ASEG Research Foundation: Progress reports on projects

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Updates on selected current projects follow:

RF21P01 Monash University, PhD student Chibuzo Chukwu (supervisor Prof Peter Betts).

Role of basement structures in controlling triple junction formation and associated basins in southern Australia.

The Precambrian-Palaeozoic boundary basement rocks of the south-eastern margin of Australia are segmented into several tectonostratigraphic provinces, bounded by broadly ~N-S trending deep-seated faults that extend into the Mesozoic and younger basins of south-eastern Australia. The location, architecture, and influence of these basement structures on the Mesozoic rift-failed rift-transform triple junction obscured by thick sequences of younger volcanic and sedimentary rocks of the Otway, Bass, and Sorell Basins developed during Australia's breakup from Antarctica remain a challenge. Consequently, the overarching goal of this project is to assess the influence of pre-breakup structures on the evolution and distribution of depocenters and structures related to southeast Australia's triple junction formation using multi-scale and integrated geoscience approaches. As the project nears its final year, our previous activities have culminated in two publication drafts slated for submission to peer-reviewed journals while we focus on the divergent arm of the triple junction.

Activities over the past years have led to two major paper drafts. The first draft, submitted to *Exploration geophysics*, introduces an innovative technique that combines Euler deconvolution with an unsupervised machine learning algorithm named Density-Based Spatial Clustering Application with Noise (DBSCAN) on potential field data. This method determines the location and dip of geologic structures at multiple scales. Additionally, we demonstrate its efficacy in imaging structures at depths of approximately 30 km, masked by the magnetic signals of the Pleistocene basaltic rocks of the Newer Volcanic Province in Victoria. It showcases how this method delineates structures in low-resolution global and high-resolution airborne magnetic data within central Victoria. We highlight both the limitations and the potential our innovative method holds in imaging structures in 3D space. Notably, our results from this method align with pre-interpretations from deep 2D reflection seismic data, as shown in **Figure 1**.

The second publication draft, destined for the *Journal of Geophysical Research*, illustrates how our novel method on magnetic data, augmented by enhanced and drill hole-constrained seismic reflection data, has identified a fresh network of Cambrian-Silurian basement faults within southeast Australia. This research redefines the boundary between the Proterozoic and Palaeozoic basement rocks stretching from southwest Victoria to western Tasmania. Our analysis further reveals that these deep-crustal faults, which appear as near-vertical dipping faults inland, undergo reactivation and transition into steep-dipping listric faults, bounding and partitioning Cretaceous faults and depocenters. They control the overall evolution of the arms of the Mesozoic southeast Australia's triple junction. Our work also provides analysis that provides a strong control in correlating the structural domains between southeast Australia and northeast Antarctica's margins.

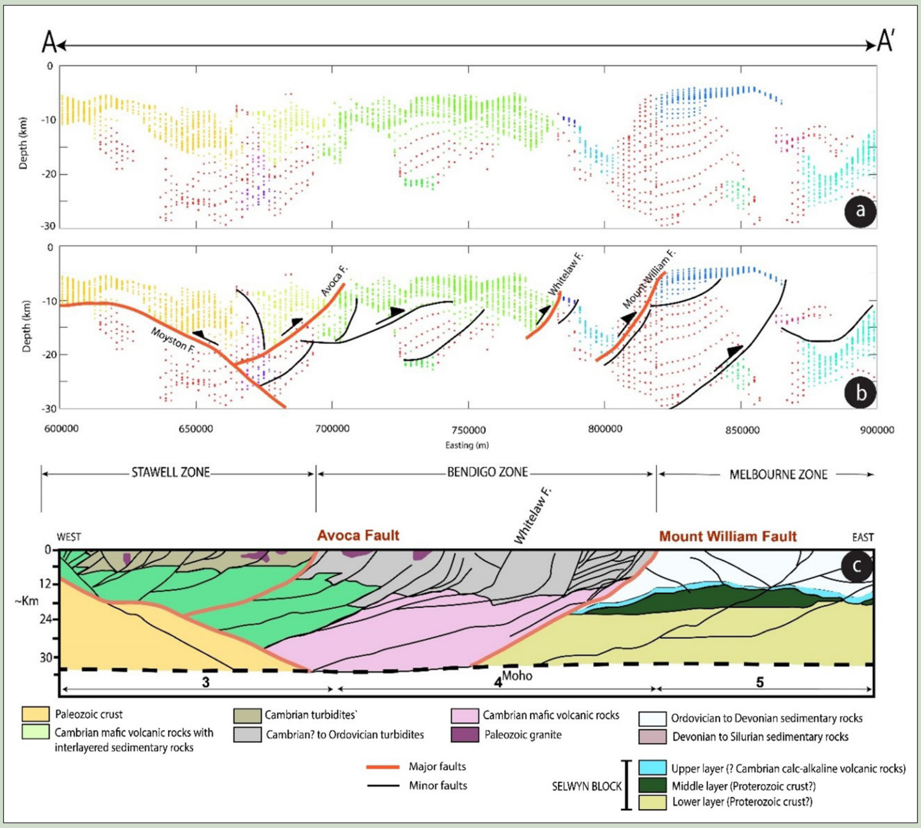

Figure 1. *Comparison of optimised clustered Euler depth solutions along A-A′ traverse with geology. (a) Uninterpreted clustered Euler depth cross-section. (b) Interpreted Euler depth traverse (c) Near-parallel interpreted seismic cross-section to A-A′ profile. Cluster boundaries strongly correlate with the locations of the major zone-bounding faults at depth. The first-order cluster boundaries are in red and, along with other cluster boundaries, in black. Notice the high frequency of cluster boundaries in (b) and faults in (c) within the Bendigo Zone compared to other structural zones.*

This year, our focus shifts to the in-depth analysis of the divergent arm of the triple junction that spans the Mesozoic depocenters of the Otway Basin. We're employing a novel approach, amalgamating petrophysical samples from 180 wells with high-resolution gravity and magnetic data, to generate 2D and 3D models of the Otway Basin. We plan to analyse these 3D models, produced through combined 2D seismic constrained forward and inverse models, to delineate the rift domains and examine the major tectonic factors steering the evolution of the divergent and transform arms of the triple junction. Seismic interpretation combined with 2D forward models of intersecting traverses covering Otway Basin has been completed. Our final endeavour is to produce constrained 3D models of the Otway Basin.

We wish to express our profound gratitude to the Members of the Australian Society of Exploration Geophysics (ASEG). Their ASEG Research Foundation grant has been instrumental in facilitating a significant portion of this PhD project.

RF21P02. University of Melbourne, MSc student Youssef Hamad (supervisor Dr Graeme Beardsmore).

Utilisation and comparison of conventional wireline precision temperature sensing, DTS, and aDTS to detect and quantify subsurface geothermal anomalies in the on-shore Gippsland Basin.

This project integrates three temperature measurement technologies, all tailored for borehole geophysical logging, and investigates how they can complement each other. The sensors include thermistor-based instruments, self-contained button-style loggers, and fibre optic distributed temperature sensors (DTS), each with its distinct advantages and disadvantages. Conventional thermistor instruments, while known for precision, contend with drawbacks such as slow logging speeds, heavy and costly wireline cables, and extended equilibration times in air-filled bore sections, diminishing their accuracy. In contrast, self-contained button-style loggers offer a more economical alternative, but not without compromising the resolution of temperature and depth measurements. DTS uniquely captures time-series spatial-temporal data, logs entire borehole profiles instantaneously, and has a potential for conducting *in-situ* thermal conductivity assessments during active operations. Nonetheless, it demands a more intricate calibration process, necessitating additional labour, processing, extended setup, and logistical considerations.

The project targets accessible boreholes in the Gippsland and Murray Basins for sensor deployment. It aims to examine these sensor technologies collectively to optimise operational efficiency, accuracy, precision, and *in-situ* calibration techniques for DTS. Gaining this understanding is pivotal for applications within borehole geophysics that rely on temperature measurements. These applications span fundamental lithospheric research (heat flow measurements), geothermal exploration, monitoring of groundwater temperatures, and the reconstruction of past land surface temperatures.

The project has advanced, thanks to partnerships between the University of Melbourne, AuScope, Geoscience Australia, CSIRO, and the geological surveys of Victoria and South Australia, which have provided crucial access to DTS equipment, boreholes, and related core samples and cuttings. We secured high-precision, lab-calibrated thermistor-based logs from eight boreholes in the Gippsland Basin, and two more from the Murray Basin in South Australia. We implemented DTS in five of those eight boreholes using passive sensing, and one of the Murray Basin boreholes with active sensing. In three of those boreholes, we also deployed button-style loggers as *in-situ* calibration sensors alongside DTS to enhance the accuracy of the DTS logs, particularly when encountering data noise. Collectively, these loggers demonstrated robust performance, capturing subsurface temperatures down to depths of 1 km and up to temperatures of approximately 65ºC. An active DTS trial was carried out in a borehole in the Murray Basin to acquire *in-situ* thermal conductivity data, facilitated by CSIRO. Furthermore, we secured legacy rock cores from the Geological Survey of Victoria core library in Werribee and conducted thermal conductivity and diffusivity measurements.

The next stage of our project involves applying numerical modelling to derive *in-situ* thermal conductivity from the active DTS data from South Australia. This model is set for refinement through the integration of thermal properties derived from drill cuttings provided by the Geological Survey of South Australia. Simultaneously, we are set on inferring the land surface temperature history using temperature data from a single borehole with a substantial air-filled section in the Gippsland Basin. To address the air-filled section our methodology merges both DTS and thermistor-based logs in this borehole, which mutually complement each other, and incorporates the thermal conductivity and diffusivity data previously acquired from cores courtesy of the Geological Survey of Victoria. We sincerely thank the ASEG Research Foundation for the financial support bestowed by the grant, which has been critical for meeting the costs associated with our fieldwork and necessary equipment.

RF22P01. University of Adelaide, PhD student Kosuke Tsutsui (supervisor Prof Simon Holford).

Geophysical-geomechanical characterisation of igneous rocks in the Browse Basin: implications for exploration, development, and gas storage in volcanic-rich basins.

Introduction

Exploration in sedimentary basins impacted by magmatic activity faces a significant challenge in accurately predicting the presence of igneous rocks within sedimentary sequences (*e.g.* Planke *et al.* 2000; Schofield *et al.* 2017; Watson *et al.* 2020). These igneous rocks can profoundly impact various aspects of petroleum systems, such as influencing reservoir deposition by controlling sediment fairways, working as fluid migration pathways or barriers, and forming trapping systems (*e.g.* Holford *et al.* 2012; Senger *et al.* 2017). Additionally, igneous rocks can complications to drilling operations such as low rates of penetration, rapid drill bit wear, drilling mud losses, and wellbore collapse, leading to unforeseen costs and complexities (*e.g.* Millett *et al.* 2016; Watson *et al.* 2020; Curtis *et al.* 2022).

The Browse Basin, covering an area of ~140 000 km^2 on Australia's North West Shelf, typifies many of these challenges, with the presence of igneous rock having been recognised since its early exploration in the 1970s. Despite being one of major hydrocarbon provinces on the continental shelf of Australia with numerous discoveries and significant production such as the giant Ichthys gas-condensate field, the extensive occurrences of igneous rocks within Mesozoic strata present ongoing challenges for exploration and development (*e.g.* Zahedi and MacDonald 2018). Their impact on petroleum exploration is demonstrated by the number of wells which encountered unpredicted or thicker than expected igneous rock units both within and adjacent to target sections. This study therefore aims to document the reasons why igneous rocks are unexpectedly encountered so frequently, and to develop capability for more accurately predicting the occurrence of igneous rock units prior to drilling in the Browse Basin. Studies on uncommercial exploration wells were conducted by integrating petrophysical and seismic reflection data, focussing in particular along the outboard part of the basin where igneous rocks are most prevalent. Our study highlights the importance of understanding both petrophysical properties, and the spatial and chemical heterogeneities of igneous rocks in basins to explain their emplacement and distribution, and thereby predict their occurrence prior to exploration and development activities.

Data and methodology

This study uses publicly available well data from the National Offshore Petroleum Information Management System (NOPIMS) which includes wireline, borehole image, core and cuttings, along with completion reports and analytical studies such as X-ray diffraction analysis and quantitative evaluation of minerals by scanning electron microscopy. Publicly available 2D and 3D seismic reflection data are also compiled and examined to understand the basin framework and to investigate seismically resolvable igneous rock units. Cutting descriptions of mudlogs from 137 wells were reviewed to screen out the wells which encountered igneous rocks. We selected five exploration wells that penetrated thick igneous sequences (>500 m) as key wells which are located along the outboard basin; Buffon-1/ST1, Maginnis-1A/ST2, Warrabkook-1, Kontiki-1 and Grace-1. Wireline logs were used to classify igneous rock facies based on combinations of log values and motifs. For instance, acoustic velocity and density logs prove effective in identifying unaltered igneous sections, while gamma ray (GR) logs, commonly used for estimating clay content, also serve as indicators to distinguish felsic rocks rich in potassium feldspars from mafic rocks poor in alkaline components. The final lithofacies logs are interpreted based on integration of wireline responses, cuttings lithology, and available thin sections.

Results

This study examined drilling results of 137 wells that were drilled in the Browse Basin and revealed that over 53% of them encountered igneous rocks in the Mesozoic interval, primarily within Jurassic-aged strata. Results from Buffon-1/ST1, Kontiki-1, and Grace-1 wells illustrate that the fault-bounded structure in the north-western part

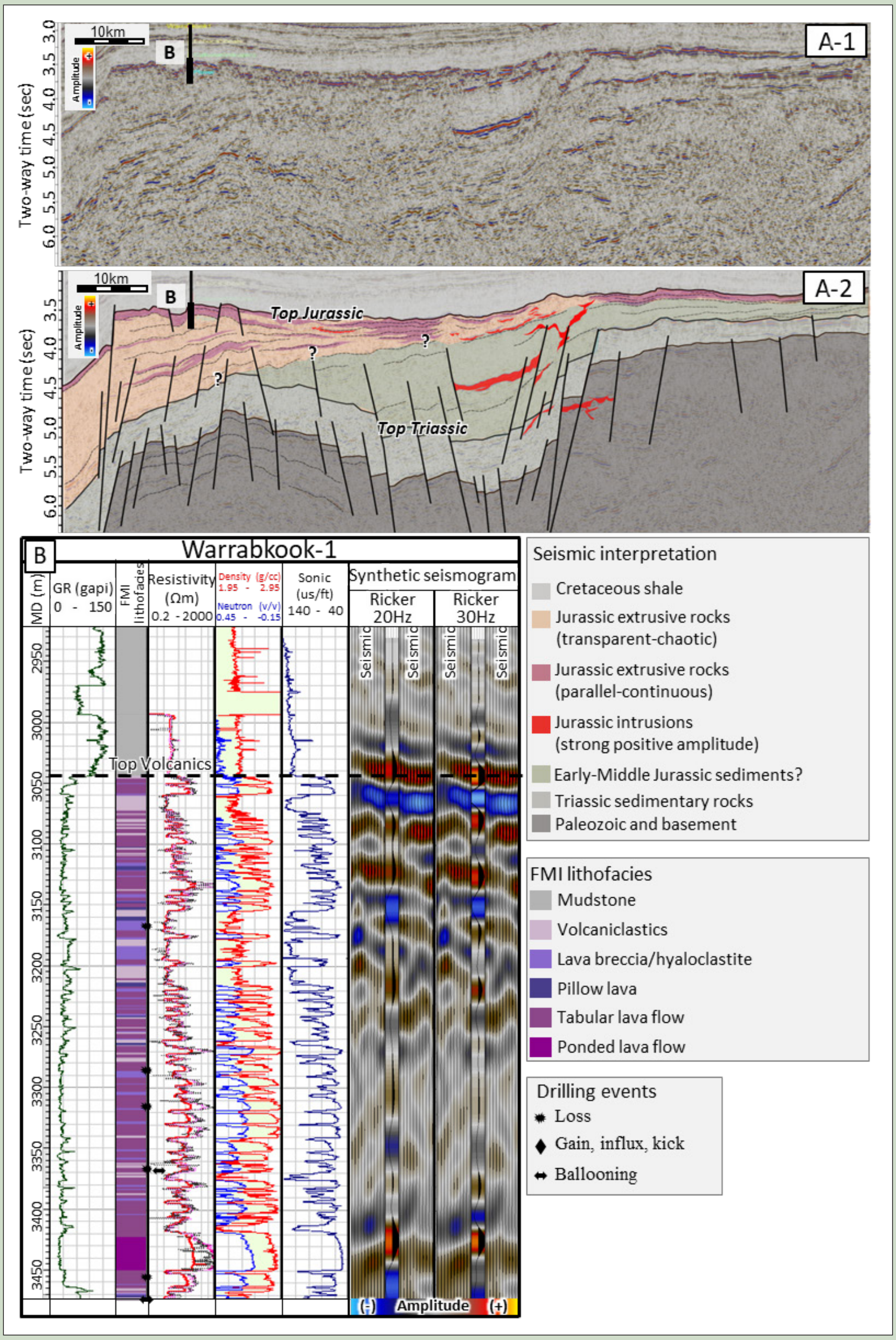

Figure 1. *Well summary of Warrabkook-1. A-1) Seismic section through Warrabkook-1 (Browse 1998 2D Spec line 26). A-2) Distribution of igneous rocks interpreted from seismic facies. B) Wireline logs and facies interpretation of the Jurassic igneous rock interval.*

of the basin contains a substantial Jurassic igneous sequence, with Grace-1 specifically confirming a thickness of at least 1100 m. The uppermost section consists of 100 to 450 m of basaltic tabular lava flows, which are characterised by low GR wireline log values and repeating high-low cyclic patterns of density and sonic wireline log values. The lower section is composed of felsic igneous rocks (with relatively higher GR values) are followed by altered igneous rock interbedded with Lower Jurassic sedimentary rocks, extending several hundred meters in thickness.

The findings from the Maginnis-1A/ST2 and Warrabkook-1 wells suggest that the western outboard area is characterised by a basaltic sequence exceeding 400 m in thickness, with limited development of sedimentary reservoirs. These substantial basaltic sections led to drilling challenges; Maginnis-1A/ST2 faced extremely low rates of penetration, required four tri-cone bits to penetrate a 483-meter interval. Meanwhile, Warrabkook-1 experienced significant mud losses and subsequent ballooning effects.

Failure to accurately predict the distribution and characteristics of igneous rock formations is a significant factor in the lack of successful exploration outcomes in the outboard basin. Variety in rock type and physical properties complicates the correlation between well interpretations and seismic data, hindering precise predictions of igneous intervals and potential sandstone reservoir locations. This study underscores the importance of comprehending igneous rock properties, connecting them to seismic data, and evaluating their distribution in a regional context. Addressing these aspects will enhance the understanding of igneous rock complexities, ultimately improving exploration efforts in magma-rich basins. The study offers valuable insights into the Browse Basin, providing lessons and implications for future petroleum exploration, field development, and the feasibility of carbon capture and storage in this region.

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RF22M02 University of Melbourne, MSc student Tom McNamara (supervisor Dr Mark McLean).

Characterisation of metavolcanic megaclast structures within the Moyston Fault hanging wall mélange (Moornambool Metamorphic Complex), western Victoria: Insights from potential field modelling and machine learning.

Stawell Gold Mine extracts ore from mineralised zones along the flanks of the metamorphosed, structurally buttressed metabasaltic Magdala Dome, an uptorn megaclast about 4 km long and 1 km across sitting in a tectonic melange. The competency contrast between the Magdala Volcanics metabasalt and the surrounding metaturbidite that makes up the Moornambool Metamorphic Complex controlled the local faulting and shear planes during Victoria's orogenic history, allowing for extensive and repeated mineralising fluid mobilisation along the flanks of the dome. There's also a significant density and magnetic susceptibility contrast between the metabasalt and the metaturbidites that make potential field methods an ideal vector for imaging buried portions of the structure.

A set of potential field anomalies analogous to Magdala occur along-strike within the structural trend of the Stawell Corridor, where the Murray Basin sedimentary cover obscures outcrop and geochemical pathfinders (**Figure 1**). A handful of the anomalies have been confirmed by drilling to be metabasalts with gold intervals at prospective grades. The Wildwood and Lubeck dome targets fall within the North Stawell Minerals tenement, where an AGG survey was acquired in 2021 to better target the structures. Lateral boundaries for Wildwood and Lubeck are well imaged by the AGG, but their cross-sectional geometries are largely unconstrained by direct drillhole intersections. On the other hand, the geometry and structural style of Magdala has been thoroughly constrained by mine mapping and drilling, but was only covered by sparse gravity measurements.

For this project, we collected ground gravity measurements in profiles across the Magdala, Wildwood and Lubeck domes to get a comparable dataset for forward modelling their geometries according to their potential field signals, at enough resolution and sensitivity to attempt to resolve the buttress structures on the dome surfaces that controlled fluid flow and mineralisation. The profiles were planned with variable station spacing, up to 25 m apart at the crests of the domes to target the fine-scale structures, and down to 100 m apart beyond the flanks of the domes to ascertain the regional trend. A total of 397 new gravity measurements were taken spanning 16 km.

The gravity profiles were forward modelled in 2D cross-sections, together with TMI data extracted from a Geological Survey of Victoria regional compilation. A section extracted from the existing mine model at Magdala was tested against the observed gravity, and while it matched the character of the main Magdala Dome anomaly, there were complexities in the signal that were unaccounted for. Incorporating surface drilling and mapping constraints, the profiles were forward modelled to account for the unanticipated anomalies. Results for each profile suggested that metabasaltic clasts may be distributed throughout the Moornambool Metamorphic Complex more widely, more frequently, and across a greater range of scales than expected. An example from the Magdala forward model is included in **Figure 2**.

The quality and coverage of the AGG data supplied by North Stawell Minerals allowed for an additional opportunity to test a machine learning model that would carry the learnings from forward modelling into a regional potential field-based predictive targeting model. The forward models were used to map the constrained dome extents, which were then used to label segments from gravity and magnetic lines as dome target signals for a training dataset. The gravity and magnetic signals were each fed to neural networks to train it on the signal, then the trained networks were applied to a set of potential field lines spatially separated from the training set.

The approach was first tested within the North Stawell Minerals tenement, taking advantage of the quality and coverage of the AGG survey data. After training the neural network on the northern or southern half of the data then testing it on the withheld half, the gravity and magnetic neural nets were each able to reliably identify, with spatial coherence, the anomalies that correlated to the dome structures. The model was then generalised to the broader Stawell Corridor using the 2019 National Compiled Gravity Grid 1VD instead of the AGG data. Neural nets for gravity and magnetics were trained on a labelled dataset in the North Stawell Minerals study area, which was extended to include Magdala and the Stawell Granite, then tasked to classify the new unlabelled data along the rest of the corridor. Outputs from the gravity and magnetic neural nets were composited to form a combined predictive potential field targeting model. The model successfully predicts the location of the Kewell Dome target, which lies 40 km northwest of Magdala, outside the extent of the training dataset. It also highlights some other areas of interest, including targets with a similar character to Kewell further beneath the Murray Basin to the east of Lake Hindmarsh, and highlights signals beneath the Newer Volcanics at Mortlake. The composited model results and some highlighted areas are included in **Figure 3**.

The model represents a method of quantifying the potential field interpretation process. The results are highly dependent on the quality of the training dataset, both in terms of the resolution of the input data and the accuracy with which the input data was interpreted. As such it's very important to have a thorough understanding of the training area, as was the goal with the characterisation of the dome targets in the forward modelling. However, with the machine learning-driven approach, a thorough exploration model of a small

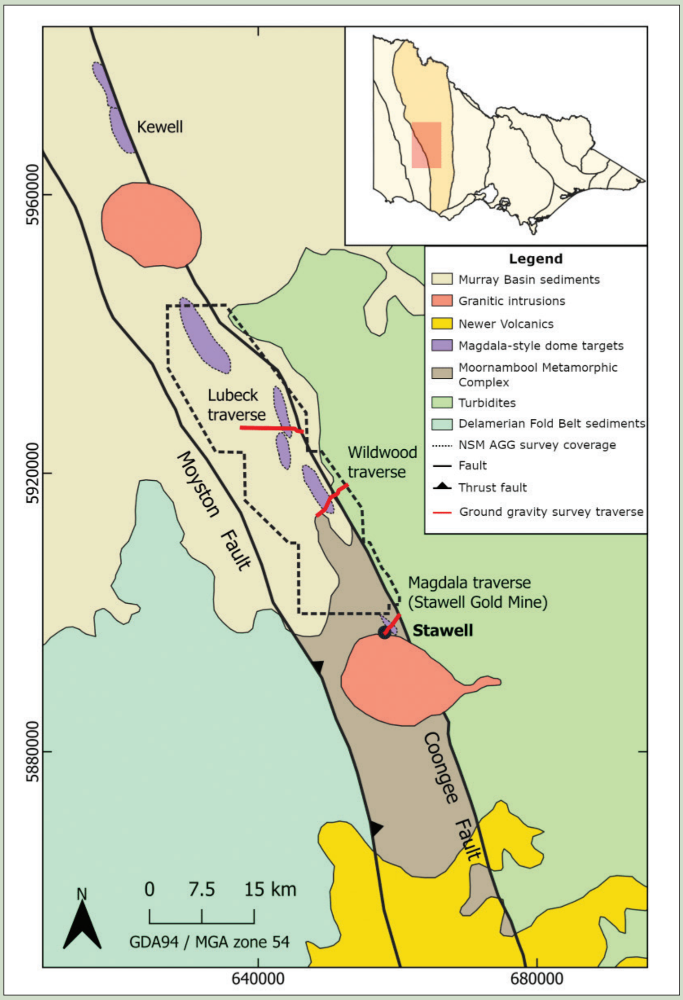

Figure 1. *Stawell Corridor study locality and geological map.*

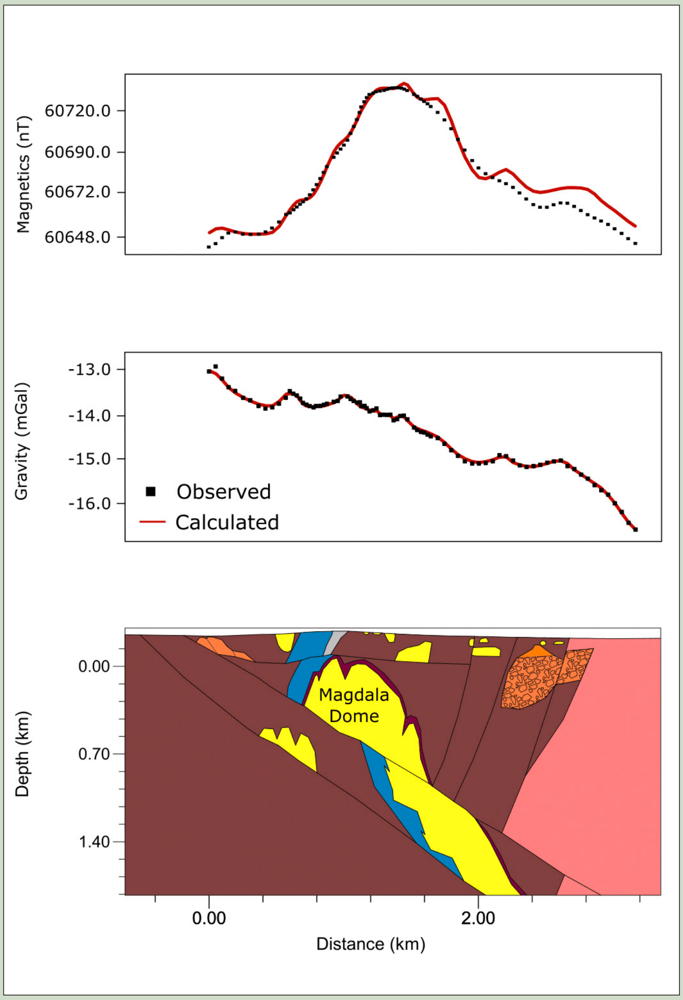

Figure 2. *Magdala ground gravity survey profile model.*

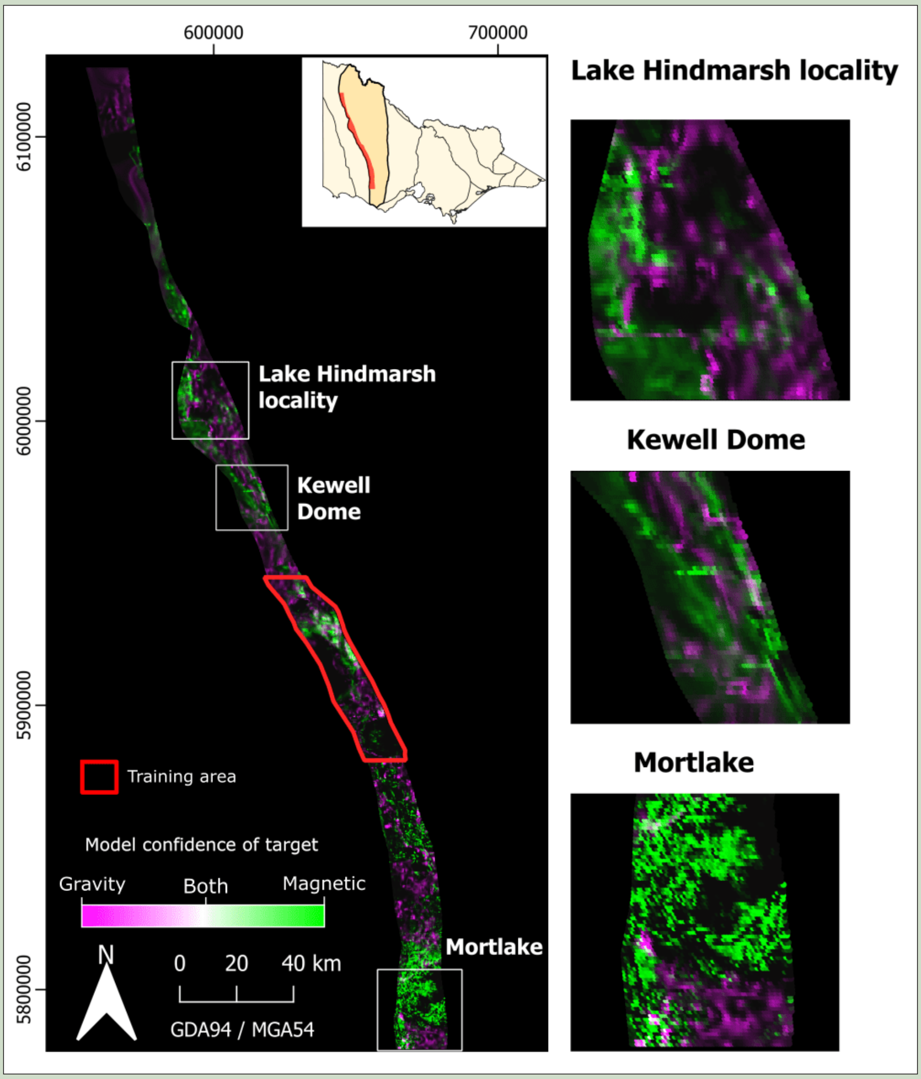

Figure 3. *Neural network predictive dome potential.*

area can be expanded to a regional scale rapidly, and at a low computational cost. The model can be used as a quantitative basis for potential field confidence as an element of a mineralisation potential model, for example, by compositing additional data about structural features and mineral occurrences.

This project was finalised as a masters thesis and submitted at the end 2023. The research has also been presented at AEGC 23 with the support of the ASEG research grant, and as a poster at the AIG OREAS Victorian Minerals Roundup. It's been a great project to see me through my post-graduate study, and I'm grateful to the ASEG for funding the project with a research grant, my project supervisor Mark McLean, North Stawell Minerals and Bill Reid for approving and supporting the fieldwork and modelling, and Mark Grujic from Datarock for mentoring the machine learning component.

RF22E01 RMIT University, PhD Student Matthew Auld (Supervisor Dr Gail Iles)

In-situ *physical property measurements with a novel multispectral, multistatic ground penetrating radar.*

Summary

Matthew is investigating the required methodology to extract meaningful physical properties from Ground and Lunar Penetrating Radar surveys. The project utilises ultra-sensitive magnetic radar (MAPRad) sensors and transmitters developed at RMIT University, small enough to be installed on autonomous rover platforms. With the use of multispectral, multi-static data, the project aims to deliver software for survey geometrical design and the extraction of accurate layer radar wave velocity, attenuation and thickness.

Progress in 2023

Technical

Over the past year, 50% of workload has been dedicated to making instrumentational improvements to the MAPRad device. The antenna design has been modified, with the number of coil turns around the magnetic core being kept the same, while changing the core length has been experimented with to determine how large an effect this has on the radars overall performance. This was briefly tested during a field test in the You Yangs, Victoria, but needs to be looked at further.

While the magnetic antenna itself has undergone minimal modifications, the electronics that the antenna feed into have undergone significant changes. The receiver antenna amplifier has been the focus of the project work, updating a previous amplifier schematic to use a four-stage amplification process before being fed through to the receiver for capture. The design consists of two channels, to provide differential signal amplification, with each channel containing four stages of approximately 15.8 dB of gain for a total of 63.2 dB gain across the entire amplifier board in each channel. Much consideration has been given to oscillations within the board and noise pickup form external sources, as such shielding and appropriate circuit design has been added to the circuit board to isolate and protect each channel from rogue signals. The PCB has gone through two major design changes thus far, as a result of initial lab testing before the current design. The software Altium is being used for designing the amplifier (**Figure 1a**) and the actual PCB has already been printed (**Figure 1b**).

The manufactured amplifier has been tested in a lab setting to verify operation across the designed range of frequencies, up to 30 MHz. Gain and phase linearity of the amplifier have been measured and has shown that the amplifier operates well within the lab and operating conditions. Real world testing is planned for the next few months to determine if the new amplifier is performing as expected when used in tandem with the other components of the system in the field.

Training

In September 2022, Matthew attended The Camp for Applied Geophysics Excellence (CAGE) which provided insight into various geophysics processes. In 2023, ~30% of the year has been spent applying aspects of what was learnt from this trip in the processing of two field tests, one to the You Yangs national park and the other to a landfill site in Ballarat. These field surveys involved the collection of magnetic and electric field sets of ground penetrating radar data which have been processed in attempts to show subsurface features in each field dataset. Both field datasets have also been used in attempts to determine the viability of using a combination of fields can be used to find the conductivity of the subsurface materials, as opposed to estimating the dielectric constant from electric field data alone. So far this has been unsuccessful, but future surveys are planned to collect more appropriate and specific data to work towards this aspect.

Dissemination

The remaining 20% of the year has been spent on disseminating scientific results from the PhD to the wider community. Matthew delivered two presentations at international conferences this year, the first on interference simulation of the antenna with a model rover body (Auld *et al*., 2023), and the second on collating lunar orbiter radar data to generate a map of potential lava tube sites in the south pole region of the moon (Tomas, 2023) that may be targeted by a rover mounted lunar penetrating rover.

Publications

In 2022 Matthew undertook an extensive field trip in Queensland to use MAPRad to map the Undara lava tubes (Auld *et al*., 2022). In 2024, we are preparing a manuscript describing the work undertaken during this field trip Auld *et al*., 2024.

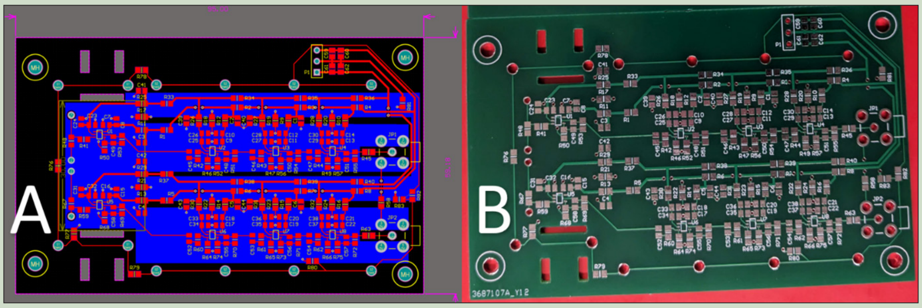

Figure 1. *MAPRad PCB design of receiver antenna amplifier. (a) Altium design (b) receiver amplifier.*

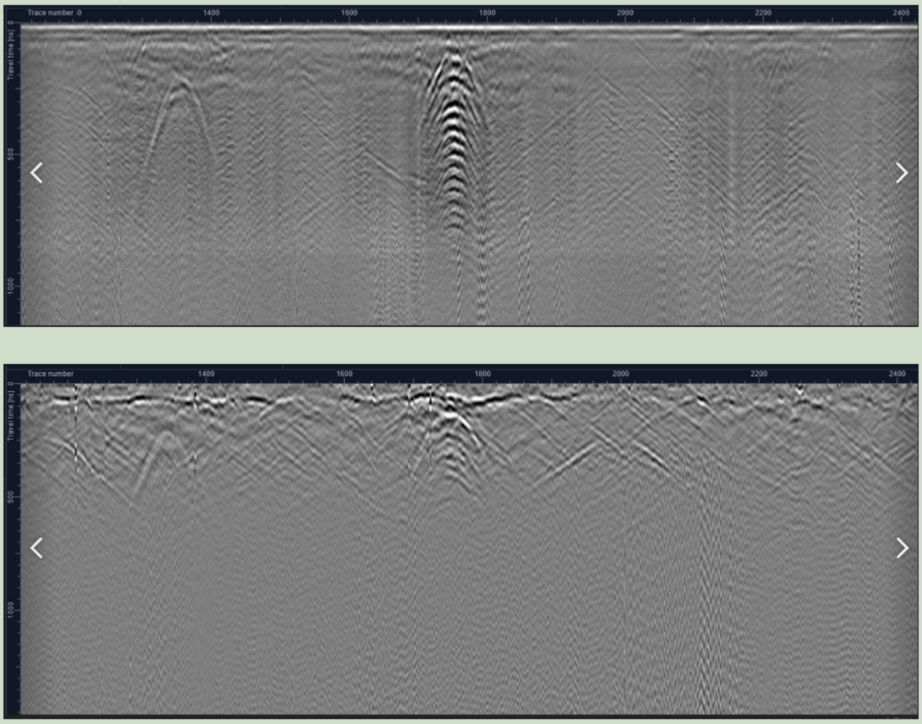

Figure 2. *GPR data collected at Undara National Park, Queensland with both electrical (top) and magnetic (bottom) data indicating the presence of an uncollapsed section of a lava tube.*

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RF23M01 University of WA, MSc Student Abhijit Kurup (Supervisor Prof Mike Dentith)

Understanding magnetic responses in high-grade gneiss terrains in the Southwest Yilgarn Craton, Western Australia.

This study involved the interpretation of high-resolution aeromagnetic data from the southwest Yilgarn Craton, a region recognised for its mineral prospectivity, by integration with magnetic susceptibility (MS), petrography and biotite geochemistry data. The study area is the amphibolite-granulite facies granite-gneiss dominant domain 2 of the Youanmi Terrane. Geology and MS data collection was made on the limited outcrops that are available. The aeromagnetic data was used to extrapolate the bedrock geology interpretation to parts of the area without outcrop.

Field work, MS data and the study of the Fe-Ti oxide minerals allowed the classification of the local granitoids based on oxygen fugacity as either oxidized magnetite-series granites or reduced ilmenite-series granites. The chemistry of biotites through electron probe microanalysis has also aided the classification of granitoids based on the I-type metaluminous and S-type peraluminous sources. The two classifications show good correlation and the four broad lithologies are recognised: a monzogranite migmatite gneiss (I-type and magnetite-series) characterised by high MS, a syenogranite (I-type and magnetite-series) with high MS, a monzogranite (S-type and ilmenite series) with low MS and a porphyritic monzogranite with two subgroups: one with high MS (I-type and magnetite series) and the other with bimodal MS (boundary of I-type and S-type and magnetite-series).

MS data demonstrates a high amount of variation within rock types at the outcrop scale necessitating a substantial number of measurements (sometimes up to a 100) per outcrop for reliable MS averages. In the monzogranite gneiss, MS is observed to increase in the mafic mineral rich melanosome layers when compared to the quartz-feldspathic leucosome, even though no significant difference in the distribution of magnetite was observed. In some regions the porphyritic monzogranite shows bimodality in MS, while in other regions it shows strongly ferromagnetic character, with thin sections showing an increased degree of martitisation of magnetite to hematite with decrease in magnetic susceptibility. The syenogranite shows a wide range in MS, which can be explained by the presence of unevenly distributed coarse grains of magnetite (possibly secondary).

The aeromagnetic data was processed to create a series of products: reduced to pole (RTP) total magnetic intensity (TMI), upward continuation (UC) and residual of UC and RTP at a series of depths, the 1st and 2nd vertical derivatives and the tilt derivative. The interpretation of the magnetic data involved combining the TMI products with satellite imagery, regional geology maps and all the data from the fieldwork. The orientation and geometries of several NE-SW trending faults, a N-S regional shear, E-W and NE-SW mafic dikes and lithological contacts have been delineated using the derivative products (**Figure 1 (b-c)**). Magnetic intensity and texture of anomalies in the RTP and residual of UC and RTP were used to map the four outcropping granitoid lithologies and an inferred mafic gneiss unit associated with intense magnetic highs predominantly present along major structures within the monzogranite and monzogranite gneiss (**Figure 1(c)**). The importance of field geological evidence to ground truth a geophysical interpretation was demonstrated with three major changes proposed to the published regional bedrock geology map of the area: (1) Change of a metamorphosed siliciclastic sedimentary unit to an ilmenite series reduced monzogranite, (2) Change of a tonalite-trondhjemite-granodiorite unit to a syenogranite and (3) Extension of the mafic gneiss along structures into the west of the area. All the regions of low magnetic intensity had previously been classified as a metasedimentary unit, which through ground-truthing has been disproved in this study. The low magnetic signature of these regions is due to an ilmenite series granite, as supported by the MS data (**Figure 1(a), Site 3**), absence of magnetite in thin sections and a presence of biotites characterised by high FeO, Al_2O_3 and low MgO composition. The magnetic responses in this area have been identified to primarily be controlled by different oxygen fugacity conditions giving rise to the two types of granites along with some local effects of weathering and alteration.

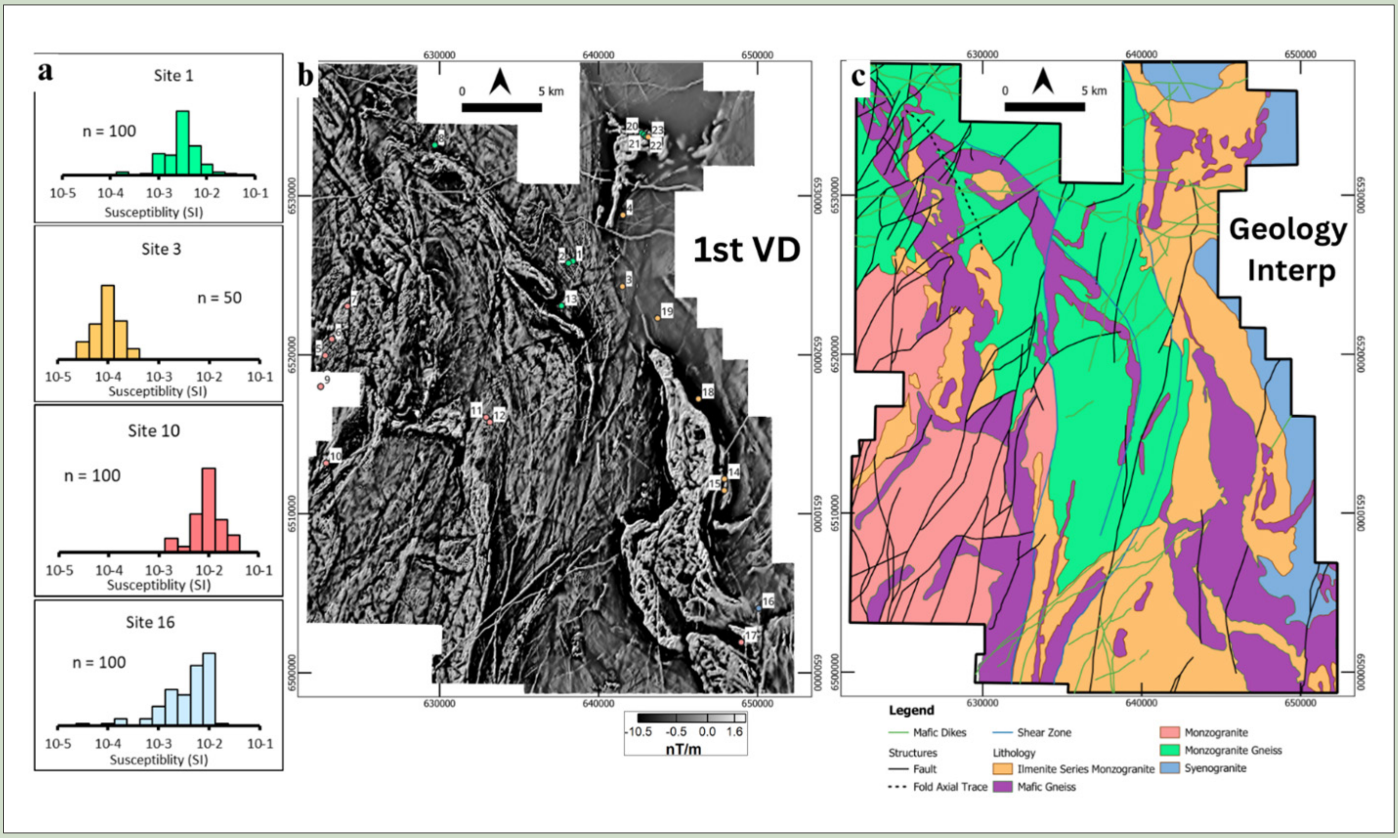

Figure 1. *(a) Magnetic susceptibility frequency histograms, (b) grey scale image of the 1st vertical derivative of the RTP-TMI and (c) the interpreted bedrock geology of the area.*

The MS, petrography and biotite chemistry data is a proxy for redox conditions of the granitic magmas which provides information pertaining to the source regions and economic mineral fertility of different granitoids.

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Geophysical-geomechanical constraints on the operating limits for basin-scale CO_2 storage.

Carbon capture and storage (CCS) is a critical component of pathways to limit global warming, but considerable upscaling is needed to meet Net Zero 2050 targets, including the identification of many new CO_2 storage reservoirs. Identifying favourable geomechanical conditions to avoid reservoir and seal deformation presents a key challenge in the selection and de-risking of safe and effective CCS sites, though the requisite geomechanical data and constraints on the presence and nature of faults and fractures are often scarce. This ASEG Research Foundation supported PhD research project will elucidate the technical and commercial viability of CO_2 storage in Australia's Cooper-Eromanga basins, which have the potential to be a world-leading CCS hub. There is a surprising lack of consensus as to the tectonic origin of this basin system, and limited data on the distribution and properties of faults, in part due to the spatially restricted focus of existing fault mapping and to difficulties in imaging basement-involved faults. The latter is particularly important for CCS, as fluid injection into supra-basement aquifers in the US has resulted in the largest induced earthquakes. The lack of an integrated structural framework for the Cooper-Eromanga basin means that the degree to both shallow and deep reservoirs that might be targets for CO_2 storage are in pressure communication with both over pressured sequences at depth, and potentially active faults in the basement beneath the basin, is a fundamental knowledge gap. This project will take advantage of the new Cooper Basin 2D^{cubed} dataset, where the complete catalogue of seismic reflection data from the South Australian Cooper-Eromanga Basin has been reprocessed to generate pre-stack time and depth-migrated pseudo-3D volumes. The project will apply a consistent fault mapping approach to this dataset, and to available 2D and 3D data from Queensland, supported by regional potential field (gravity, magnetic) datasets, resulting in a whole-basin fault-framework from which reactivation potential can be elucidated through geomechanical modelling, whilst also maximising the broader resource (e.g. natural gas, geothermal, natural hydrogen) potential of the basin.