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Education matters

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The future of our profession as seen via student theses

Our annual summary of higher-degree and Honours theses demonstrates the breadth of geophysical activity in Australia today. Three theses apply seismic interpretation to basin structural analysis for hydrocarbon applications, and six apply potential field and electrical methods to mineral geophysics, especially the understandings necessary for mineral provinces. Seven theses deal with development of geophysical technology such as the use of unmanned aerial vehicles, palaeomagnetism, thermal conductivity, controlled-source EM and passive seismic methods. Four apply electrical and airborne EM methods to hydrology, CO_2 sequestration and soil erosion studies, and two take a cold hard look at the use of a suite of geophysical methods to study characteristics of the Sørsdal Glacier and ice sheets, East Antarctica. And congratulations to Ben Witten of UWA on completion of his PhD thesis on the use of passive-seismic methods for micro-seismic monitoring of fluid movement. Ben's project was supported by an ASEG Research Foundation award, so it is a hearty three cheers to Ben for a magnum opus completed, and to the ASEG RF for underwriting another successful student project!

Editor's note: Ben Witten will be reporting on the results of the research that was part-funded by the ASEG RF in greater detail in a future issue of Preview.

2017 Student theses

BSc Honours Theses

Elizabeth Grange, The University of Melbourne: *Geophysical and geochronological constraints on the emplacement and geometry of the Pilot Range Suite north-eastern Victoria.*

The Lachlan Fold Belt in south-eastern Australia records widespread magmatism during the Devonian. In the north-eastern Tabberabbera Zone (north-eastern Victoria) this magmatism and the spatially related molybdenite mineralisation is poorly understood. This study retrieved new petrophysical, high-resolution gravity, and geochronological data from the Murmungee region north-eastern Victoria to better constrain the geometry and emplacement ages of all major Pilot Range granites. Nine rock types were analysed for their density and magnetic susceptibility to provide constraints for the forward modelling of the gravity and magnetic data. U-Pb zircon LA-ICP-MS analysis was completed on six intrusive bodies to provide accurate ages of emplacement. Geophysical interpretation suggests these intrusives are much more extensive at depth than the surface outcrop distribution implies. The highly-magnetic Murmungee Granodiorite was interpreted over an area of ~150 km^2 compared with a surface outcropping of ~1 km^2. Geophysical forward modelling identified a close spatial relationship at depth between the highly magnetic Murmungee Granodiorite and the non-magnetic Beechworth Granite to the north. Previous geochronological data from the intrusives ranges over ~15 myr between the different units with very large errors. The new geochronological analysis identified a temporal relationship, whereby the intrusive emplacement ages calculated were all statistically similar occurring between ~380–390 Ma. These new geophysical and geochronological data identify a temporal and spatial relationship, between the Murmungee Granodiorite and Beechworth Granite. Combined with similar geochemical relationships to other Lachlan Fold Belt granite suites, this relationship implies the granites were all sourced from the same melt and separated due to fractionation. The molybdenite mineralisation formed at 379.6±1.9 Ma (Huston pers. comm., 2016) and the mineralisation is most likely genetically linked to the Everton Granodiorite.

Hamish Stein, University of Melbourne: *Geological and rock-physical considerations for building facies dependent elastic property models in shallow carbonates: interrogating sonic velocity, porosity, density and pressure relationships from the North West Shelf of Australia.*

Modern imaging projects can lack geological context and rock physical constraints when building complex, high resolution velocity models of the shallow overburden. This is especially prevalent in the case of shallow strata often overlooked by drilling regimes, or in carbonate lithologies that may express significant lateral variation of elastic properties. International Ocean Discovery Program Expedition 356 retrieved abundant high-resolution geological and physical property data from Neogene strata at four sites in the Northern Carnarvon Basin on Australia's North West Shelf. The unique data set comprises of core, well-logs, density and porosity data from the upper 1000 m below mudline. Geochemical and petrographical analyses were conducted

on 140 core samples and 49 thin sections to characterise the carbonate facies. Porosity-depth analysis identified a point of geological significance at ~450 m below seafloor where widespread cementation occurred. Prior to cementation porosity loss was controlled dominantly by compaction. Current industry standard rock physics models, when tested for velocity predictive capability in the region, were unable to accurately estimate the porosity-velocity response of sediments in both compaction and cementation domains. Subsequently a hybrid-model is proposed whereby the contact-cement model is preferred until widespread cementation, at which point the Sun model best captured the trend. Velocity response was found to be facies dependent throughout the compaction dominated domain, whereas following cementation the porosity-velocity response was similar for all facies. The predictive velocity model generated from this work may be suitable for improved characterisation of the elastic properties of carbonates throughout the North West Shelf.

Martin M. Nguyen, Monash University: *Structural and lithogeochemical characterization of the Depot Domain, Eastern Yilgarn – a study in gold prospectivity.*

The Depot domain located in the highly gold-endowed Kalgoorlie terrane of the Eastern Goldfields has experienced little scientific attention in recent times despite the presence of major gold-hosting structures such as the Zuleika and Kunanalling Shear Zone. Geophysical mapping, field mapping and lithogeochemistry have been used to characterize the structural evolution, stratigraphy and prospectivity of the Depot domain. A regional geophysical interpretation constrained by field observations revealed six deformation phases which correlated well with existing literature. Lithogeochemistry and petrographic quartz-feldspar-lithics anlaysis (QFL) point towards deposition of the volcanics and volcaniclastics in a back-arc basin proximal to a continental volcanic arc environment. The dacites and andesites of the Depot domain show striking similarity to modern day arc-related volcanics, which may reflect a deep, fertile mantle source based on trace element geochemistry. Field mapping found the Depot domain to have deformed rigidly with respect to the neighbouring domains. Strong strain partitioning during post-D_3 deformation along the Zuleika and Kunanalling Shear Zone and the lack of rheological and geochemical contrast has had negative effects on the prospectivity of the Powder Sill Syncline although syn- to post-D_3 structures which have crosscut major D_3 shear zones may be attractive targets for gold exploration. This may be due to the imposition of heterogeneous strain fields which would produce dilational sites, promote fluid flux and increase the generation of dynamic porosity and permeability within 2nd and 3rd order structures off D_3 shear zones. The Depot domain also shows petrological, geochronological and structural similarities with the Yamarna and so exploration strategies used for gold exploration at the Depot domain may have corollaries for gold exploration within the Yamarna terrane.

Karlo Vickov, Monash University: *Developing an exploration model for the Glenlyle base metal prospect using geophysical methods.*

An exploration model based on geophysical data was developed for the Glenlyle base metal prospect in Willaura North, Western Victoria. The prospect was initially targeted due to a circular (5 km diameter) magnetic anomaly overprinting the linear north trending Mount Dryden Belt of the Mount Stavely Volcanic Complex. Newly acquired high-resolution gravity data was used to model a plug like porphyry that terminates as a sub-horizontal dyke at shallow levels. The porphyry is coincident with a high magnetic, low gravity anomaly in the centre of the prospect. Cross-cutting relationships of the 2D modelled geometries suggest that the porphyry was intruded post-tilting of the Mount Stavely Volcanic Complex, possibly contemporaneous with the Bushy Creek Granodiorite (502–498 Ma). A strong correlation between gold and copper concentrations is encountered within the quartz feldspar porphyry. The top of the upright porphyry system encounters propylitic alteration suggesting that at deeper levels a potassic, highly magnetised central zone containing significant mineralisation may be encountered.

Luke Smith, Macquarie University: *Precision positioning in unmanned aerial geophysics.*

This research investigates the implementation of precision GPS to Unmanned Aerial Vehicles for use in geophysical exploration. The prompt for this research was the Desert Fireball Network's meteorite recovery program, where an advanced impact site prediction system is followed by manual search and recovery. A small, automated, search vehicle is needed to explore the likely impact zones, which would require precise and accurate positioning in conjunction to its sensor capabilities. This thesis presents a Kalman filter implementation to improve and interpolate positioning during post-processing. This thesis also presents a sub-2 kg UAV magnetometer system utilising an RTK GPS to achieve centimetric positioning. A RTK GNSS module was integrated with an Arduino microcontroller for acquisition of in-house magnetometer gradiometer data. Results are presented for two field trials, testing both positioning and magnetometer performance. Magnetic performance was limited, particularly due to flight effects and sensitivity, however under ideal conditions the system was capable of locating a meteorite sample.

Dropout of DGPS during flight was found during surveys, which the Kalman filter was successful in ameliorating.

Kathryn Job, University of Tasmania: *Palaeomagnetic analysis of the Palaeozoic orocline model for Tasmania.*

Palaeozoic units of the Dundas Trough in western and northern Tasmania form an arcuate trend, noticeable in outcrop and aeromagnetic images, which appears to wrap around the Pre-Cambrian Tyennan region. Kinematic and structural analysis of this arcuate feature are important in reconstructing the tectonic history of Tasmania. Previous modelling suggests the region is a primary arc and attributes the arcuate shape to sedimentation in rift and graben systems. Recent modelling suggests the arcuate trend is a result of oroclinal rotation of a former linear orogen. Examination of palaeomagnetic data from around the Dundas Trough indicates far north-eastern sections of the arc have undergone ~90° clockwise rotation while western regions have undergone no rotation.

Palaeomagnetic samples were collected from selected early Palaeozoic sedimentary sequences at 22 localities around the Dundas Trough and correlates in the Adamsfield-Jubilee region. Low-temperature and thermal demagnetisation was conducted on most samples with selected units also demagnetised with the alternating field technique. From the 22 localities sampled 11 produced clear demagnetising results. Principal component analysis was used to determine characteristic remanent magnetisation directions with site mean directions and palaeomagnetic poles calculated from available data. Using mean palaeomagnetic data an orocline test was conducted and rotations around a vertical axis simulated.

The orocline tests, with gradients between 0.67 and 0.82, indicate palaeomagnetic declinations vary with regional strike. Average declinations in the north-east section of the study area (Dm 97.2°, Im 36.2°) suggest a clockwise rotation ~90°. Results from the northsouth trending western region (Dm 021.1°, Im 14.8°) indicate this proposed limb has remain fixed. Average directions from the central region (Dm 003.7°, Im 8.5°) show less confidence in the orocline model. Further study of the east-west trending section of the region is required to constrain rotation and determine if observed palaeomagnetic directions are due to oroclinal rotation of the whole region or localised rotation of thrust sheets.

Thomas Schaap, University of Tasmania: *Geophysical investigation into Sørsdal Glacier, East Antarctica.*

Numerical models of outlet glacier dynamics provide indicators for the state of the ice sheets from which they originate. Basement characteristics and englacial meltwater behaviour are important considerations in these models. Seismic, airborne radio-echo sounding, ground-penetrating radar, and gamma-ray spectrometry surveys have been analysed for information which may improve dynamics modelling of Sørsdal Glacier, East Antarctica.

Seismic reflection data indicate that Sørsdal Glacier sits on a retrograde bed, with measured ice thickness above water ranging from 611 ± 28 m towards the calving front to 1045 ± 48 near the grounding line. The maximum measured grounded ice thickness was 1647 ± 77 m. The maximum measured water column thickness was 500 ± 13 m. The grounding line position was constrained to within 4 km between seismic soundings. Refraction and surface wave analyses indicate that there is no near-surface low-velocity firn layer in the lower portion of Sørsdal Glacier.

Two airborne radio-echo sounding profiles have revealed internal stratigraphy and basement topography in the ice sheet adjacent to Sørsdal Glacier, but do not show the base of the glacier likely due to the effects of scattering of radio waves in highly deformed ice.

Ground-penetrating radar surveys in the Channel Lake area delineate subsurface reflective features at depths between 5 and 10 m. There features are interpreted as former englacial drainage conduits beneath the basin and may indicate the presence of an interconnected network of channels.

Heat production values between 1.1 ± 0.4 $\mu W/m^3$ and 1.6 ± 0.5 $\mu W/m^3$ were estimated using gamma-ray spectrometry for lithologies in the Vestfold Hills adjacent to Sørsdal Glacier. These values are low compared to estimates from other East Antarctic rocks, and global averages.

Sam Jennings, University of Adelaide: *A new compositionally-based thermal conductivity model.*

I report on 340 new thermal conductivity measurements of (mostly) plutonic rocks using an optical scanning device, coupled with major element geochemistry and modal mineralogy to produce broadly applicable empirical relationships between composition and thermal conductivity. Predictive models for thermal conductivity are developed using (in order of decreasing accuracy) major oxide composition, CIPW norms and estimated modal mineralogy. I find that SiO_2 content is the dominant elementary control on thermal conductivity due not only to its relationship with quartz but also its relatively large abundance over the entire compositional range. The feldspars are the major control on thermal conductivity for both mineralogy based models, with particular emphasis on the transition from Na-rich albite to Ca-rich anorthite. Four common mixing models (arithmetic, geometric, square-root and harmonic) are tested and, while the results are similar, the geometric model produces the best fit. The preferred model uses five commonly reported oxides (SiO_2, Al_2O_3, FeO, Na_2O and K_2O) plus loss on ignition

to predict thermal conductivity across the entire compositional spectrum of plutonic rocks to within 0.27 W m^{-1} K^{-1}. A comparison of thermal conductivity and oxide-based estimates of P-wave velocity and density reveal systematic trends across the compositional range.

Ben Vincent Kay, The University of Adelaide: *Testing the UNCOVER paradigm: crustal fluid pathways in the Curnamona Province.*

In July 2017, scale-reduction was undertaken to improve the bandwidth and resolution of the AusLAMP defined Curnamona Conductor (Robertson et al., 2016) by way of a broadband magnetotelluric profile with site spacing of 2 km, extending from the Erudina Domain across the Mudguard and Quinyambie Domains in the Curnamona Province. A fossil fluid pathway has been identified from the lower mid crustal conductor to the near surface situated near a topographic basement high. The upper crustal conductor has been further delineated beneath the Quinyambie Domain to within 5 km of the surface situated alongside a major crustal feature.

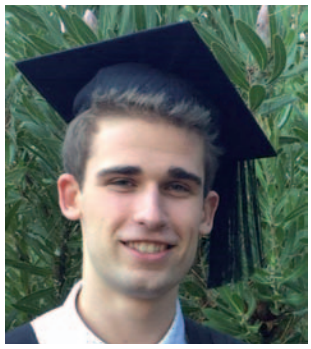
Musab Al Hasani, Curtin University: *Optimising geophone placement for land seismic measurements.*

Geophone placement is an essential aspect of land seismic measurements, and optimising this placement is a need for better data quality. This study focuses on geophone coupling, which can be described by a resonance frequency observed in the amplitude response. The approaches used to study the coupling phenomenon are laboratory and field experiments. The laboratory experiments were conducted a shaker-table and they described the effect of coupling conditions on the data as distortions in the signal, where poorly coupled geophones showed noticeably lower distortions compared to well-coupled geophones. The field experiments included different scenarios of geophones spikes and baseplates as well as several different soil types. I observed that horizontal components are more sensitive to coupling as a shift to lower resonance frequency for poorly-coupled geophones compared to well-coupled geophone. Also, longer spike and larger baseplates better coupling (i.e. higher resonance frequency). Also, the effect of stiff soil is shown as resonances observed at higher frequencies.

Chanel De Pledge, Curtin University: *Basement structure and evolution in the Ceduna SubBasin.*

The basement in the Ceduna Sub-Basin has been poorly understood due to its increasing depth and limited availability of deep crustal geophysical datasets. With the availability of the BightSPAN dataset provided by ION Geophysical, a new model of the basement has been produced with the use of PSDM, 2D seismic data, depth migrated to 40 km, and potential field data acquired along the same lines. Seismic interpretation constrained in deep areas of uncertainty by gravity forward modelling and combined interpretation of magnetic grids has aided in further defining basement depth and structure. A revised depth of 25 km to basement is proposed in this model, unlike previous depths of ~15 km. A new depocentre is defined in the NW of the study area trending in an E–W direction. Both depocentres structure and orientation support the prior evidence of oblique NW–SE rifting that occurred during the final break up of Gondwana, following old E–W oriented rifting. Basement thickness and structure indicates extensional faulting, with the increase of shallow basement in the south indicative of flexural uplift likely due to mechanical unloading of the lithosphere. The thickness, change in density, and introduction of serpentinised mantle also point towards evidence of the continental-oceanic transition zone.

Tom Dronfield, Curtin University: *Delineation and modelling of clay features within a saline water interface, Cockburn Sound, Perth WA.*



Clay lensing can significantly impact hydraulic flow, and is prominent throughout shallow aquifer systems in Perth, Western Australia. The impact of such lenses on the geoelectrical response and the extent of seawater intrusion must be considered. Electrical resistivity imaging (ERI), through numerical modelling techniques, was used to simulate clay lensing scenarios in shallow coastal aquifers. A clear dependence between electrode configuration and electrode spacing was identified. Hydraulic flow and solute transport modelling was able to additionally highlight the impact of these lenses on the extent of saline water intrusion, with clay layers at various depths within the mixing zone impeding the salient water plume. Field testing at a location south of Perth indicates the possibility of clay lensing from geoelectrical inversion. Crossline ERI surveys were deployed and detected additional lithological information that pertained to the calibration of the study area. A hydraulic flow model, based on geophysical and geological data, was created, to aid interpretation for the position of the saline water interface.

Olumide Adepoju, Curtin University: *Characterization of the shallow soil layer at the OTWAY CO_2CRC site using electrical geophysics.*

An ERI survey was completed at the CO_2CRC Otway Site in other to assist in characterizing the shallow clay layer prior to a planned controlled release and monitoring experiment which would involve injecting CO_2 into a fault zone. The major objective of the ERI survey was to map the thin surficial clay layer that exists within 5 m of the surface.

An interpreted surface of surficial clay is produced based on four 10 m spaced E–W transects in proximity to the proposed injection site. Two inversion algorithms Res2dinv and Boundless Electrical Resistivity Tomography were employed for inverting these lines.

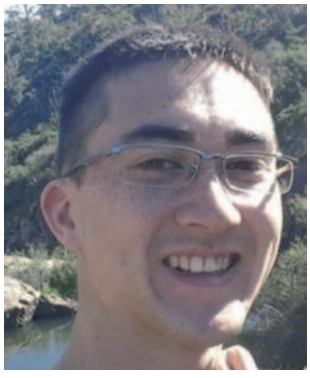
The results from the Res2dinv algorithm revealed a shallow conductive layer with conductivity values ranging from ~250 mS/m to ~150 mS/m while the BERT results provided conductivity values ranging from ~194 mS/m to ~127 mS/m. These values reflect a high fraction of clay and a region of low permeability.

The two algorithms show good similarities in the continuity of the clay distribution and also showed regions in the shallow clay layer which exhibited lower conductivity values and may warrant consideration in future planning.

Dane Peter Padley, Curtin University of Technology: *Controlled source electromagnetics using a long electrical bipole Antenna.*

Controlled source EM using a high-powered bipole transmitter together with electric field sensors provides high-quality electrical resistivity data from the near surface to depths of several kilometres. Aquifers in the Gnangara groundwater system located in the Central Perth basin provides a majority of Perth water resources. The aquifers are cut by the North-South trending Badaminna fault. The electrical resistivity data from CSEM could be used to differentiate clay and shales (aquicludes) from sands units (aquifers) and resistivity changes produced from salinity change could have the benefit of indicating transmissivity across the fault. The project analyses the electric response from different geoelectrical models (based on existing geological/geophysical models) and different transmitter and receiver configurations, providing additional information for planning a CSEM survey over the Gnangara groundwater system.

Brendan Ray, Curtin University: *The coastal hydrogeology of the north and central Perth Basin using airborne electromagnetics.*



A study of the coastal hydrogeology of the north and central Perth Basin, with emphasis on the saline water interface (SWI) was performed using airborne electromagnetic (AEM) data. A strong correlation was found between the inland extents and gradient of the SWI with relation to the depth of the underlying Kardinya Shale. Deeper Kardinya Shales led to shorter SWI inland extents and steeper gradients and vice versa. This trend was found along the length of the entire survey area (40 km) with the southern-most edge of the survey located 34 km north of Perth. The geometric extents of the SWI along with the Kardinya Shale were mapped and 3D surfaces were created, allowing the visualization of the change in vertical extents and relationship between the two features. Furthermore, a 3D conductive volume was created for the SWI which reveals the decrease in electrical conductivity with inland extent. Validation of the AEM data was also performed using two coastal electrical resistivity imaging (ERI) surveys and three well logs all of which were situated within 1.5 km of the ERI surveys. Guidelines were also developed for further studies of coastal AEM data to increase the accuracy of interpretations of the SWI along the coastline.

Aidan Shem, Curtin University: *Optimisation of the Horizontal to Vertical Spectral Ratio (HVSR) passive seismic method in the Hamersley Province of Western Australia.*

The Horizontal to Vertical Spectral Ratio (HVSR) passive seismic method is becoming an increasingly popular technique to cost effectively determine the depth of cover layers for mineral exploration. As the method has only recently been adapted as a tool for low cost mineral exploration, the optimum acquisition parameters are still insufficiently investigated. This project evaluates the potential of the HVSR

method for mineral exploration through modelling and specialised experiments.

Subsurface conditions typical of the Hamersley Province were examined through theoretical modelling and I identified the shear wave velocity, depth to interface and acoustic impedance contrast as having the most profound effect on the amplitude and peak frequency of the H/V results. Controlled experiments varying key acquisition parameters were conducted to investigate their effect on the application of the HVSR technique for mineral exploration. As a result, I identified a 4 minute recording time, 50 m station spacing and coupling with long tapered spikes, as optimal acquisition parameters for the HVSR technique in the Hamersley Province, verifying the method as an accurate and repeatable mineral exploration tool.

Louis Paterniti, University of Western Australia: *Basement structure of the Caswell Sub-basin and its impact on Permo-Triassic inversion tectonics.*

The Browse Basin hosts some of Australia's most valuable hydrocarbon reservoirs that are related to Permo-Triassic inversion. Despite this, little is known about the nature and origin of these compressional episodes. Deep seismic profiles are used to develop a structural and tectonostratigraphic framework for the Caswell Sub-basin, and are integrated with 2D cross- section restorations to understand the mechanical controls on inversion. The Browse Basin initiated sometime in the early Palaeozoic in response to northeast-oriented extension. Extension rotated to north-northwest in the Late Carboniferous, coinciding with the regional Meda Transpression. The collapse of a Proterozoic mobile belt guided extension during this time and developed a low-angle crustal detachment along the western margin of the basin. Intermediate heat flows and crustal thicknesses resulted in the formation of a wide rift basin and the separation of the Sibumasu Block from Australia. A phase of thermal sag succeeding extension was punctuated by episodes of regional compression in the Late Permian and at five stages throughout the Early–Late Triassic. Faults on the basin margins accommodated the majority of the contractional strain while minor inversion occurred in the central Caswell Sub- basin along Palaeozoic rift faults. Simultaneous transtensional faulting resulted in the development of significant accommodation on the western margin of the basin in the Mid-Late Triassic. Thermal relaxation and cooling of the lower crust/upper mantle throughout the sag phase triggered the formation of Mesozoic narrow rift basins along localised necking zones in the outboard Seringapatam Sub-basin. Extension culminated with the separation of the Argo Block from Australia in the Callovian/Oxfordian and represents the final phase of rifting in the Browse Basin.

MSc Theses

Andrew Pearson, The University of Melbourne: *Redefined structure and evolution of the Wentworth Trough.*

The Wentworth Trough is a 300 km northeast trending trough, which underlies the Cenozoic Murray Basin in southeast Australia. The extent of the Wentworth Trough is characterised by a gravity low (O'Brien, 1981) and has been modelled to be approximately 5–20 km wide and 1.6–5 km deep (Knight et al., 1995). Little is known about the contents of the trough as no boreholes penetrate it in Victoria and it does not outcrop. 724 new gravity stations were collected to provide higher resolution gravity data over the trough. Qualitative interpretation of the gravity data refined the shape and distribution of the Wentworth Trough and suggests it is bounded by linear normal faults. Forward modelling of the gravity data constrained by interpretation of the reprocessed MEMV96 seismic survey and drilling formation intercepts has resolved the geometry and depth of the trough. The Wentworth Trough was modelled to be 400 m wide and 800 m deep compared to previous interpretations of 1.5–5 km deep. Moreover, this study shows that interpreted faulting within the fill of the Wentworth Trough precludes previous suggestions that the trough is filled with Permian or Cretaceous rocks. Instead, the trough is believed to contain Silurian Grampians Group sediments that outcrop further to the south and are known to be poly-deformed. The new interpretation of the fill of the Wentworth Trough redefines the timing of the trough from Permian to the Silurian, constraining the evolution of the trough to the extensional phase of the Benambran Orogeny. This interpretation is supported by the new tectonic model of the Lachlan Orocline proposed by Cayley et al. (2012), which suggests that southeast oriented extension proximal to the Wentworth Trough occurred in response to southeast directed slab rollback in the Late Silurian. The redefinition of the timing of the trough may mean that the Wentworth Trough played a more active role in the Lachlan Orocline than previously thought.

Anthony Finn, Macquarie University: *Tracing shallow lateral preferential pathways of fluid movement using electrical geophysics.*

Assessment of gullies is essential in understanding the effects soil erosion has on resource management, urban planning, agricultural productivity and local environmental conditions. Commonly prediction of gully head cut retreat has been disregarded due to the inherent complexities; this study proposes a method of analysing data to interpret potential pathways of gully retreat. Through the implementation of electrical geophysical (Electrical Resistivity Imaging & Frequency Domain Electromagnetics) surveys positioned uphill of existing gullies shallow conductor's representative of Lateral Preferential Pathways (LPP) will be detected. ERI results detected conductors uphill of the head cut at

varying distances showing resistivity values of 1–40 Ωm; these identified anomalous zones were confidently linked to form an LPP. Integrated geophysical datasets were generated allowing for interpreted traces of LPP to be drawn that are representative of the future pathway of head cut retreat. Comparison of currently existing gully assessment techniques suggests that a combination of geophysical prediction of LPP and LiDAR data is necessary for a complete understanding of existing gullies. Based on the results of this integration, informed and targeted management decisions can be developed to remediate current landforms and mitigate future gullying.

Harrison Jones, Macquarie University: *Geophysical signatures of small-scale base metal occurrences in southeastern NSW.*

The aim of this thesis is to ascertain the usefulness of specific high-resolution, ground-based geophysical methods in identifying and evaluating two small-scale polymetallic massive sulphide deposits, located in southeastern NSW. Standard exploratory methods are typically applied at a prospecting or regional scale and may disregard smaller deposits, thus a greater understanding of the resolution required is needed for the range of geophysical methods. Recently obtained time-domain electromagnetic, magnetic and gravity data were analysed using a forward modelling approach. Results showed that a coincident loop time-domain electromagnetic survey effectively delineates the sulphide mineralisation and is useful in mapping deposit parameters such as the azimuth, dip and strike length. Based on the two areas studied, it was determined that high-resolution magnetic and gravity surveys were not effective ways for directly targeting the deposits due to the nature of the mineralisation and its host rocks. However, these methods were effective in delineating the surrounding geology, such as intrusive volcanic plugs and basement geologies and structures.

Lara Urosevic, The University of Western Australia: *Wilkes Land, East Antarctica: using subglacial geology as a key test for ice sheet stability.*

Ice sheets have been of global interest because of their influence on sea level rise in the currently warming world. Ice sheet stability is difficult to model, especially in relation to destabilisation events that occurred in the past. Studying ice-rafted detritus allows for ice sheets processes to be better understood, but are limited by provenance determination. The aim was to simulate the provenance of detrital signatures from Wilkes Land by mapping geophysical data and spatially analysing the erosive potential within these maps *via* ice sheet modelling. The ice sheets models used were 'retreat models' and analysed the retreat mechanisms of an ice sheet under different air and ocean temperature forcing states. Results showed that using this approach could determine unique detrital signatures for different modelled ice sheet states, allowing for a better understanding of ice sheet processes and dynamics near Wilkes Land. This understanding can be improved upon with additional data, therefore this process can be used as a preliminary step in determining ice sheet dynamics of a system with limited outcrop data. The ice sheet models used were not time constrained meaning that the detrital signatures could be predicted for different forcings but not for a past climate. They also did not account for processes after erosion, such as entrainment, transport and deposition, which combine to form the IRD 'signature' observed today. Despite the limitations, this study shows that a complex system can be better understood through a multidisciplinary approach.

PhD Thesis

Ben Witten, The University of Western Australia: *Elastic velocity estimation using image-domain adjoint-state inversion of passive seismic data.*

Detection and location of small (microseismic) earthquakes is critical due to increasing subsurface fluid injection activities. Accurately locating recorded earthquakes is paramount for improving productivity and reducing potential hazards. A fundamental parameter for location accuracy is the 30 velocity mode. Current seismological velocity building techniques based on large earthquakes rely on high signal-to-noise data. I present a new method to jointly invert for the velocity structure and accurately locate small magnitude earthquakes that is suitable for micro-seismic monitoring. Thus, it is useful for varied applications from induced seismicity to tele-seismic monitoring.

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