systems or a single system expressed differently along strike. Resolving this is particularly challenging across much of the Yilgarn Craton, where transported cover and deep weathering limit direct observation and drilling provides only narrow, spatially biased subsurface samples. This study examines how regional architecture influences the position and geometry of mineralised corridors across approximately 140 km of strike in the Ora Banda-Davyhurst tenements, situated between the crustal-scale, east-dipping Ida Fault and the transpressional Zuleika Shear. The architectural framework is defined by integrating field mapping, oriented drill core and outcrop kinematic data with reprocessed airborne gravity gradiometry (FALCON AGG) and magnetics, using derivative, upward-continuation and worming products to trace structural trends at depth. Potential-field data define a dominant N-S to NNE grain cut by NW-SE to WNW-ESE lineaments, and a prominent gravity-high body whose margins may inform the debated position of the Ida boundary in this segment of the belt. Mineralised corridors are spatially associated with intersections between the belt-parallel grain and these cross-cutting trends. Deposit-scale geometry nonetheless varies systematically along strike, from steep multi-strand lodes in folded metabasalt at Riverina, to low- to moderate-angle east-dipping shears and NNW-NW shear veins at Mulline, to contact-controlled lodes within the steepened mafic-ultramafic sequence at Waihi-Round Dam. This variation corresponds to both host-rock package and position relative to the bounding structures. Kinematic data are consistent across corridors, recording sinistral to oblique-sinistral displacement on steep N-S to NNE surfaces, and shoot plunges remain comparable between corridors even where lode strikes differ; S-C-C′ relationships are clearly preserved in metasedimentary rocks, while metabasalt-hosted measurements are considerably more scatt

Oral presentation

The evolution of syn-deformational porosity in a marble mylonite over increasing strain: Insights from EBSD and 3-D microcomputed tomography

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Deformation-controlled fluid flow is a first-order control on the localisation and upgrading of hydrothermal ore systems in ductile shear zones, yet how porosity itself evolves with progressive strain remains poorly constrained at the microstructural scale. We track this evolution in a calcite-rich marble mylonite from the Western Mary Kathleen Shear Zone, adjacent to the Mary Kathleen REE-U deposit in the Mount Isa Inlier, NW Queensland. Microstructural evolution and pore-network topology are followed along a natural strain gradient using electron backscatter diffraction (EBSD) and synchrotron 3-D micro-computed tomography (micro-CT). EBSD shows a progressive shift from twin-rich, dislocation-dominated calcite fabrics at lower strain to uniformly fine-grained, foam-like mosaics at higher strain, where grain-size-sensitive creep (diffusion creep and grain-boundary sliding) takes over and crystallographic preferred orientation weakens. At lower strain, pores occur mainly as isolated to weakly connected cavities along subgrain and grain boundaries, concentrated at boundary junctions and locally associated with twin lamellae. As strain increases and grains are refined further, porosity reorganises into fewer but larger, high-aspect-ratio grain-boundary networks that link into laterally continuous pore sheets. The normals to these sheets, derived from micro-CT, cluster close to the instantaneous shortening direction, so connected pore sheets sit oblique to both the S- and C-planes rather than parallel to foliation. Together, these observations show that finite-strain-driven grain-size reduction can generate transient, strongly anisotropic permeability in carbonate shear zones by organising boundary-hosted porosity into interconnected, sheet-like conduits. This provides a microstructural mechanism for deformation-controlled fluid focusing and REE-U redistribution at Mary Kathleen, and more broadly for fluid-rock interaction in carbonate-hosted shear zones across Australian mineral systems.

Dating sericite to constrain deformational events

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Sericite, a very-fine grained aggregate of white mica, is often formed during hydrothermal alteration and low-temperature metamorphism of feldspar associated with alteration, mineralisation and deformation. Sericite contains appreciable K+ and Rb+, which makes it amenable to 40Ar/39Ar and Rb-Sr geochronology, dating the transformation of feldspar to sericite. With its moderate closure temperature (~350-500 °C), sericite ages can often preserve the final tectonic events in both igneous protoliths and sedimentary basins. Here, we present three mini case studies using both 40Ar/39Ar and in situ Rb-Sr geochronology from Proterozoic and Phanerozoic examples from across Australia to evaluate their ability to record tectonic events. One case study from along c. 1550 Ma felsic volcanics and intrusives in the western Georgetown Inlier yielded slightly disturbed 40Ar/39Ar spectra with dates at c. 320-280 Ma, correlated with deformation along the Tasmanides. A second case study from refolded metapelites in the Meso- to Neoproterozoic Badgeradda Basin, just east of the Darling Fault, yields in situ Rb-Sr ages of c. 950 Ma that are tentatively associated with a D2 event known from the nearby Northampton Complex. Our third case study is from very low-grade pelites in the Proterozoic Cardup Group, just west of the Darling Fault, recording scattered ages of c. 600-500 Ma related to Gondwana assembly, with the scattering partly a function of fine intergrowth of sericite and quartz. Through all case studies, we highlight it is crucial to date fully-sericitised material and, for in situ Rb-Sr, to properly matrix-match sericite to appropriate white mica reference materials.

Spiral Garnets: A Reaction-Front Model of Spiral Development

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Spiral garnets are conventionally interpreted using “string models”, in which a pre-existing, continuous matrix foliation is progressively incorporated into a growing porphyroblast and advected relative to its boundary. We introduce an alternative reaction-front “dot model”. Garnet growth occurs through successive reaction increments at an outward-migrating interface, and each increment records the local intersection between the matrix fabric and the reaction front. The internal reaction trail is therefore constructed through time rather than inherited as a pre-existing continuous material line. The dot model is conceptually related to the broader class of reaction-front replacement processes, including interface-coupled dissolution-precipitation and approximately constant-volume replacement, in which reactant material is consumed and product mineral is generated at a migrating interface. It couples spiral development directly to reaction, mass transfer and interface migration. The two models are topologically distinct and make different petrographically testable predictions. A continuous string should remain continuous through the garnet and connected to the corresponding external foliation unless subsequently disrupted by reaction or deformation. In the dot model, the reaction trail consists of time-ordered growth increments. Trail segments can therefore initiate or terminate where the matrix fabric becomes tangent to the reaction front, where reaction ceases, or where the active part of the interface changes position. Truncations and discontinuities are thus natural products of reaction-front growth. The models also make different kinematic predictions. Under two-dimensional homogeneous simple shear, monotonic outward growth and an explicitly prescribed rotation of the porphyroblast relative to the matrix, a continuously advected string and an incrementally constructed reaction trail develop opposite apparent chirality. Spiral chirality therefore cannot be translated directly into shear sense without first determining how the trail was constructed. Continuity, truncation, relationships to successive growth zones and chirality relative to the external foliation provide independent tests of the two models. The dot model consequently offers a new reaction-based and petrographically testable framework for interpreting spiral garnets.

Poster presentation

Early Recognition of Extreme Endowment in Hydrothermal Ore Systems

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Giant ore bodies commonly do not possess exceptional grades. They are giant because favourable grades are sustained, connected and repeated through exceptional volumes of rock. Extreme endowment is therefore not simply a problem of metal concentration, but of system organisation. The exploration challenge is to recognise that organisation before the full scale of the system has been established by widespread drilling. We propose that extreme endowment is the extensive expression of a distinct dynamical regime. Hydrothermal systems operate far from equilibrium, and near nonlinear thresholds the coupling among fluid flow, reaction and deformation can generate repeated transitions between transport and mineralising states. These transitions focus metal into efficiently connected sites and allow mineralisation to recur across large volumes. Grade is an intensive variable and cannot alone predict endowment. Nevertheless, the form, tail behaviour and differential entropy of within-system grade distributions may provide early fingerprints of the concentrating regime. This organisation also leaves an observable structural record. Stockworks, laminated veins and cemented breccias preserve successive episodes of fluid-rock interaction, while the continuity, repetition and spatial coherence of mineralised structures reveal whether an efficient concentrating process operated locally or throughout a much larger system. We explore whether features observable in early drill core, including structural recurrence, vein architecture, grade-distribution form and differential entropy, can provide early guides to the development of this organisation. When these statistical and structural signatures converge, exploration can move beyond ranking anomalies towards diagnosing whether a hydrothermal system entered a regime capable of extreme endowment. This provides a more defensible basis for early recognition of Tier 1 potential and for concentrating exploration expenditure on systems capable of becoming genuinely large.

Poster presentation

Do Not Avoid Electrical Resistors When Exploring for Minerals: A Case Study from the Broken Hill, Australia

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Magnetotellurics (MT) is widely used in mineral exploration as ore deposits often coincide spatially with electrically conductive zones in the subsurface. Not all mineral systems, however, preserve a diagnostic conductive signature. Here, we report a high-resolution MT investigation of the crust hosting the world-class Broken Hill Pb-Zn-Ag deposit in NSW, Australia. Our resistivity model reveals an upper crust that is overwhelmingly resistive (>1000 Ωm), with isolated, near-surface conductive zones that coincide with the Broken Hill lode and with sulphide-bearing units of the Broken Hill Group, particularly the Hores Gneiss. These shallow features show no clear vertical electrical linkage to conductive anomalies at depth in the lower crust. We interpret the Broken Hill mineral system as genetically related to a deep-seated lower-crustal conductor associated with the rifting event that gave rise to the syngenetic ore deposit. We suggest that the Olarian high-grade metamorphism that followed may have electrically and structurally severed the shallow, mineralisation-associated conductors from their deeper source. Hence, exploration programs targeting conductive anomalies at a regional scale may have missed Broken Hill entirely, had its outcrop been concealed beneath a sedimentary cover. Collectively, these results caution against ruling out resistive crust at regional surveys as an unlikely exploration target, and show how tectono-metamorphic overprinting, combined with the scale of a geophysical survey, can alter the diagnostic signatures of major ore systems.

Joint seismic and magnetotelluric constraints on mantle composition and melt: insights from the western United States and future applications in eastern Australia.

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The western United States hosts remarkable diversity in volcanic and tectonic styles, from active subduction beneath the Cascade Arc, to possible hotspot volcanism along the Yellowstone-Snake River Plain track, to widespread extension across the Basin and Range Province. This diversity offers a natural laboratory for investigating how lithospheric architecture and mantle properties govern magma generation. However, most existing geophysical studies have relied on single-method interpretations that cannot uniquely resolve temperature, composition, melt fraction, and volatile content.

Here we present an integrated analysis of mantle structure across the western US, using complementary constraints from magnetotelluric (MT) conductivity models, seismic tomography, basalt and xenolith geochemistry and thermobarometry. By combining these datasets within a probabilistic framework, we can separate the competing effects of temperature, water content, composition, and partial melt that individually may produce non-unique signatures.

Our approach employs the open-source Python library pide to conduct joint petrophysical/thermodynamic inversions, calculating probability distributions for mantle properties at each location. We integrate MT results from the most recent multi-scale MECMUS model with Vp and Vs models from full-waveform tomography, with existing geochemical datasets of basalts and xenoliths. This study serves as a methodological stepping stone, with the same integrated approach intended for future application in eastern Australia.

Disentangling multi-stage gold mineralisation at the Hyperion deposit, Tanami Region, Northern Territory

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The Paleoproterozoic Tanami Region of the North Australian Craton hosts numerous orogenic gold deposits. The Hyperion deposit, located in the northern Tanami Region, comprises four gold lodes: three trend west-northwest-east-southeast (Hyperion, Tethys and Hyperion South) and one trends north-south (Seuss). The lodes are spatially associated with faults of similar orientation. Although preliminary studies have identified gold within quartz veins and fault breccias in dolerite, the mineralisation styles, distribution of mineralised veins, alteration footprint, and relationships between mineralisation and the deposit-scale structural architecture remained poorly constrained.

Petrographic observations and sulfide geochemistry analysis of samples from diamond drill cores through Tethys and Seuss lodes identified two stages of gold mineralisation. Stage 1 is characterised by high-grade native gold with low sulfide abundances in quartz-rich fault breccias, with subordinate Co- and Ni-rich arsenopyrite and pyrite. A lower-grade Stage 1 expression occurs in extensional veins and comprises Cu- and Co-rich sulfides associated with chlorite-sericite-biotite alteration and disseminated fine-grained arsenopyrite. Stage 2 overprints Stage 1 and is predominantly hosted in fault breccias, where gold is closely associated with As-rich pyrite and massive Sb-rich arsenopyrite.

Limited bedding measurements from mafic sediments (Killi Killi Formation) indicate an upright antiform plunging moderately (48°) toward the south-southwest. Structural analysis identified four extensional vein sets and three shear vein sets. Among these, steeply dipping, east-southeast-west-northwest striking extensional veins host native gold. However, comparison with assay data shows that this vein set is not consistently mineralised.

Integration of structural, petrographic, and mineral chemistry datasets indicates that Stage 1 mineralisation is the dominant contributor to the west-northwest-east-southeast-trending lodes and is associated with fault breccias and extensional veins. In contrast, Stage 2 mineralisation dominantly contributes to the north-south trending lode and is hosted within a ~47 to 53 m thick (apparent thickness) fault-breccia zone.

From extension to contraction: Vein sets as recorders of basin evolution in the Neoproterozoic Yeneena Basin, Western Australia

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Inverted basins record polyphase deformation in which contractional structures overprint extensional structures, complicating reconstruction of basin evolution. Veins preserve evidence of deformation kinematics, paleostress evolution, and fluid flow. Their widespread occurrence in sedimentary basins makes them ideal structural markers to unravel basin evolution. This study evaluates whether veins can be used to understand the structural evolution of an inverted basin. We tested this approach in the inverted Neoproterozoic Yeneena Basin, which also hosts vein-hosted Cu mineralisation at Nifty.

Structural measurements from 17 drill cores were integrated with hyperspectral mineralogical characterisation of >2,000 veins and interpreted within an independently constrained structural framework derived from regional balanced cross-sections. Veins were initially classified according to their angular relationships with bedding and cleavage as bed-parallel (0-20°), oblique (21-69°), bed-perpendicular (70-90°), and axial planar (parallel to cleavage) vein sets. Fold tests, crosscutting relationships, microstructural observations, and mineralogy were used to establish the relative timing of vein formation.

During basin extension, two orthogonal bed-perpendicular vein sets and bed-parallel veins formed during structural diagenesis under elevated fluid pressures. Early inversion phase (pre-folding) generated bed-subparallel veins associated with layer-parallel shortening. Subsequent folding produced two additional bed-perpendicular vein sets in response to local stresses during fold growth and bed-parallel veins related to flexural-slip folding. Although the term axial planar implies a genetic link to folding, our results indicate that axial planar cleavage formed during basin inversion parallel to bed-perpendicular veins that formed early during basin extension. This can explain the axial planar veins. Oblique veins predominantly postdate folding and represent the youngest vein generation.

The results demonstrate that geometrically similar vein sets can form during both extensional and contractional stages of basin evolution. Integrating structural, microstructural and mineralogical data provides a robust framework for linking vein formation to the structural evolution of inverted sedimentary basins.

Oral presentation

Evolution of subducted oceanic mantle: The Marlborough Ultramafic Suite, central Queensland

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The Marlborough Ultramafic Suite is the largest ultramafic massif in eastern Australia. It comprises harzburgite, serpentinite, and high-grade serpentinite containing antigorite and metamorphic olivine. Major and rare earth element (REE) systematics of the ultramafic rocks resemble residual peridotites from oceanic spreading centres. The rocks preserve early lizardite serpentinisation and evidence of high-temperature fluid-rock interaction that took place at or near the ocean floor. High bulk alkali/U ratios and the abundance of prograde antigorite and talc in the ultramafic rocks are attributed to subduction of the Marlborough Ultramafic Suite. Olivine in high-grade serpentinite are highly magnesian (Fo95) and is associated with subduction-related prograde metamorphism. Based on the petrological and geochemical signatures of the ultramafic rocks, we suggest that they represent the upper mantle beneath the now-subducted Palaeo-Pacific Ocean. Slivers of the subducting slab were detached and later mixed in the subduction channel before being exhumed and accreted onto the accretionary complex. Our results provide new constraints on the evolution of a now-consumed oceanic domain along the eastern Gondwanan margin, offering insight into the fate of oceanic lithosphere upon subduction.

Tectonic origin of metagabbros in the Marlborough Ultramafic Suite, central Queensland

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The Marlborough Ultramafic Suite is the largest exposure of ophiolitic rocks in eastern Australia. It is exposed as massive serpentinite, peridotite, and metagabbro blocks enclosed in a serpentinite matrix. To unravel the primary melt characteristics and tectonic origin of the ophiolitic complex, we conducted field, geochemical, and geochronological analyses of the metagabbro blocks. The original assemblage of the gabbros include clinopyroxene (pseudomorphed to amphibole) and plagioclase (sericitised). Cumulate textures are discernible in the plagioclase and pyroxene pseudomorphs. Geochemical data show low total alkali (Na2O+K2O) and silica concentrations, typical of mafic rocks. The metagabbros are characterised by high bulk MgO (>6 wt.%), Al2O3 (>15 wt.%), and CaO (>10 wt.%). Bulk Th and Nb systematics are akin to mid-ocean ridge basalt (MORB) and range from depleted-MORB to enriched-MORB compositions. Chondrite-normalised rare earth element (REE) patterns of relic clinopyroxene define flat middle to heavy REEs and depletions in light REEs similar to mid-ocean ridge gabbros. Apatite U-Pb data show ages ~250 Ma and ~270 Ma, possibly corresponding to greenschist- to amphibolite-facies metamorphism during the Hunter-Bowen Orogeny. Low light REE concentrations (<102 ppm) in apatite and static growth of amphibole in the metagabbros support metamorphic overprint. Further geochronological analysis by U-Pb dating of zircons and Lu-Hf dating of apatite are required to constrain the magmatic age of the mafic crust represented by the metagabbros.

Low-angle thrusts as fossil fluid pumps: implications for giant ore deposits

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The formation of giant ore deposits requires not only fertile source regions, but also mechanisms capable of focusing fluid flow into restricted rock volumes over geological timescales. Although transient permeability is widely invoked in hydrothermal systems, the processes controlling its recurrence and spatial localisation remain poorly understood. Here we investigate whether low-angle, large-displacement thrusts preserved within the Australian crust represent the fossil footprint of deformation-driven fluid pumps capable of sustaining repeated mineralising fluid pulses. Our hypothesis is inspired by a chemo-mechanical oscillator model developed to explain episodic tremor and slow slip in modern subduction zones. This model predicts massive cyclic permeability enhancement, allowing deep fluids to ascend through otherwise impermeable crust. We postulate that the same model may be applicable to movement on low-angle thrusts during compressional events. Rather than testing the physical model directly, we evaluate a geological prediction arising from it: that giant ore deposits should preferentially occur near low-angle thrust systems generated during large-scale compressional deformation. 1094 mineral deposits from the Geoscience Australia database were classified using a size ranking scheme. The locations of deposits above a given size threshold were compared with low-angle surfaces extracted from national-scale crustal boundary models using a Berman-type analysis, which was repeated for a range of size thresholds. The results support a statistically significant association between deposit locations and low-angle surfaces, although the small sample size (n = 64) for giant deposits makes the analysis unreliable at higher size thresholds. This deficiency is addressed by independent analysis of geological evidence for the 64 giant deposits, which confirms the relationship between giant deposits and major low-angle thrusts. The results suggest that transient permeability generated during compressional tectonics represents an underappreciated control on ore formation. By linking fossil thrust systems with deformation cycles observed in modern subduction zones, the proposed framework implies a mechanism for episodic permeability enhancement. More broadly, the study illustrates how physics-based models can generate testable exploration criteria and highlights the need for improved characterisation of low-angle thrust geometries for predictive mineral exploration.

Stratigraphic anomalies in the Delamerian Orogen of the Mount Lofty Ranges, South Australia: thrusts, extensional faults or unconformities?

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Interpretations for some stratigraphic anomalies in the Mount Lofty Ranges are proposed as working hypotheses. Basement inliers within the Neoproterozoic-Cambrian Adelaide Superbasin are bounded by reverse faults at their western margins, long recognised as inverted rift faults, but their eastern boundaries with overlying Adelaide Superbasin sediments are partly unconformable and partly faulted, juxtaposing cover (including Cambrian Kanmantoo Group) against basement. These must record major extension with limited contractional reactivation.

Near Strathalbyn, a northeast-trending fault separates thick deltaic sediments (Backstairs Passage Formation, Keynes Subgroup) from various Neoproterozoic formations. The absence of Keynes Subgroup north of this fault is best explained by a Cambrian syn-depositional extensional fault, which must sole out into a sub-horizontal shear zone within the Neoproterozoic cover. The relationship is complicated by Delamerian folding and reactivation of the shear zone as a thrust.

Nearby, anomalous lithostratigraphy in the Strathalbyn Anticline substitutes for typical Keynes Subgroup below the Nairne Pyrite marker bed. The Kanmantoo Group here rests on various underlying formations. The contact is best interpreted as a southward continuation of a known down-cutting unconformity associated with the Cooalinga Member at the base of the upper Kanmantoo Group.

The Nairne Fault forming the western boundary of the Kanmantoo Group between Mount Barker and the Barossa Valley is also extensional, but cuts across regional Delamerian folds. It may represent late extensional reactivation of a Cambrian rift fault in the basement.

Other Cambrian faults controlling deposition that have been inverted in the Delamerian Orogeny include the Willunga, Meadows and Williamstown Faults, and the Kangaroo Island Shear Zone. The latter, and the Willunga Fault precursor, formed the northwest boundary of the Kanmantoo Trough. Reverse movement on the Williamstown Fault juxtaposes amphibolite facies Neoproterozoic rocks against greenschist facies to the west, implying pre-metamorphic extension.

Deep crustal architecture of the southwest Yilgarn Craton revealed by the 23GSWA-SW1 seismic reflection profile: implications for Neoarchean tectonics and crustal evolution

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The 630 km-long deep seismic reflection profile 23GSWA-SW1 starts in the Albany-Fraser Orogen and traverses the southern Youanmi Terrane, South West Terrane, Perth Basin and Leeuwin Inlier, providing new insights into the crustal architecture and tectonic evolution of the southwest Yilgarn Craton. The line was designed to test key outcomes of recent geological mapping, including the revised South West Terrane-Youanmi Terrane boundary, the crustal-scale significance of the Corrigin Tectonic Zone (CTZ) and the nature of major mineralization-related structures. Integration of seismic reflection data with geological and gravity datasets reveals major crustal variations across the craton. In the eastern part of the profile, the Moho is well-defined and underlies a strongly reflective mid-crust and dome-and-keel upper crustal structure. In the central part, the CTZ is expressed as a crustal-scale west-verging thrust system associated with widespread exhumation of mid-pressure granulite-facies rocks. This domain coincides with a pronounced crustal root where weakly reflective lower crust is thickened and duplicated along a mid-crustal ramp. Metamorphic data indicate burial of supracrustal rocks to approximately 18 km depth, accompanied by mid-pressure granulite-facies metamorphism at 2665-2635 Ma and exhumation prior to emplacement of the c. 2615 Ma Yandinilling Dolerite Suite. The crustal root imaged beneath the CTZ is unique among existing Yilgarn Craton's deep-crustal seismic profiles and is interpreted as an Archean feature linked to the CTZ event. Gravity modelling is consistent with the root comprising dense garnet-bearing mafic lower crust, interpreted as residues of lower-crustal anatexis derived from the Yarraquin Seismic Province. Together, these observations define a tectonic style distinct from both dome-and-keel Archean provinces, distributed transpressional shear zone pattern and younger plate-margin orogens. We interpret the CTZ as a transitional tectonic regime characterised by moderate strain localisation, crustal thickening and exhumation, representing an intermediary stage between Archean "ultra-hot" and more modern Proterozoic-style orogens. These results indicate that significant Neoarchean crustal shortening and preservation of a crustal root accompanied final stage of cratonization in the southwest Yilgarn Craton, providing new constraints on Archean lithospheric evolution and stabilisation.

Poster presentation

Deep seismic imaging of the western Yilgarn Craton: contrasting crustal architecture, tectonic styles and margin modification along the 23GSWA-MW1, MW2 and SW1 transects

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The 23GSWA-MW1, MW2 and SW1 deep seismic reflection profiles provide a crustal-scale framework for investigating the architecture of the western Yilgarn Craton, modification of its western margin, and evolution of the Perth Basin. Together, the transects image contrasting crustal domains that preserve different stages and styles of crustal evolution. Several first-order features are common to all three profiles. Within the craton interior, the Moho is generally sharp and continuous, whereas towards the western margin it becomes increasingly diffuse. This transition commonly coincides with domains affected by Proterozoic and younger tectonism, suggesting substantial modification of the lower crust and crust-mantle boundary. Proterozoic domains are also typically less reflective than adjacent Archean crust. The transects reveal marked variations in Archean tectonic style. In the Yalgoo region, MW1 images a generally simple layered crust with weakly reflective lower crust associated with upper crustal dome-and-keel architecture. To the east, a well-defined two-layer crust with strongly reflective lower crust is associated with thick greenstones and a network of distributed transpressional shear zones in the upper crust. MW2 and SW1 image domains characterised by stronger strain localisation, crustal thickening and lower-crustal duplication. SW1 uniquely reveals a weakly reflective lower crust thickened along a mid-crustal ramp forming a pronounced crustal root, overlain by strongly reflective mid-crust and a variably reflective upper crust. The crustal root appears associated with compressional structures of the Corrigin Tectonic Zone, which exposes widespread mid-crustal granulites. Collectively, the three transects demonstrate that the western Yilgarn Craton preserves architectures produced in a spectrum of tectonic styles ranging from buoyancy-driven tectonics, bulk inhomogeneous transpressional shearing and localised orogenic shortening. Along the western craton margin, all three profiles indicate significant Proterozoic and/or Phanerozoic modification. A poorly reflective to non-reflective crustal domain beneath the Yilgarn Craton’s western margin, Perth Basin and Pinjarra Orogen may represent either extensively reworked Archean crust and/or juxtaposition of younger crustal material. These observations provide new constraints on Archean lithospheric evolution and subsequent reworking of the western Australian continental margin.

Oral presentation

Crustal structure controls coseismic rupture extent, segmentation and displacement in Australian intraplate earthquakes

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Australia's contemporary surface-rupturing earthquakes provide an exceptional natural laboratory for examining how inherited crustal structure influences earthquake rupture in stable continental regions. Morphological characteristics of surface ruptures from historical Mw 4.7-6.6 reverse-faulting earthquakes are compared with aeromagnetic, gravity and regional stress data. More than 90% of mapped surface rupture traces align with geophysical structures in the underlying basement, suggesting a strong influence of inherited crustal anisotropy on rupture propagation. This is further verified with field evidence. Crustal structure influences not only where ruptures occur, but their length, segmentation and coseismic displacement distributions. Ruptures may propagate along multiple intersecting structural fabrics, whereas high-angle magnetic lineaments and lithological boundaries can act as barriers, producing abrupt rupture termination and steep displacement tapers. Conversely, fault bends, step-overs and intersections commonly localise enhanced slip: maximum displacement occurs at or near geometric complexities. Shallow hypocentres and restricted rupture widths additionally promote unusually long surface ruptures and large displacements relative to earthquakes of equivalent magnitude elsewhere. These relationships are used to propose a three-type classification of cratonic rupture behaviour. Type 1 ruptures exploit a dominant, favourably oriented crustal fabric and are comparatively straight and weakly segmented. Type 2 ruptures propagate through multiple intersecting fabrics and display greater segmentation and geometrical complexity. Type 3 ruptures occur where dominant inherited fabrics are poorly oriented for failure, producing strongly segmented, asymmetric rupture geometries through interaction between regional stress and secondary structures. These observations show that earthquake rupture extent and displacement in stable continental crust cannot be understood from magnitude and regional stress alone. Inherited crustal architecture exerts a first-order control on where ruptures propagate, segment, concentrate displacement and ultimately terminate.

Birimian Multiphase Fold-and-Thrust Development, Côte d'Ivoire, West Africa

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Endeavour's Lafigué Gold Deposit, situated along the northern margin of the Paleoproterozoic Oumé-Fétékro Greenstone Belt in the Baoulé-Mossi domain, central Côte d'Ivoire, comprises 2.2-1.9 Ga metamorphosed Birimian mafic intrusives and metavolcano-sedimentary supracrustals intruded by syntectonic granodiorite complexes. Geophysical survey interpretations, field mapping, and 3D modelling of exploration drillhole data characterize a NW-SE-oriented deformation sequence of early recumbent, tight- to isoclinal-folds (D1), followed by upright, open-to-closed folding and thrusting (D2), and eventual sinistral transpression with strike-slip reactivation (D3) - defining a broad NNE-SSW belt architecture developing between ca. 2250 - 1800 Ma during the Birimian-Eburnean Orogeny. Regional belt formation is characterized by a late-developing S-C configuration because of protracted shortening along a NW-SE-axis. The entire sequence is subsequently overprinted by late conjugate ENE-WSW- and WNW-ESE-trending upper crustal, strike-slip, brittle structures (D4). Early deformation (D1a-b) involved WNW-ESE-directed, subhorizontal shortening, producing NNE-SSW-trending upright, isoclinal F1a folds progressively overturned to recumbent F1b folds. D2 NW-SE-oriented shortening caused the refolding of apparent subhorizontal, recumbent tight- to isoclinal D1 strata, now locally dipping SSE, and development of belt dissecting NNE-trending high-angle thrusts. Late D3 reactivation of pre-existing (D1-2) strata contacts and NNE-trending thrusts to sinistral-oblique shear zones (C3) resulted in the formation of sigmoidal-shaped ENE-WSW-trending (S1-2) domains, with moderate SSE-dipping strata parallel shearing (S3). Local transpression and ongoing (D3) thrust reactivation of the strata, and predominant strain partitioning along lithological contacts of mafic volcanic and granodiorite contacts define deposit-scale architecture and Au mineralization. More locally, contact-bound and transgressive mineralized thrusts largely envelop low-strain lozenges of granodiorite, emphasizing preferential rheological control in the development of mineralized shears and associated dilational zones. Structural evolution of the Lafigué deposit showcases the importance of protracted, multiphase deformation in the generation of a world-class Birimian Au Deposit.

Structural Geology and Its Allies: An interdisciplinary Approach to Tectonic Reconstruction

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Tectonic reconstruction is challenging because tectonic processes operate across different spatial and temporal scales and available data may be patchy and incomplete. We present an example from the northeastern Tasmanides where the combination of structural geology, geochronology, and provenance analysis, allows us to unravel the tectonic history of complex areas. The study area includes an orogenic curvature (Broken River Orocline; BRO), bounded by the Clarke River Shear Zone (CRSZ) along its southern limb, and the fault-bounded Graveyard Creek Subprovince (GCS) near the orocline hinge zone. We integrated field mapping, structural analysis, geochronology and provenance analysis to investigate orocline formation and its broader tectonic implications. Structural mapping indicate that the BRO formed through bending of pre-existing structures around a NE–SW-trending axial surface, likely during the Middle-Late Devonian. Oroclinal bending is also reflected in the spatial arrangement of basement blocks and lithospheric architecture, consistent with deformation at the lithospheric scale. Microstructural analysis combined with texturally targeted $^{40}Ar/^{39}Ar$ and in situ Rb–Sr geochronology constrains two episodes of dextral shearing along the CRSZ, at 415 ± 9 Ma and 348 ± 13 Ma. These ages do not overlap with the timing of oroclinal bending, suggesting that movement along the shear zone was not the primary mechanism driving orocline formation. In the GCS, detrital zircon U–Pb data link reactivation episodes recognised along the CRSZ with changes in depositional architecture and localised sediment-source shifts, highlighting the prolonged influence of basin-bounding structures on basin evolution. In contrast, oroclinal bending coincided with sustained Devonian transgression and subsidence, with limited sediment input from the uplifted fault margins, suggesting that bending was not associated with major movement along the CRSZ or other basin-bounding structures. Spatiotemporal relationships place the BRO near the transition between non-retreating northern and retreating southern subduction segments, potentially reflecting accommodation of along-strike contrasts in trench migration. Subduction segmentation may also have promoted strike-slip deformation along subduction-oblique shear zones, including the CRSZ, and the development of an intra-arc pull-apart basin represented by the GCS. This study demonstrates how structural geology and its allied disciplines can be integrated to reconstruct tectonic histories and test causal relationships.

Poster presentation

Data Integration Across the Yilgarn Craton: What Are We Learning?

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High-resolution geochemical, isotopic, metamorphic and seismic datasets acquired by the Geological Survey of Western Australia across the Archean Yilgarn Craton reveal that the dominant set of crustal structures coexists with compositional trends with only subtle surface expression. Passive-source seismic imaging confirms ENE-trending igneous source domains previously identified through regionally extensive geochemical and isotopic datasets. There are instances where geochemical and seismic domains spatially coincide and extend across NNW-trending shear zone systems that have traditionally been interpreted as boundaries between accreted terranes. This composite fabric is difficult to reconcile with existing geodynamic models. Our data indicate that the craton has been shaped by the interaction of discrete crustal-scale shear zones and broad compositional domains that can be traced across the craton. Our findings suggest that ENE-trending compositional domains represent fundamental building blocks of the Yilgarn Craton that have not undergone plate-boundary scale displacements characteristic of accretionary orogenic systems. Given their age and scale, these compositional domains are unlikely to be younger than the NNW-oriented structural framework. Instead, the two boundary types may reflect the segmentation of primary magmatic belts, analogous to transform structures in rift settings, or the segmentation of proto-arc systems.

Semiquantitative metamorphic assemblage facies map of the western Yilgarn Craton

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[1] Geological Survey of Western Australia

The Archean Yilgarn Craton is dominated by granites, granitic gneisses, and greenstone belts that have all been variably metamorphosed. Understanding the metamorphic history of the Yilgarn Craton is fundamental to better constrain its tectonic evolution and mineral systems. Metamorphic constraints are typically derived using calculated phase equilibria modelling (pseudosections) and conventional thermobarometry, or interpreted from petrographic observations. Quantitative phase equilibria modelling is generally regarded as the most robust technique for constraining the metamorphic pressure-temperature conditions that rocks record. However, these studies require appropriate rock types with low-variance metamorphic assemblages. For the western Yilgarn Craton, to leverage the extensive legacy catalogue of historic petrographic descriptions and expand the spatial coverage of metamorphic constraints, metamorphic data have been retrieved using: (a) calculated phase equilibria modelling for 20 samples; (b) more than 1,500 petrographic reports integrated with over 3,000 site and sample observations to establish metamorphic facies. This synthesis has provided a new and large dataset of metamorphism for the western Yilgarn Craton. In addition, an even larger number of legacy petrographic descriptions are for (meta)granites. For these, the metamorphic facies are difficult to determine due to the lack of key metamorphic index minerals. To address this by proxy, a relative foliation intensity index was developed to classify the degree of temperature-dependent deformation based on descriptions of mineral alignment, gneissic bands, and other diagnostic features that occur during progressive metamorphism. Together, these three modules produce a comprehensive metamorphic dataset. The significance of this new dataset is clearly demonstrated across the Corrigin Tectonic Zone (CTZ), where hundreds of samples within it record granulite-facies metamorphism and granitic gneisses compared with amphibolite- to greenschist-facies rocks and minor mineral alignment to schistose granitic rocks in the western footwall. By integrating an array of metamorphic data types, this study provides a more complete picture of metamorphic and structural (strain) patterns, improving our understanding of tectonic reworking across the western Yilgarn Craton.

Poster presentation

Testing competing hypotheses for the collision of the Ontong Java Plateau with the Solomon Islands Arc

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The collision of the Ontong Java Plateau with the Solomon Islands Arc is commonly cited as the classic example of a flipped subduction zone, whereby the arrival of a thick oceanic plateau leads to subduction congestion that triggers the formation of a new subduction zone with an opposite polarity. Nonetheless, the tectonic history of this collision is a contentious issue, mainly because the timing of collision is poorly constrained. The most popular model (Hypothesis 1) is based on the assumption that a hiatus in arc volcanism in the Solomon Islands occurred at 20-10 Ma. Hypothesis 1 thus invokes that collision occurred during the Early Miocene (at 25-20 Ma), although evidence for contemporaneous collision-related structures is lacking. It has therefore been referred to as ‘soft docking’. Hypothesis 2 assumes that the plateau collision occurred much later (at <5 Ma), and Hypothesis 3 considers an earlier emplacement of a piece of an oceanic plateau fragment (Malaita Terrane; a rifted fragment of Ontong Java Nui) at ~35 Ma, followed by a plateau collision at ~10 Ma. By contrast, both Hypotheses 1 and 2 assume the Malaita Terrane to have been contiguous with the rest of the plateau until the plateau collision.

We tested the alternative hypotheses by determining the age and origin of volcanic ash and volcaniclastic sandstone samples from the Malaita Terrane (Malaita and Santa Isabel, Solomon Islands). Volcanic material in our samples shows a calc-alkaline geochemical affinity, consistent with arc magmatism. Using LA-ICP-MS U-Pb dating, we found abundant zircon grains in our samples that yielded Miocene ages, ranging from 17.15 ± 0.39 Ma to 10.88 ± 0.51 Ma. This interval lies within the supposed volcanic hiatus of Hypothesis 1. Our results, therefore, refute Hypothesis 1 and indicate that the Solomon Islands Arc was active until at least 10 Ma. This implies ongoing subduction of the Pacific Plate during the Miocene. The study calls for a re-evaluation of the ‘soft docking’ model. Based on our results, the Ontong Java Plateau more likely collided with the Solomon Islands Arc at 10-8 Ma, triggering arc polarity reversal and subduction of the Indo-Australian Plate since the Late Miocene. The presence of Early to Middle Miocene volcaniclastics on the Malaita Terrane, showing that the terrane’s emplacement on the arc significantly preceded plateau collision, invalidates Hypothesis 2 and leaving Hypothesis 3 as the only one consistent with the data.

Why is it so difficult to create plate tectonic reconstructions of the Tasmanides (and other old orogens) and what we can do about it?

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Plate tectonic reconstructions of the Tasmanides are rudimentary and relatively poorly constrained. This assembly of subduction-related orogens represents the youngest portion of Australia, arguably the part of the continent that should be best reconciled with our understanding of modern tectonics. The lack of rigorously constrained models for the evolution of the Tasmanides, therefore, is a humble reminder that basic questions regarding the evolution of continents are yet to be resolved. Here, I present examples from modern convergent plate boundaries, highlighting complex interactions that might have operated in eastern Gondwana. First and foremost is the role of trench retreat, which inevitably leads to continuous changes in tectonic settings. For example, the present-day Calabrian trench has migrated 600 km since 6 Ma; if such rates of retreat affected the Tasmanides, it is possible that vast areas across the strike of the orogen were under the influence of supra-subduction processes during relatively short intervals. Second, retreating plate boundaries drive overriding-plate extension, particularly in backarc regions, thinning the continental crust and potentially exhuming sub-continental lithospheric mantle and/or creating new oceanic crust. The overriding plate could thus transform into a broad hyper-extended continent-ocean transition zone. A modern example in the southern Tyrrhenian Sea comprises two incipient oceanic domains separated by hyper-extended continental crust. Large sedimentary basins in the Tasmanides, and possibly some of the dismembered ophiolite suites, may represent such backarc regions. Third, large-scale extensions lead to lateral translations of crustal blocks, forming oroclines and implying that crustal elements of the Tasmanides may have rotated and translated prior to obtaining their present-day configuration. Fourth, signatures of arc and backarc magmatism could be complex and potentially misleading. Arcs superimposed on a hyper-extended continental crust could be wrongly interpreted as intra-oceanic arcs (e.g., Gympie/Calliope arcs, Tasmanides; the Aeolian volcanic arc as a modern analogue), while arc-like S-type granitoids may represent crustal melting in hot backarc regions. Taken together, future discoveries may come to fruition by integrating such conceptual processes with the ever-increasing information on the Tasmanides, including the timing of geological events and the structure of the rocks under cover.

The Aotearoa Belt: New Zealand’s Late Cretaceous-to-Recent mineralising orogen

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New Zealand is one of the few places in the world where mineralising processes can be simultaneously investigated in active and ancient hydrothermal settings. In this unique laboratory, time-scales and length-scales of critical geologic processes can be quantified and assessed within the much larger context of a single evolving convergent plate boundary. Both extensional and contractional tectonics produce meshes of faults and fractures that when subject to elevated temperature and hydrothermal fluid flow, generate precious metal epithermal deposits in the North Island and orogenic deposits in the South Island. Importantly, these disparate styles of mineralisation appeal confined to a geological corridor that favours metal transport and deposition: the Aotearoa Belt. This hypothesis implies the existence of a single deep crustal-scale control on metal supply, which where tapped leads to concentrations of metals in the upper crust. In this talk, I will focus particularly on the interplay between this inherited feature and that part of the orogen that is currently under extension to illuminate controls on ore-forming hydrothermal fluid flow in epithermal environments.

The viability of plastic faulting beneath the neutral plane of bending oceanic plates

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Subducting oceanic plates bend as they enter the trench, a deformation expressed in their bathymetric curvature and gravity anomalies and broadly described by flexural mechanical models. Within this well-established setting, intraplate earthquakes show a systematic depth-dependent separation: normal faulting occurs above the flexural neutral plane and, more rarely, reverse faulting at ~30-60 km depth in old oceanic lithosphere, consistent with extension above and shortening below the neutral plane (Craig, 2014). These deeper earthquakes present a distinctive mechanical problem. At depths of order 40 km, frictional failure of dry mantle rocks requires very high differential stresses, while the origin of through-going faults in old oceanic lithosphere is unclear. Fluids could facilitate frictional failure, but their transport below the neutral plane may itself require deep fault networks. Despite these difficulties, reverse-faulting earthquakes occur at these depths, with the largest exceeding magnitude 7.5 (Ye, Lay & Kanamori, 2021). The mechanics of deformation beneath the neutral plane have been discussed since early yield-stress models of bending plates (Chapple & Forsyth, 1979). One possible mechanism is thermal shear instability, or plastic faulting, quantified for olivine and applied to deep slab seismicity by Hobbs & Ord (1988). Related mechanisms have been invoked for pseudotachylytes in exhumed mantle shear zones and revisited in models coupling shear heating, grain-size reduction and strain localization. Direct geological constraints are limited because the deep outer rise is subsequently subducted, leaving seismology and mechanical modelling as the principal constraints. Here we combine analytic instability criteria with visco-elasto-plastic subduction models to examine whether conditions in the deep compressional domain approach those required for shear instability. In the models, deformation occurs by ductile creep, with mechanical dissipation concentrated in a narrow near-trench region. This localization connects plate-scale bending with conditions favourable for shear instability, while its limited extent may be consistent with the rarity of deep outer-rise earthquakes. These events thus provide an unusual constraint on the mechanical response of oceanic lithosphere during subduction under a comparatively well-defined loading geometry.

Oral presentation

Transient permeability in ductile shear zones: the role of metamorphic reactions

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Metamorphic reactions in deformed rocks are commonly frozen part way through, with reaction seams, coronas and partial pseudomorphs sitting alongside unreacted domains of the same rock at similar pressure and temperature. A reaction proceeds only where the components it requires are delivered and retained, so the domains that reacted are those where fluid was present and moving. Frozen reactions therefore map the fluid pathways of a shear zone while it was active. Two competing controls set where a reaction is expressed and how far it goes: transport of components towards the reaction site fixes the thickness of the reaction front, whereas fluid flow through the site removes those components and limits completion. Deformation acts on both. It widens reaction fronts by opening transport pathways, but the same pathways drain the site, so the most strongly deformed part of a rock need not be the most completely reacted. Experimental data on permeability, pore closure and creep cavitation allow a model to be built in which connected porosity is a balance between creation by deformation, creation by metamorphic reaction, and thermally activated closure. Permeability switches on only once connected porosity exceeds a percolation threshold, so a shear zone is either a seal or a conduit. Deformation alone falls four to six orders of magnitude short of that threshold at natural strain rates, and metamorphic reaction closes the gap at geologically reasonable rates. Shear-zone permeability is therefore controlled not by porosity creation during deformation alone, but by whether a net porosity-producing reaction is running, and a conduit lasts only as long as the reaction that opens it. The permeability of an exhumed mylonite is a lower bound on its value while active, and fluid flow through the deep crust is expected to be episodic, timed by metamorphic reaction rather than by deformation.

Geologic Evidence for Quaternary Earthquakes on the Para Fault, Adelaide Central Business District, South Australia

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The Para Fault is expressed as a prominent topographic scarp and poses a significant seismic hazard to the Adelaide Central Business District (CBD) in South Australia. Its moment magnitude potential (Mw), slip rates, and earthquake chronology are unconstrained. We integrate historical and modern borehole data with new surficial geologic and fault mapping to characterise fault geometry, the most recent earthquake (MRE) displacements, and Plio-Quaternary slip rates. Our study indicates that fault slip is concentrated on a major fault strand north of Adelaide CBD before splaying into six segments to the south, providing implications for ground shaking and fault displacement hazards. The rupture traces are inferred to underlie critical infrastructure, including hospitals, the airport, and tunnels. A fault scarp along segment s1 records 1.1 ± 0.5 m of fault slip offsetting the Late Pleistocene Pooraka Formation, estimated to indicate a Mw 6.5 to 6.9 earthquake after 167 to 71 ka; undeformed river terraces further constrain the MRE to predate 8-3 ka. Monte Carlo simulations of borehole offsets yield Plio-Quaternary slip rates of 65.9 (+5.9/-5.2) m/Myr (Late Pliocene) and 77.4 (+7.6/-6.8) m/Myr (Early Pleistocene), averaging 72.0 (+8.4/-7.3) m/Myr. Slip rates integrated over the entire fault, derived from displacement-length scaling under two rupture scenarios (stepover termination and full-length rupture), converge at 59.8 (+7.1/-5.8) m/Myr and 62.1 (+7.4/-6.1) m/Myr, respectively. Collectively, these geologic evidence confirm that the Para Fault may fit the definition of ‘active fault’ following Australian National Committee on Large Dams criteria (activity in the last 35 ka). We present a transferable framework for characterising fault systems in low strain rate, urban settings, and demonstrate an uncertainty-integrated slip rate approach suitable for probabilistic seismic hazard and fault displacement hazard analyses.

The lithospheric mantle fabric beneath the southern New England Orogen

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The lithospheric mantle preserves a long-lived record of deformation associated with continental assembly, subduction, and lithospheric reworking. Mantle xenoliths provide a unique archive of the compositional, structural, petrophysical, and mechanical heterogeneity of the upper mantle, enabling direct assessment of the sources of seismic and electrical anomalies. Because mineral shape-preferred orientation (SPO) constitutes a fundamental element of mantle fabric and a primary control on physical and mechanical anisotropy, its quantification provides a critical link between upper mantle deformation, geophysical signatures, and the tectonic evolution of the overlying orogen.

We investigate lithospheric mantle deformation beneath eastern Australia using a suite of spinel peridotite xenoliths from three volcanic centres in the southern New England Orogen. The xenoliths were entrained in Oligocene-Miocene (ca. 32.9-20.7 Ma) alkali olivine basalts from Armidale, Miocene (ca. 19.8-18.5 Ma) olivine nephelinites from Inverell, and Eocene-Oligocene (ca. 43.9-31.9 Ma) nephelinites from Glen Innes (Simpson & Sutherland, 2022). We used X-ray computed tomography (XRCT) to quantify the orientation, strength, and geometry of spinel-defined fabrics in mantle xenoliths, following the standardised workflow of Li et al. (2026).

Comparison of the results from the three volcanic centres aims at determining the structural heterogeneity within the lithospheric mantle beneath the southern New England Orogen and inferring the deformation processes that have shaped the deep roots of the orogen. The XRCT-derived finite strain principal directions also aim at guiding the preparation of thin sections relative to the xenolith fabric, which is essential for the analysis of dominant slip systems and petrophysics.

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Imaging the third dimension: X-ray computed microtomography (micro-CT) applied to orogenic gold mineralisation characterization

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Ore textures and assemblages are crucial features for understanding metallogenetic processes. In orogenic gold deposits, ore is usually described as free visible gold or invisible gold, when fine-grained or associated with sulphides. Additionally, gold is known to be associated with a number of vein textures. However, gold occurrence in these deposits is mainly interpreted based on two-dimensional analysis limited to the surface area of the sample. Usually, the analysis consists of describing the size of gold particles that are visible to the naked eye, or in petrography data. Gold ore characterisation studies using X-ray computed microtomography (micro-CT) are relatively recent and still underexplored. This non-destructive technique allows three-dimensional imaging of internal structures highlighting material density and composition differences. When applied to gold-bearing rocks, micro-CT allows the identification of denser phases such as sulphides and gold, unravelling aspects of metallogenesis and deformation. This work explores the analytical capabilities of micro-CT data segmentation, distribution, shape, orientation, and mineral association of gold particles. Selected samples include a high-grade quartz-gold fault-fill vein with contrasting massive and laminated textures from the Riverina Gold Mine in the Eastern Goldfields Superterrane, Yilgarn Craton. The acquired images revealed that in the oriented half-drill core samples, the three-dimensional distribution of gold particles is spatially associated with the laminated domain. Shape characterisation revealed a population of elongated gold particles, which were used to determine the mineral fabric orientation of the ore and compare it with regional deformation structures. The technique proved that the gold spatial distribution in three dimensions provides useful insights related to ore deposition and deformation in structurally-controlled mineralisation environments.

Poster presentation

Eocene Coral Sea Tectonics: Constraints from the Louisiade Plateau, Mellish Rise, and Louisiade Trough

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The eastern Coral Sea in the SW Pacific is a tectonically complex region, that has little to no constraints on its formation. Dredges from IN2019_V04 that sampled the submarine features of the Louisiade Plateau, Mellish Rise and Louisiade Trough within this region recovered a variety of igneous, sedimentary, and minor metamorphic rocks. These rocks are some of the only samples from these locations, and present a rare and valuable opportunity to place much-needed constraints on the tectonic history of the eastern Coral Sea. Samples from the northern Louisiade Plateau have defined the Louisiade Ophiolite, and this study constrains this ophiolite further as an SSZ ophiolite which formed in the Early Eocene, obducted in the Middle Eocene, with later magmatism likely intruding through the plateau. Mellish Rise and Louisiade Trough samples contain a variety of mafic rocks that include NMORB, EMORB, and BABB dated to ~52-48 Ma. Isotope geochemistry suggests the interaction of multiple mantle sources,while volatiles-in-glass paleobathymetry and geophysics are used to suggest some of these rocks intruded through and erupted atop the Mellish Rise during a later phase of Louisiade Trough spreading, however the contrasting chemistry remains an enigma. This research allows an updated tectonic model of the eastern Coral Sea to be constructed and raises further questions for the nature of the region throughout the Eocene.

Measuring Mantle 3D Strain using CT Data on Xenoliths

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Three-dimensional (3D) finite strain reconstructed from centroids of high density inclusions measures the magnitude and geometry of deformation for rocks devoid of strain markers. The widely-used centre-to-centre (Fry) family of strain estimators was conceived for 2D analysis, assumes grains are initially anti-clustered, and neither created nor destroyed during deformation. In this work, we use synthetic 3D data to test the accuracy of six 3D finite-strain estimators: 3D Continuous Function Method (3D CFM), 2D CFM , 2D Fry generalisation, 3D Delaunay, raw 3D Fry, and shape preferred orientation (SPO). X-ray computed tomography (CT) enables non-destructive 3D visualization of rock volumes and provides direct measurements of grain morphology, shape, orientation, and spatial distribution. We analysed nine spinel-bearing peridotite xenoliths from the Newer Volcanics Province (NVP) in western Victoria. Spinel occurs as isolated grains within a lower-density aggregate of silicate minerals. CT data show that spinel grains are spatially clustered, violating the anti-clustering assumption underlying the centre-to-centre strain analysis methods. Because the strain of natural samples is not known we develop synthetic 3D grain distributions, reproducing observed grain-size, aspect ratio and clustering statistics in natural samples. These synthetic rocks are then deformed by a known amount with simultaneous pure and simple shear (Rs = 1.2-5, k = 0.2-5, Wk = 0-1). To mimic CT data, we degrade deformed synthetic grains by including random loss, attenuation, and resolution cut-off. We then invert the deformed fabric using the six estimators yielding 78,000 ranked strain estimates. Our results show that the percentile-void estimator (3D CFM) is most accurate. It shows fourfold greater accuracy than 3D Fry/Delaunay, and sixfold improvement over SPO methods. We carry out mechanistic assumption tests that reveal that initial clustering makes Fry method underestimate strain by ~26% while the percentile void stays accurate. Applying this method to the NVP xenoliths reveals contrasting finite strain in the mantle underneath Gnotuk (Rs = 2.30-2.39) and Noorat (Rs = 1.4-1.97) volcanic centres. Interestingly, grain shape displays no significant contrast, the mean spinel aspect ratio varies by only 10% across the sample suite. This method offers a robust avenue to map mantle 3D strain.

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Poster presentation

Provenance and ore-forming processes of the Lumwana Deposit, Central African Copperbelt, Zambia: constraints from geochronology and microstructural petrography

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The Central African Copperbelt in Zambia and Democratic Republic of Congo hosts the world's largest sediment-hosted Cu-Co deposits. The ore deposits are mainly emplaced in the Katanga Supergroup, within the Katanga Basin, in an inter-cratonic area located in a region of relatively thin lithosphere with a sedimentary and tectonic history that spans from approximately 880 Ma to 560 Ma. The Lumwana copper deposits are part of this system in Zambia; it is composed by the Malundwe and Chimiwungo orebodies and it has a distinct geological setting within the Mwombezhi Dome of the Western Zambian Copperbelt. Despite the classic sediment-hosted stratiform ore deposits typical of the Copperbelt, Lumwana's mineralization is hosted within highly deformed, metamorphosed kyanite-bearing mica schists (informally named the Ore Schist) interlayered with Paleoproterozoic basement gneisses dated to ca. 1.88-1.87 Ga. However, the protolith and age of the host rock and the origin of the copper remain unclear. An epigenetic metasomatic model argues that the schists were formed when pre-Katanga basement gneisses underwent ductile shearing and hydrothermal alteration. Another model proposes a multi-stage evolution, where initial diagenetic sulfides were subsequently remobilized and recrystallized during the passage of highly saline metamorphic fluids during the Pan-African Lufilian Orogeny. We compare detrital zircon age distributions in the ore schist, gneissic basement, and Katangan sequences to constrain host-rock provenance and establish new timing on metamorphic growth, structural fabric development, and sulfide recrystallization. This will allow us not only to provide predictive criteria to target sedimentary basins prospective for sediment-hosted deposits, but also to improve genetic and exploration models for non-traditional copper deposits in complex metamorphic terrains. To address these issues, we have analysed drill core samples from Lumwana orebodies. We present new microstructural petrography and U-Pb zircon age data to help constrain the age, origin and evolution of the Lumwana deposit.

Exploring a buried trans-crustal shear and suture zone

Spaggiari CV[1]; Le Vaillant[1]; Schoneveld[1]; Salama[1]

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The Rodona Shear Zone represents the tectonic boundary between the Paleo- to Mesoproterozoic Albany-Fraser Orogen (AFO) and Madura Province (MP) beneath the Nullarbor Plain in Western Australia. The depth to basement is up to 500 m and the cover comprises the limestone-dominated Eucla Basin overlying the mudstone-dominated Bight Basin, creating one of the most challenging mineral exploration environments in Australia. Hence, understanding the geological evolution and mineral prospectivity is limited to the use of sub-surface data only. Terrane-scale geophysical datasets show the major structures, and sparse drill holes have provided lithological and structural information. Aspects of promising mineral systems are evident but vast differences in scale between geophysical datasets and drill holes and the ability to scale that information present major obstacles to reducing target blindness. The basin cover is largely transparent in potential field data and valuable insights into the structural architecture are provided by combining interpretations with information from deep crustal reflection seismic and magnetotelluric data. The Rodona Shear Zone is imaged as a broad corridor and drill core data shows that it separates dominantly continental rocks of the AFO from dominantly oceanic-affinity rocks of the MP. Linking drill core, magnetic and seismic data shows variations in fold styles both within the hanging wall and either side of the Rodona Shear Zone and fold formation timing is indicated by cross-cutting relationships with igneous intrusions. The development of new methodologies to investigate mineral prospectivity, utilising drill core samples from both the cover and basement, is being applied to determine workflows for exploration. These complement structural analysis and include detailed mineral chemistry, presence and nature of indicator minerals to test for the presence of nearby sulphides, and presence of detrital sulphides and other minerals along unconformities in the cover linking to paleo-topography, leading to an improved understanding of mineral prospectivity.

Oral presentation

Deep Crustal Architecture Across Northern Queensland: A Revised Interpretation of Seismic Line 07GA-A1

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This study presents a revised seismic interpretation of deep seismic profile 07GA-A1 across the eastern margin of the North Australian Craton. The interpretation identifies a complex crustal architecture characterised by a low-reflectivity upper crust, a structured middle crust with variable thickness, and a reflective lower crust above a well-defined Moho. Major crustal-scale structures associated with the Palmerville Fault system, together with half-graben geometries and systematic variations in seismic reflectivity, provide new constraints on the internal crustal architecture. The seismic architecture indicates that the eastern margin of the North Australian Craton preserves evidence for multiple tectonic stages, recording the Paleo-Mesoproterozoic assembly and break-up of the Nuna Supercontinent, and subsequent episodes of terrane addition and reworking from the Mesoproterozoic to Phanerozoic times. These results provide a refined framework for understanding the crustal architecture and tectonic evolution of the eastern margin of the North Australian Craton.

Oral presentation

Tonian to Cryogenian volcanic arc development and subduction evolution in the northern Arabian Shield

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The Arabian-Nubian Shield (ANS), the largest tract of juvenile Neoproterozoic crust on Earth, is a collection of terranes that is believed to have formed sequentially over separate subduction zones and amalgamated together during the formation of the supercontinent Gondwana. The Al Ays arc formed in the Mozambique Ocean, a vast palaeo-ocean that once separated the proto-Indian and proto-African cratons. Despite the Al Ays volcanic arc representing a major component of the Hijaz terrane in the western ANS, its volcanic rocks have not been studied systematically. This project aims to analyse the evolution of volcanism in the Al Ays arc through space and time, by constraining the age of the volcanic rocks and comparing the chemistry of rocks from different parts of the arc's history. By understanding this change through time, it can provide insight into whether the Al Ays arc records a progression consistent with subduction initiation, and what this implies for the subduction polarity at the Yanbu suture and the tectonic assembly of the northern ANS.

Informing tectonic architecture and structural controls on mineral systems through MinEx CRC outcomes

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The Mineral Exploration Cooperative Research Centre (MinEx CRC) is a 10-year, industry-led research program developing new exploration tools, technologies and approaches with improved cost, efficiency and environmental benefits. Research is undertaken collaboratively across academia, government and industry, with leveraged Australian Government funding. MinEx CRC is now in its eighth year.

This talk will provide an overview of outcomes from the three MinEx CRC Programs and how they inform understanding of tectonic architecture, structural geology and mineral-system processes from regional through to mine scale.

Program 1 has developed a coiled-tubing drilling system for reconnaissance-style deep mineral exploration, capable of rapidly drilling through cover and into prospective basement. The system generates high-quality geological samples, including diamond-drill-core tails, providing new opportunities to characterise geology and structural architecture beneath cover.

Program 2 is developing downhole sensing technologies for rapid acquisition of geochemical, seismic and petrophysical data, increasing capability of subsurface characterisation. These datasets are being integrated into software that supports the development of real-time 3D geological models, providing new approaches to interpreting geological architecture and structural relationships.

Program 3 focuses on novel techniques to improve understanding of mineral systems from basement rocks hosting mineralisation to overlying cover. These approaches provide new constraints on structural architecture, alteration, geochemistry and geological processes that can be integrated into mineral-system and prospectivity interpretations.

All Programs link into the National Drilling Initiative (NDI), which has undertaken drilling campaigns in multiple case-study areas in collaboration with Geological Survey organisations. The NDI campaigns provide regional-scale datasets that improve understanding of geological architecture and mineral-system prospectivity in three dimensions, while also providing test sites for MinEx CRC technologies and workflows.

Together, outcomes of the three programs demonstrate how advances in drilling, downhole sensing, data integration and geological modelling can provide new ways to investigate tectonic architecture and structural controls on mineral systems, particularly in regions of extensive cover.

Oral presentation

Linking slab reorganisation, mantle modification and metallogenesis in the East Lachlan

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The East Lachlan Terrane of eastern Australia records prolonged Ordovician-Devonian subduction-related magmatism and hosts major mineral systems. Despite extensive geochronological, isotopic and whole-rock geochemical datasets, evolution of the underlying slab-mantle system remains poorly constrained. We integrate 1,523 igneous whole-rock samples with ~7,000 Nd and Hf isotopic analyses from the Macquarie and Wagga-Omeo regions between ~495 and 390 Ma. Mafic to mafic-intermediate rocks provide the primary constraints on mantle processes. Arc-like signatures persist through most of the interval, defining a long-lived subduction baseline. Superimposed on this are two geochemically distinct episodes. Between ~458 and 435 Ma, a spatially restricted, broadly E-W belt is characterised by mantle enrichment and elevated Th/Nb coupled with low La/HREE ratios, consistent with enhanced Th mobility during unusually high-temperature slab-derived transfer rather than crustal inheritance. Intermediate-felsic rocks corroborate this signal through Nb/Y classifications with relatively elevated Nb and low Y, consistent with deep fractionation under conditions of rutile instability, together with locally adakitic compositions. Combined with the mafic proxies, these felsic signatures suggest elevated slab temperatures and possible slab-derived melting. This corridor uniquely retains juvenile Nd-Hf isotopic compositions during the Benambran Orogeny while the remainder of the East Lachlan becomes isotopically evolved. A second episode between ~430 and 410 Ma reproduces the same association over ~700 km along strike, but juvenile isotopic domains are more isolated and slab-derived melt classifications less abundant. We interpret these patterns as two periods of slab reorganisation. The earlier E-W event is most consistent with localised slab tearing, permitting hotter asthenospheric mantle to flow into and thermally perturb the mantle wedge, promoting mantle enrichment and high-temperature slab transfer. This anomaly overlaps spatially and temporally with the Cadia mineral district and Lachlan Transverse Zone, providing a plausible mantle-scale driver of elevated thermal conditions, metal fertility and slab-derived fluid flux during porphyry formation. The younger along-strike event may record progressive slab break-off associated with the termination of the Benambran Orogeny. These results link transient slab-mantle reorganisation to metallogenesis along the East Gondwana margin.

Focal mechanisms and InSAR analysis of the 2022-2024 Arthur River earthquake sequence

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Southwest Australia is one of the most seismically active regions in Australia, dominated by spatially clustered earthquake swarms. One such swarm is the 2022-2024 Arthur River earthquake sequence, punctuated by a magnitude 4.0 earthquake on 5 January 2022. It is among the best recorded earthquake swarms in Western Australia, owing to the deployment of the Southwest Australia Network and WA-Array, recording over 5,000 predominantly shallow events (<5 km). Aside from two reverse-motion moment tensors and a single InSAR snapshot from the start of swarm activity, the kinematic evolution of the sequence remains poorly understood. Thus, we use high-quality seismic data and a recently published earthquake catalogue to develop a suite of focal mechanisms, supplemented by long-term Interferometric Synthetic Aperture Radar (InSAR) analysis, to better characterise the source kinematics. We utilise the first-motion method to compute focal mechanisms, which is uniquely suited for small-magnitude events, relying only on a small number of stations. We use the RPNet and CFM deep learning models to automatically derive polarities, and the FOCMEC software to fit nodal planes. Finally, we use the pySATSI Python package to conduct focal mechanism stress inversion. To complement the focal mechanism results, we conduct InSAR analysis, a remote sensing technique for measuring ground deformation. Using HyP3, a cloud-based, on-demand InSAR service, we obtain 322 descending Sentinel-1 interferogram pairs spanning 20 December 2021 to 22 December 2024. We then use the MintPy Python library to map the temporal evolution of ground deformation. In total, we derive 87 dominantly reverse focal mechanisms for the Arthur River cluster. These solutions range in magnitude from 0.42 to 4.85 and have a west-northwest maximum horizontal stress orientation, in line with current literature. The focal mechanism locations coincide with the observed InSAR deformation region, which shows uplift of up to 6 cm ± 0.15 cm. Importantly, the InSAR analysis reveal a northeast to southwest migration of ground deformation, consistent with the spatial migration of the focal mechanisms. Together, these results provide the first detailed picture of the kinematics driving the Arthur River sequence, offering new insight into the mechanisms sustaining earthquake swarms in Southwest Australia.

Reconciling legacy data and scale: structural puzzles in Australia's Pine Creek Orogen

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Geological investigations are commonly founded on diverse legacy data from a variety of sources, collected at multiple scales, and with different scopes. To maximise the scientific success of a project, such legacy data need to be assessed and incorporated into new datasets at appropriate scales. This is particularly important during projects that aim to characterise regional tectonics at large scales. As an example, the Northern Territory Geological Survey is currently investigating the structural geology of the ~47 000 km2 large, Palaeoproterozoic Pine Creek Orogen (PCO) in the Top End of the Northern Territory. This region has been structurally studied since the late 1950s; publications are related to short-term, deposit-scale projects through to regional, long-term mapping campaigns by students, researchers, and explorers. The structural legacy data are invaluable in an area of limited land access; however, their variability requires thorough assessment and confirmation through targeted field work and drill core studies. The data show that local-scale structures and their relative timing differ significantly across wider areas in the PCO, which led many early researchers and prospectors to propose up to seven deformation events related to complex stress fields. These events were fit into one of two regional tectonic models that were proposed in the mid-1980s: fold (and thrust) belt or inverted grabens. In contrast, modern structural publications tend to integrate faulting and folding into a framework of progressive deformation and linked geometric relationships. Such models include as few as two deformation events, which may have been progressive in a single stress field. We will show that a modern structural understanding of evolving fold and thrust belt tectonics, detachments, and doming can account for the complexity of structures in the PCO at local and regional scales. Developing such a relatively simple, regional structural and tectonic model from complex local systems can only be achieved by reconciling the likewise complex legacy data at various scales with new observations.

Piezoelectric potential in quartz-rich mylonite's and relationship to earthquakes

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Quartz is the most abundant piezoelectric mineral in crustal rocks. It is a non-centrosymmetric mineral and when distorted under external stress produces an electrical potential. The applied mechanical force that accompanies earthquakes can produce elastic deformation and generate this electrical potential energy due to a piezoelectric effect in the quartz crystallographic lattice. With a Mw 7-8 magnitude seismic event, electrical signals occur 10 to 20 minutes before an earthquake. These include anomalous electrical resistivity, conductivity, piezoelectricity and electromagnetic signals in the atmosphere or ionosphere. Here we will be describing the crystallographic preferred orientation (CPO) and piezoelectric potential in a quartz-rich mylonite from the Risfjället shear zone, Sweden, and compare these with textural development in other classic mylonite zones. The Risfjället samples are high-grade mylonitic orthogneisses intercalated with mylonitic quartzites that record a high piezoelectric potential. This is because both the [c]- and {a}-axes are highly aligned and the quartz-rich portion of the shear zone records a high J-index. This was established by comparing crystallographic preferred alignment obtained by neutron diffraction texture distributions, and 2D fabric analyses with the piezoelectric tensor, predicted and experimentally obtained. It is shown that microstructural features are the main influence on the degree of preferred orientation, and are controlled by temperature, shear strain and matrix phases. With a high piezoelectric potential in the monomineralic quartz-rich Risfjället mylonite consistent with lattice realignment and heterogeneous slip. This coincides with an inclined single [c]-axis girdle with two distinct maxima, indicative of rhomb<a>-slip. Intercalated with the quartz-rich units are polymineralic orthogneiss mylonites, which have a second phase (e.g. biotite and/or muscovite), coinciding with a reduction in the degree of preferred orientation and reduced piezoelectric potential. These mica-rich mylonites have a low J-index, an elongate single maximum at the girdle centre coinciding with the Y-strain axis and are dominated by prism<a> slip. These results indicate that to produce piezoelectricity in crustal environments requires a high degree of preferred orientation of quartz grains an applied stress, and is commonly associated with earthquakes.

Building Complexity from Simplicity: Experimental Approaches to Fault-System Evolution

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When we look at natural fault systems, we see only a snapshot of processes that may have taken millions of years to develop. Fault systems form through the interaction of tectonic forcing with the mechanical and structural properties of the crust, producing complex architectures that are difficult to interpret from their final geometries alone, because the geological record preserves the cumulative effects of deformation. Analogue modelling provides a means of scaling these processes into the laboratory and observing their progressive development. The power of the approach comes from simplifying nature: by isolating and controlling boundary conditions, individual processes can be investigated in terms of their influence on deformation. In doing so, relatively simple initial conditions can generate complex spatial and temporal patterns of deformation.

The newly established Adelaide GeoModelling Laboratory provides a platform to investigate how geological heterogeneity influences this evolution, with current research focusing on the effects of mechanical and rheological contrasts on fault development across geological scales. Previous experiments investigating strain localisation and migration within the Marlborough Fault System, New Zealand, demonstrate how first-order tectonic boundary conditions can reproduce key aspects of fault-network evolution while revealing temporal changes in strain accommodation. Building on this approach, initial experiments at Adelaide investigate how mechanical layering influences fault propagation and the transfer of deformation during shortening. Contrasting rheology’s produce markedly different structural architectures, with weak layers promoting decoupling and thin-skinned deformation. Incremental analysis further indicates that mechanical layering influences not only where deformation is accommodated, but how it is organised through time, with individual structures becoming active and inactive during progressive shortening. Ongoing experiments extend this approach to rate-dependent rheological behaviour and the interaction between brittle deformation and viscous lower-crustal flow. Together, these experiments seek to establish how mechanical architecture and relative timescales govern the localisation and propagation of deformation, providing new insight into complex fault systems and their role in controlling fluid pathways and reactivation in natural geological settings.

Mid-to-High Latitude Open Water Environments During the Marinoan Snowball Earth of Oman

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The Cryogenian is marked by the most severe glaciations in Earth's known history: the Snowball Earth events. The time between the first known occurrence of complex multicellular life in the Tonian and their subsequent rise to dominance in the Ediacaran is truncated by the Snowball Earth glaciations. Therefore, the question remains; how did the ancestors of present-day life endure these climatic extremes during the Neoproterozoic? Previous numerical models permit the existence of intermittently open water environments strictly at low latitudes (≤ 20°) during Cryogenian glaciations. Such environments would have provided vital refugia, allowing complex life to survive throughout Snowball Earth. The Neoproterozoic successions of Oman preserve Cryogenian stratigraphy with extensive examples of deposition in ice-free, oxygenated oceans - presumed to be deposited in these equatorial, partially open-water seas. In this study, we test this assumption through palaeomagnetic analysis from the Hadash Formation, a post-glacial 'cap carbonate' overlying the Marinoan glacial sequences of Oman. Herein we present a palaeomagnetic pole that shows these cap carbonates (and hence the underlying stratigraphy) were deposited at mid-to-high latitudes. A successful fold test and antipodal magnetic directions make this the most robust palaeomagnetic constraint for Oman-India during the Cryogenian to Ediacaran prior to their amalgamation into Gondwana, thereby constraining India's Neoproterozoic collision with Australia in the Ediacaran. In conjunction with new geochronological constraints of these sedimentary successions, our study strongly supports the persistence of open water environments at high latitudes during Snowball Earth. This assertion conflicts with previous models and therefore demands reassessment of the Snowball Earth hypothesis in its current form.

Refining Neotectonic Fault Scarp Mapping with Multi-Resolution Digital Elevation Models and Machine Learning

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This study presents a machine-learning workflow that uses the approximate locations of mapped neotectonic features and higher-resolution digital elevation models (DEMs) to relocate mapped fault traces to their geomorphic expression. The method scans a 2km corridor around each catalogued trace in the National Seismic Hazard Assessment 2023 (NSHA23) and applies a multi-scale curvature-based detector to identify scarp bases and crests where coherent topographic signals are present. The relocated traces are cross-checked using a geomorphology-based machine-learning classifier trained to distinguish fault scarps from non-tectonic features with similar surface expressions. Each relocated trace is assigned a confidence rating and a set of geometric parameters, including strike (azimuth), vertical separation, scarp width, length, and throw. Applied to the Axedale region of central Victoria, the workflow demonstrates that relocation using airborne 10 m DEMs and 0.5 m LiDAR DEMs produces more spatially constrained trace positions and geometric estimates than the original mapping derived from 30 m topography. The results show the potential for higher-resolution elevation data to refine legacy fault databases and provide a more consistent basis for subsequent geomorphic and tectonic assessment. The workflow is intended as a preliminary step towards automated identification and prioritisation of potential fault-scarp trenching sites. The inference and classification rely primarily on surface morphology, thus they cannot by themselves establish a tectonic origin; geomorphically similar features such as terrace risers, road cuts, and artificial embankments may produce comparable signals. Assessment of lithology, bedrock structure, geomorphic setting, and other independent geological evidence is therefore required to determine whether a relocated scarp is geologically plausible and suitable for further investigation.

Vertical Deformation Partitioning and Thermal Coupling During Late Paleozoic Arc-Arc Collision in the Chinese Altai

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The response of rheologically layered crust to sustained orogenic convergence may vary substantially with depth, but linking these contrasting records within a single tectonic framework remains challenging. The southern Chinese Altai Orogen preserves different structural and metamorphic histories at distinct crustal levels formed during Late Paleozoic arc-arc collision and orogenesis. We integrate field structural observations, petrography, phase-equilibrium modelling, and zircon and monazite U-Pb geochronology from the Kekesuli Lake and Fuyun areas to establish their pressure-temperature-time-deformation (P-T-t-D) evolution. The upper structural level underwent contractional deformation marked by steep fabrics and syn-tectonic growth of cordierite, andalusite, and late sillimanite. Phase-equilibrium constraints indicate progressive heating from ~550-570 °C to ~610-670 °C with only minor pressure increase, while monazite ages place this deformation and metamorphism in the Early Permian. The lower structural level records a more complex evolution, beginning with crustal burial and heating and followed by high-temperature (T = ~680-710 °C), near-isothermal decompression. This decompression coincided with penetrative ductile deformation and sub-horizontal orogen-parallel flow in the Early Permian, before later transpressional folding and exhumation. Importantly, the timing of deep-crustal flow and decompression overlaps with contraction and low-pressure heating at shallower levels. We therefore interpret these apparently contrasting records as synchronous responses at different depths rather than as successive stages of collision. Orogen-parallel flow and thinning of the deep crust promoted rapid exhumation of hot rocks and may also have increased heat transfer toward shallower levels, contributing to contemporaneous high-temperature/low-pressure metamorphism. These results reveal a vertically partitioned collisional system in which shallow-crustal shortening, deep-crustal sub-horizontal flow, and thermal redistribution operated together during continued arc-arc convergence.

Episodic arc behaviour in an accretionary orogen: the New England Orogen, eastern Australia

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The New England Orogen, the youngest component of the Tasmanides, preserves a relatively continuous Carboniferous-Triassic magmatic record. As such, it provides an ideal opportunity for investigating the cyclic evolution of continental arcs. To understand the episodic arc behaviors of the New England Orogen, and the geodynamic processes driving this cyclicity, we integrate new detrital zircon U-Pb ages and trace-element data from Triassic-Jurassic basins with published sedimentary and primary magmatic-rock records. Dominant zircon clusters at 270-230 Ma and 340-300 Ma in these basins were likely sourced from contemporaneous magmatism in the New England Orogen and therefore provide a record of the arc magmatic evolution. Integrating new and published data identifies three magmatic pulses at ca. 320 Ma, ca. 285 Ma and ca. 255 Ma. The ca. 320 Ma pulse coincided with landward arc migration. Elevated zircon crustal-thickness proxies (Eu/Eu* and Sm/YbN) and increased U/Yb during this period suggest crustal thickening and enhanced slab-fluid input during slab shallowing. In contrast, the ca. 285 Ma pulse accompanied trenchward arc migration and overriding-plate extension. Higher zircon crystallization temperatures, lower oxygen fugacity, and reduced U/Yb suggest decompression melting in a back-arc setting during slab rollback. Renewed contraction from the Middle Permian was characterized by crustal thickening, arc advance, and increasing slab-fluid input, culminating in a magmatic flare-up at ca. 255 Ma. We propose that alternating slab rollback and slab shallowing governed the cyclic arc evolution of the New England Orogen, comparable to processes documented in the Sierra Nevada batholith.

Poster presentation

Spatiotemporal geochemical fingerprints of magmatism in the New England Batholith, eastern Australia

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The southern New England Batholith of eastern Australia preserves a compositionally diverse Carboniferous-Triassic magmatic record formed during prolonged subduction, accretion and reorganisation of the eastern Gondwanan margin. While previous studies have established the ages and petrogenetic characteristics of individual magmatic suites, these findings have yet to be integrated into a batholith-scale spatiotemporal framework. Here, we integrate spatiotemporal-geochemical records to investigate how lateral arc migration, transcrustal magma transport and episodic silicic magmatism contributed to batholith construction. We integrate zircon U-Pb geochronology, whole-rock major- and trace-element geochemistry, and available Sr-Nd-Hf-O isotope data from the southern New England Batholith. Temporal variations in source-sensitive and pressure-dependent proxies, including εHf, εNd, $\delta^{18}O$, Sr/Y, La/Yb and incompatible-element ratios, are used to test whether successive magmatic episodes record systematic migration of the arc front, changes in crustal thickness and repeated reorganisation of the magmatic plumbing system. Integrating these spatial and temporal patterns reveals how magma sources, crustal conditions and transport processes varied across the New England Batholith and through successive stages of its development. We aim to clarify how changes in magma sources and transcrustal transport contributed to batholith construction and to provide broader insights into the development of continental-margin magmatic systems during prolonged subduction.