THE UNIVERSITY OF WESTERN AUSTRALIA

School of Earth Sciences

Potential research projects offered for Level 4 (Honours) and Level 5 (Masters) students commencing in 2021.

- Geology
- Geochemistry
- Geophysics
- Environmental and Marine Geoscience
- Hydrogeology
- Mineral Geoscience
- Petroleum Geoscience
- Numerical Modelling and Data Analytics

The projects outlined in this booklet are not necessarily all of those available. Please feel free to talk to staff members about designing projects around your interests.

Geoscience Projects

This document describes projects suitable for students undertaking a 24pt research project as part of an Honours or Masters degree. Some projects are also suitable for the larger 36pt thesis in the Master of Science by Thesis & Coursework degree.

We encourage you to consider what types of geoscience research problems interest you and to choose a project topic that will motivate you to do your best work throughout the year. The aim of the 24pt project is to provide you with an opportunity to learn how research works and to begin developing your research skills.

The 24pt project is one of the ***best ways*** to demonstrate skills in problem-solving, communication (reading, writing and speaking), and completing a major task on time – *all key elements for employment in the resources industry and government agencies*. It is also a pathway to higher degrees by research (MSc, MPhil, PhD) and students often discover a passion for research during their Honours or Masters research!

This document does not summarise all possible projects and you are welcome to speak with any staff in the School who supervise projects in the areas of interest to you. We recommend that you have a UWA supervisor and a general idea of your project *by the end of this year for both semester 1 and semester 2 commencements in 2021*. Do not leave organising a project until the first teaching week of 2021 or late July! Remember that many of the supervising staff take leave through January and in July between semesters.

Geoscience is a broad discipline that includes Geology, Geophysics, Geochemistry, Geobiology and Computation/Numerical Modelling and its application to environmental, marine, groundwater, energy and mineral deposits exploration and/or management. The breadth of research activity in the School of Earth Sciences means opportunities for students to undertake diverse research projects. Research may be focused on resolving questions related to fundamental Earth processes and knowledge as well as applied to natural resources with social and economic benefits.

You are welcome to contact staff directly (contact details are provided in the booklet) to discuss projects where they are listed as the main contact. If you are interested in an **MSc by thesis & coursework degree**, some of the projects outlined in this booklet can be extended into or set up as larger projects (e.g. 36pt projects). You are welcome to contact supervisors to discuss as required.

Project:	**Automated 3D gravity & magnetic inversion**
Majors or Masters:	Geoscience, Geology, Computer science
Supervisor:	Alan Aitken, alan.aitken@uwa.edu.au, 6488 7147
Description:	Geophysical inversion is a modelling process that generates a spatial property model (e.g. density) directly from geophysical data. Projects are available to apply new technologies to gravity and magnetic inversion problems. Work will be completed making full use of Pawsey Centre supercomputer infrastructure and will involve testing new codes, assessing performance and helping to further develop the approach. Software is designed to be used by non-specialists, however, computing experience and reasonable maths ability are desirable.

Project:	**How the West was one…the Rodona-Totten Shear Zone**
Majors or Masters:	Geology, Geophysics
Supervisor:	Alan Aitken, alan.aitken@uwa.edu.au; 6488 7147
Description:	The reconfiguration of Mesoproterozoic Australia occurred between ca. 1600 Ma and ca. 1300 Ma, through a complex series of plate margin processes. The culmination of this was the collision of the South and West Australian cratons inferred to have occurred along the Rodona Shear Zone, east of Israelite Bay. This project involves the use of high-resolution aeromagnetic and gravity data from Australia and Antarctica to understand shear-zone structure and kinematics. This new map of the shear zone will be tied in with new data from beneath the Eucla Basin, from the Albany Fraser Orogen, and from Antarctica

Project:	**Into the twilight zone of the North Australian Craton**
Majors or Masters:	Geology, Geoscience or related
Supervisor:	Alan Aitken, alan.aitken@uwa.edu.au, 6488 7147
Description:	The concept of the North Australian Craton is central to models of Australia's formation. However its true nature and the details of its formation remain cryptic due to extensive cover of sedimentary basins. This project will seek to map the cratonic architecture, in particular using new geophysical models to map the poorly known zone from 20 – 80 km depth. Revealing the key features of this little known zone will allow a more comprehensive appreciation of cratonic development with impacts for the development of Australia and the Nuna supercontinent.

Project:	**Mapping workflows for subglacial geology: A data analytics approach**
Majors or Masters:	Geology, Geoscience, Computer Science or related
Supervisor:	Alan Aitken, alan.aitken@uwa.edu.au, 6488 7147 and Eun-Jung Holden, eun-jung.holden@uwa.edu.au, 6488 5806
Description:	Knowledge of the geology beneath the Antarctic Ice Sheet is essential to understand ice-sheet bed conditions. Antarctic Geology is very poorly known with <2% outcrop and very few subglacial samples, with an understanding developed mainly from geophysical data. Human interpretations of these data are subjective and are difficult to validate. This project will seek the first implementation of an integrated analysis workflow, including automated image analysis and machine learning approaches to minimise interpreter biases to map the subglacial geology in parts of Antarctica.

Project:	**4D mapping of the thermal evolution of Aus-Ant-India triple junction**
Majors or Masters:	Geology, Geoscience, Computer Science or related
Supervisor:	Alan Aitken, alan.aitken@uwa.edu.au, 6488 7147
Description:	Low temperature thermochronology data constrain the evolution of orogens and rifts, however the patterns of thermal evolution in these settings is complex. This project will use new data from Antarctica and from submarine plateaux alongside published data to review the thermal evolution of the Australia-Antarctica-India triple Junction region since the Cambrian. Using tectonic reconstructions, the project will place the thermal data in the 4D framework of Pangea and Gondwana, and will generate spatial representations of temperature, associated with uplift, burial, magmatism and glacial events.

Project:	**Interpreting Geophysical Datasets**
Majors or Masters:	Geology, Geoscience, Environmental Geoscience, Mineral Geoscience, Petroleum Geoscience
Supervisor:	Mike Dentith Michael.dentith@uwa.edu.au 6488 2676
Description:	Projects are available in numerous applications of geophysical data interpretation, especially involving the integration of geophysical, geochemical and petrophysical datasets. Subject areas include mineral exploration, petroleum exploration, agricultural geophysics and earthquake studies. Projects involving more quantitative studies are also available for students with appropriate computing and numerical skills.

Project	**Oxygen isotope make-up of the Archean mantle**
Majors or Masters:	Geology
Supervisor:	Marco Fiorentini, marco.fiorentini@uwa.edu.au, 6488 3465 and Laure Martin
Description:	Komatiites are remarkable rocks. These crystallised products of the hottest lava flows ever erupted on the surface of the planet provide a snap shot of the Early Earth and a glimpse of the planet's origin. Most of the preserved komatiites are Archaean and Proterozoic in age, although a few rare but notable examples formed in the Phanerozoic, such as the ones outcropping on Gorgona Island off the coast of Columbia. Komatiites are thought to be associated with mantle plumes sourced from deep mantle reservoirs, possibly at the core-mantle boundary. Thus, these lavas provide invaluable insights into the composition of the deep mantle, the nature of core-mantle differentiation processes and the chemical, physical and thermal state of the Early Earth. The modern mantle has an inferred bulk oxygen isotope composition ($\delta^{18}O$) of about 5.5‰. Hadean and Archaean magmatic zircons derived from sources in the upper mantle have $\delta^{18}O$ compositions in a similar range, implying that the oxygen isotopic composition of the upper mantle has remained relatively constant, and comparable to the modern mantle throughout Earth's history. Conversely, the composition of the deep mantle - inferred from $\delta^{18}O$ measurements on olivine crystals from komatiites - appears to have changed through time. Whereas the source of the Gorgona lavas exhibits signatures between 4.4 and 5.5‰, recent works shows that the source of ca. 3.3 Ga komatiites from the Barberton greenstone belt of South Africa is significantly lighter, about 3 to 4‰. This discovery is puzzling because there was previously no indication that the Archaean mantle may have had a different oxygen make-up to its modern counterpart. This project, part of a larger ARC-funded project, aims to understand whether the light oxygen isotope signature recorded in the South African komatiites is an isolated phenomenon or whether any secular evolution in the oxygen isotope composition of Archaean and Proterozoic komatiites globally can be ascertained. To address this conundrum, the project involves petrographic, minero-chemical and isotopic study of fresh olivine grains from a selected range of 2.7 Ga Australian komatiites and 1.9 Ga Russian ferropicrites.

Project:	**Fluxing of mantle carbon as a physical agent for metallogenic fertilization of the crust (funded by Australian Research Council)**
Majors or Masters:	Geology, Geochemistry
Supervisor:	Marco Fiorentini, marco.fiorentini@uwa.edu.au, 6488 3465

Description:	Sulfur is a fundamental element that links the evolution of the Earth´s main four spheres. Although the cycling of this volatile element across the atmosphere, hydrosphere and biosphere is relatively well understood, the long-term evolution of the sulfur budget in the lithosphere and its flux across from the mantle into the crust remains enigmatic. This knowledge gap may be addressed through new insights into the transport mechanisms of sulfide in magmatic systems. Recent work has shown that carbonate may be ubiquitously associated with sulfides from some of these magmatic systems, especially the volatile-rich ones emplaced at the lowermost levels in the continental crust that display a genetic connection with the lithospheric mantle. The consistent occurrence of mantle-derived carbonate intimately associated with magmatic sulfide mineralisation in these settings attests to a critical role of carbon, as a volatile or fluid phase, in the physical and chemical flux of sulfur and metals across the lithosphere. This project will be undertaken within a larger project run by a multi-national team of researchers, and will focus on the role of carbonate in sulfide transport along magmatic conduits. The work will involve the integration of whole-rock geochemical measurements of selected samples with in-situ minero-chemical information from a range of silicate, carbonate, phosphate and sulfide mineral phases using the analytical infrastructure available at UWA including scanning electron microscope, laser ablation ICP-MS and the ion probe. Depending on logistics, work will be undertaken on already available material and/or there is a possibility to visit selected field areas for sampling. It is expected that the project will lay the foundations required to develop much needed new tools for the successful exploration of elusive Ni–Cu–Co–PGE systems.

Project:	**Garnet chemistry to constrain ore processes and establish exploration methodologies for orthomagmatic systems in high temperature metamorphic settings (funded by Independence Group NL)**
Majors or Masters:	Geology
Supervisor:	Marco Fiorentini, marco.fiorentini@uwa.edu.au, 6488 3465 and Laure Martin
Description:	Given its resilience to both chemical and physical processes, garnet has been widely used in exploration targeting as an indicator mineral in diamond exploration, especially in the northern hemisphere. Its mineral-chemical record is known to reflect precious information on the P-T conditions that characterised its genesis in a range of magmatic and metamorphic conditions. Furthermore, garnet is commonly recovered in heavy mineral concentrates. However, it is still unknown whether garnet can provide useful information on the conditions that favoured nickel-sulfide ore genesis, or whether garnet survives the weathering and regolith environment in Australia. Hence, it is unknown whether garnet can be used as an indicator mineral in exploration targeting for orthomagmatic systems. It is argued that there is potential for garnet to retain information about the ore forming process that formed the Nova-Bollinger Ni-Cu-sulfide deposits,

	Western Australia. However, at this stage this is just a working hypothesis that needs to be tested as it is currently based only on a significant but rather restricted range of anomalous trace element data. The objectives of the Honours/Masters project are: 1- Expand our database on garnet occurrences and compositions (chemical and isotopic) in the different lithologies, in both the Nova and Bollinger deposits as well as in the metasedimentary country rocks, mafic granulites and mafic/ultramafic intrusions that host disseminated magmatic sulfides up to 5km from known mineralisation. 2- Document the garnet-forming reactions in the different lithologies composing the Nova-Bollinger deposits to understand the chronology of garnet crystallisation versus the formation of the Ni-Cu-sulfides. 3- Unravel the metamorphic history associated with the Ni-Cu Nova-Bollinger deposits. This objective is key to refine the geological model of the Nova-Bollinger deposits for further exploration by providing quantitative P-T conditions for the deposit, depth of formation, geothermal gradient and presence or not of a metamorphic gradient.

Project	**Refining the Mesoproterozoic Australian-Antarctic connection with new *P-T-t* constraints on high-temperature metamorphism in southwestern Australia**
Majors or Masters:	Geology
Supervisor:	Naomi Tucker, naomi.tucker@uwa.edu.au
Description:	The Albany-Fraser Orogen (AFO) preserves an intriguing record of long-lived thermally extreme metamorphism that occurred during Mesoproterozoic suturing of parts of Australia and East Antarctica. The orogen is also unique for its seemingly rapid exhumation rate, which is an unusual feature, compared with other Mesoproterozoic orogens. Despite these remarkable characteristics, the AFO is understudied, with a lack of quantitative *P-T-t* constraints on the peak metamorphic conditions, prior to exhumation. These new data are needed to: (1) provide robust *P-T-t* constraints across the full extent of the orogen; (2) make inferences about the likely thermal drivers of metamorphism, and (3) to contextualise exhumation and better understand how fast the orogen was cooling. This project will investigate the *P-T-t* evolution of amphibolite-granulite facies rocks from spectacular coastal exposures near Albany. Work will involve petrography and a combination of P-T modelling, geochronology (zircon, monazite) and/or mineral chemistry. Some familiarity with metamorphic petrography is essential. This project also has broader implications for our understanding of the subglacial geology of Antarctica. Metamorphic rocks from the AFO correlate with outcrops in Wilkes Land, East Antarctica. Much of East Antarctica is covered by ice and snow, so our understanding of what lies below is limited. Using the coastal exposures from Albany as a proxy, this project will provide further insight into the hidden geology of Antarctica.

Project	**Igneous and Metamorphic Petrology of crustal rocks**
Majors or Masters:	Geology, Geochemistry, Geoscience, Mineral Geoscience
Supervisor:	Tony Kemp, tony.kemp@uwa.edu.au, 6488 7846
Description:	Projects are available in the general fields of igneous and metamorphic petrology and analytical geochemistry. Topics include, but are not limited to - (1) petrology and geochemistry of Proterozoic dolerite and gabbro intrusions in the Yilgarn Craton and Albany-Fraser Orogen, (2) use of hornblende-plagioclase geobarometry in granites to reconstruct Archean geodynamics, (3) formation and magmatic evolution of Archean anorthosite complexes, (4) critical mineral resources – lithium and rare metal mineralization in pegmatites and S-type granites, (5) partial melting processes in metasedimentary rocks from garnet and cordierite chemistry, (6) tracking ancient continental growth using detrital chromite and rutile. All projects would involve petrography and mineral chemistry, with scope for whole rock geochemistry and, potentially, U-Pb isotope geochronology. Projects can be tailored to suit individual interests, and may be extend to the 36 pt MSc project.

Project:	**Mapping in high grade shear zones, Bremer Bay, WA**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Myra Keep, myra.keep@uwa.edu.au, 6488 7198
Description:	There is potential for a suitable student to conduct a detailed field mapping study of a high-grade ductile shear zone at Banky's Beach, Bremer Bay. This project would involve mapping of a detailed transect across the exposed ductile shear zone, and collection of detailed structural measurements across the exposed shear zone, with a view to interpreting the history of the shear zone.

Project	**Geological mapping of Venus**
Majors or Masters:	Geology, Geoscience
Supervisor:	Myra Keep, myra.keep@uwa.edu.au, 6488 7198
Description:	Our record of the early evolution of Earth is limited by erosion, burial, tectonic dismemberment and periods of impact cratering. The Venusian surface preserves a rare and pristine record of terrestrial planet evolution. We aim to map in detail parts of the Atalanta Planitia Quadrangle (V4) of the northern hemisphere. Our proposed area contains vast areas of Venusian

	"tesserae" that is thought to represent the oldest surviving Venusian landscapes, and which provides a rich and detailed history of the evolution of the Venusian planetary surface. This project will involve interpreting SAR data and using first-order geological relationships to understand the kinematic evolution of the ancient tessera terrains in this block. Students must have a good understanding of structural geology and tectonics to 3rd year level. The scope of the project is compatible with extension to Masters level.

Project:	**Neotectonics and mass transport deposits in offshore petroleum basins of northern WA**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Myra Keep, myra.keep@uwa.edu.au, 6488 7198
Description:	The northwest of WA hosts Australia's largest recorded earthquakes (ML 7.3, Meeberrie, 1941). Identification of modern surface offsets (fault scarps), both onshore and offshore, together with recently calculated earthquake focal mechanism data suggests that modern geomorphology may yield evidence as to recent earthquake activity throughout north-western WA, which may have triggered mass transport deposits. This project seeks to map modern mass transport deposits and fault reactivation in offshore areas in the Carnarvon and Browse basins, using seismic data, with a view to understanding the pre-reactivation geometries and timing, and relating them to the modern tectonic setting.

Project:	**General projects in seismic structural interpretation**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Myra Keep, myra.keep@uwa.edu.au, 6488 7198
Description:	Projects are available in seismic structural interpretation across the North West Shelf, on a range of topics including: fault reactivation and inversion, neotectonics, igneous distributions, cross section restoration and potentially also in microstructure and geomechanics for qualified students. Please see Myra for details.

Project	**Modern fluvial-deltaic reservoir analogues for subsurface Reservoir modelling**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Simon Lang, simon.lang@uwa.edu.au; Mick Oleary@uwa.edu.au; Victorien.Paumard@uwa.edu.au

Description:	Subsurface reservoir facies modelling (for oil, gas, geo-sequestration, waste disposal and water resources) requires a range of uncertainty to be considered regarding the size, shape and 3D geometry of geobodies in the subsurface. Predicting likely spatial relationships of facies both in 2D and in the connected 3D space is critically important because it can impact the outcome of flow simulations it models (high-permeability networks, barriers and seals). This project focussed on coastal-deltaic geobodies and specifically on aspects of several modern Deltas on the WA coast from the Gascoyne region to the Pilbara. The project will be GIS based followed up by a field sortie to confirm facies predictions and to obtain vital statistics on texture and sedimentary structures. Sediment sampling, augering, coring, and a range of geophysical tools will be used to make facies maps that will be used to characterize the Deltas in the mode of the WAVE3 classification scheme and ultimately to guide reservoir modelling as training images. Field work will be conducted between May and August. The project will be supported by funds from the new Reservoir Analogues Consortium funded by industry.

Project	**Quaternary to Recent coastal processes and evolution from high resolution seafloor mapping of the Western Australian continental shelf**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Simon Lang, simon.lang@uwa.edu.au; Mick Oleary@uwa.edu.au; Victorien.Paumard@uwa.edu.au
Description:	Regional scale seafloor mapping of the West Australian continental shelf based on high resolution 3D seismic datasets and satellite imagery offers a valuable dataset for understanding larger scale coastal processes and shoreline evolution based on sedimentation patterns observed from bathymetric datasets. The project will help create improved datasets from various data sources and using GIS mapping (enhanced by sediment sampling and shallow borehole data), will focus on the evolution of selected clastic and/or carbonate geobodies and their spatial and temporal relationships. The results will be used to improve our understanding of the evolution of the continental shelf during significant changes in relative sea-level and variable climate history, with spin-off value for sedimentology of shallow marine and shoreline deposits, including geotechnical aspects and geo-archaeology. The opportunity to conduct field work may arise in conjunction with related projects by the School. The project will be supported by funds from industry and related research grants and related research grants focussed on climate change and its impact on coastal evolution.

Project	**Quantitative Seismic stratigraphy**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Simon Lang, simon.lang@uwa.edu.au; Victorien.Paumard@uwa.edu.au; Anthony.Gartrell
Description:	With ~15% of siliciclastic hydrocarbon reservoirs located within deep-water basins, a key challenge for the industry is to predict when and where coarse-grained sediments are delivered from the edge of continental margins (i.e. shelf-edge) to the continental slope and basins, and how these sediments accumulate in deep water (i.e. type and architecture of deep-water systems). This project aims at applying the innovative approach of quantitative 3D seismic interpretation (QSS) to investigate the linkages (quantified relationships) between shelf margin architecture, hydrodynamic processes along deltaic shorelines and reservoir properties (type, volume, architecture) in deep water in a variety of basin settings. The project is underpinned by state-of-the-art, full volume, semi-automated 3D seismic interpretation methods that enable very high-resolution seismic stratigraphic analysis of large datasets in a short time frame. The project will involve detailed analysis of one or more subsurface case studies (margins in a variety of climatic and tectonic settings), including the use of appropriate analogues from literature and outcrops. This study will evaluate how quantitative measurement of shelf edge parameters on seismic data can be a useful exploration tool to predict shallow marine depositional style and deep-water play development.

Project	**Depositional history and reservoir characterisation, North West Shelf and onshore basins**
Majors or Masters:	Geology, Petroleum Geoscience
Supervisor:	Annette George, annette.george@uwa.edu.au, 6488 1923
Description:	A variety of petroleum reservoirs are encountered in the offshore basins of the North West Shelf and onshore basins in WA. These projects can be undertaken in shallow or deep marine depositional systems to reconstruct depositional and tectonic history of specific basins or through specific stratigraphic units (notably reservoirs, both conventional and unconventional). Projects typically use core to petrographic-scale description and interpretation to establish depositional and relative sea-level history (using sequence stratigraphy and related techniques) and/or major controls on reservoir quality (i.e. principally distribution of porosity and permeability). Projects may include Hylogger® spectral analysis and portable XRF analysis of core to obtain geochemical data for characterising facies, chemostratigraphy and establishing diagenetic history. Some projects could involve application of higher level microscopic techniques (scanning electron, cathode luminescence). Also suitable for 36 pt Master of Science projects.

Project:	**Tectonic assembly of northern Thailand**
Majors or Masters:	Geology, Geoscience
Supervisor:	Annette George, annette.george@uwa.edu.au, 6488 1923, Luis Parra Avila
Description:	Thailand, like much of SE Asia, is an amalgam of a number of significant geological terranes that accreted to Indochina in the late Paleozoic–Mesozoic during the Indosinian Orogeny. There are opportunities for projects, within a larger industry-sponsored project, focusing on specific elements of the tectonic history: e.g. characterisation of igneous suites (rocks and mineral grains) related to volcanism and potential back-arc basin development; detrital zircon geochronology and geochemistry to constrain sediment provenance and sediment dispersal during basin development. This region is well known for hosting a wide array of mineral deposits. These topics are also good for 36 pt Master of Science projects with suitable prior learning.

Project:	**Tectonostratigraphy and Basin History, Thailand onshore and offshore basins**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Annette George, annette.george@uwa.edu.au, 6488 1923 and Victorien Paumard
Description:	The basins of northern Thailand and related offshore basins record the impact of late Paleozoic–early Mesozoic collision overprinted by Cenozoic strike-slip tectonics. They are geologically younger analogues of older onshore basins in WA. These complex basins are also associated with significant gas resources and hence unravelling their depositional and deformational history is critical to understanding resource formation and distribution in the basin fills. There are opportunities for projects using seismic and well data to interpret the tectono-stratigraphic history of these Paleozoic–Mesozoic basins, reconstruct paleogeography and consider implications for energy prospectivity. These topics are also very suitable for 36 pt Master of Science projects.

Project	**Consequences of the Pliocene?–Pleistocene Coolgardie asteroid impact on the vegetation of Western Australia**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience, Botany
Supervisor:	Daniel Peyrot, daniel.peyrot@uwa.edu.au, 6488 2672
Description:	The crater of Calgoordie (NW Kalgoorlie), resulted from the impact of a <200m-wide asteroid likely to have crashed between c. 5 Ma and 800ka on the gold-bearing, Archean, Yilgarn Craton. The impact produced a 600m-wide and <150m-deep conical structure, where peat including plant fragments accumulated. The project will analyse the palynological content of the post-impact sedimentary succession in order to i) confirm the age of the impact,

	and ii) reconstruct the evolution of the wetland vegetation having colonized the sheltered, small-scale, habitat.

Project:	**Consequences of the 100Ma-old Ora Banda asteroid impact on vegetation and marine ecosystems of Western Australia**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Daniel Peyrot, daniel.peyrot@uwa.edu.au, 6488 2672
Description:	The crater of Ora Banda (NW Kalgoorlie), resulted from the impact of a <200m-wide asteroid likely to have crashed 100Ma ago on the gold-bearing, Archean Yilgarn Craton. The impact produced a conical structure with an approximate 5km diameter and several hundreds of meters of depth which became soon after an unusual depositional setting having accumulated mudstones of probable marine origin. The project will analyse the palynological content of the post-impact sedimentary succession in order to i) confirm the age of the impact, and ii) evaluate the consequences of the asteroid impact in both marine and terrestrial ecosystems by comparing the assemblages with other coeval assemblages from WA.

Project:	**Taxonomic description of *Leptodinium* FM *sensu* Backhouse and its biostratigraphic significance for the Lower Cretaceous dinoflagellate cyst succession of Western Australia**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Daniel Peyrot, daniel.peyrot@uwa.edu.au, 6488 2672
Description:	Dinoflagellate cysts are important biostratigraphic markers to date and correlate Berriasian-Valanginian (Lower Cretaceous) hydrocarbon-bearing strata from the North-West Shelf of Australia. Among other numerous informal taxa defined by consultants, *Leptodinium* FM *sensu* Backhouse has been widely used to refine the regional stratigraphy but has never been formally described. The project will focus on the morphologic characterization and taxonomic formalization of this taxon and its significance to improve the biostratigraphic framework of Western Australia.

Project	**Drivers of coastal erosion and accretion along the Coral Bay Coast**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Mick O'Leary, mick.oleary@uwa.edu.au

Description:	The Coral Bay Coast is home to some of Western Australia's most iconic beaches. They are typically comprised of carbonate sediments that were produced within the nearshore reef system and transported cross and/or along shore under the prevailing coastal hydrodynamic regime. However, there is increasing evidence to show that many of the beaches along the Coral Bay coast are currently experiencing a regime of net sediment loss and erosion. The aim of the project is the investigate the historical trends in shoreline position along the Coral Bay Coast using historical aerial photography, and using recently acquired bathymetric Lidar for the region develop a hydrodynamic model to map current movement and sediment transport and identify whether recent coastal infrastructure or increased coral cover along the Coral Bay coast have resulted in the impounding or trapping of sediment, limiting supply to the beach.

Project:	**Legacy and preservation of tropical cyclone deposits along the Pilbara Coast**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Mick O'Leary, mick.oleary@uwa.edu.au
Description:	Climate models are yet to accurately predict how tropical cyclone intensity and frequency might change under future climate scenarios. An alternative approach is to reconstruct time series of cyclone activity/intensity from the geological record. However, the nature of cyclone generated storm deposits and their preservation potential has not been explored. The aim of this project is to investigate the sedimentary deposits of recent and historical cyclone events along the Pilbara coast and establish what kind of sediment logical deposit constitutes a cyclonic event and whether these types of deposits are able to preserved within in the coastal sedimentary environments.

Project:	**Submerged paleocoastal environments on the NW Shelf**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Mick O'Leary, mick.oleary@uwa.edu.au
Description:	During the last glacial cycle (80,000 to 10,000 yrs BP) sea level was between 20 and 120 metres lower than present. This period of time captured major climatological events, as well the arrival of first Australians and extinction of Australia's mega fauna. In order to reconstruct how these coastal paleoenvironments may have supported human populations, and responded to changing regional climate this project will analyse a collection sediment cores collected on the North West Shelf. The student will employ sedimentological and geochronologial methods to reconstruct paleoevironmental evolution of the NW Shelf during this late Pleistocene period.

Project:	**Evaluating heterogeneity in carbonate reservoirs and their controlling influences: seismic to pore-system studies**
Majors or Masters:	Geology, Geoscience, Petroleum Geoscience
Supervisor:	Moyra Wilson moyra.wilson@uwa.edu.au
Description:	Carbonate systems host ~50% of the world's hydrocarbon reservoirs and form major subsurface aquifers, yet their poroperm characteristics remain notoriously fickle and difficult to predict. Unlike siliciclastics, carbonate systems commonly show a greater range of pore types (e.g., intragranular, biomouldic), significant secondary porosity, bi- to tri-modal pore systems, as well as connected and unconnected pores. Better understanding of the heterogeneity in carbonate reservoirs is reliant on evaluating the considerable depositional and diagenetic variability in carbonate systems. A number of often industry-supported projects are available, including at Masters level. These projects will variably involve training in the study and integration of: core, outcrop, seismic, sequence stratigraphic, facies, microscopy, geochemical and petrophysical datasets.

Project:	**Coral Reefal Environmental change during periods of global climatic shifts**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Moyra Wilson moyra.wilson@uwa.edu.au
Description:	Environmental change during global climatic shifts may be manifest in marine carbonate successions through changing: biota, mineralogy, facies, platform structure, early diagenesis and geochemistry. Projects are available to investigate controls on regional versus local change during times of major climatic shifts. These periods include the shift from greenhouse to icehouse conditions during the Cenozoic and the switches from glacials to interglacials that are particularly marked in the Plio-Pleistocene to Recent. These projects will variably involve training in the study and integration of: core, outcrop, seismic, sequence stratigraphic, facies, microscopy and geochemical datasets. This topic is also suitable for a 36 pt Master of Science project.

Project:	**Reefal and carbonate edifices: integrated seismic and sample studies to evaluate environmental change and economic aspects**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Moyra Wilson moyra.wilson@uwa.edu.au; Victorien Paumard victorien.paumard@uwa.edu.au
Description:	Reefal and carbonate systems are sensitive indicators of environmental change, building edifices or platforms that are some of the world's largest bioconstructions. In the subsurface the origins, evolution, controlling influences on, and economic potential of such edifices are best investigated through combined seismic, log and sample datasets. A range of studies on subsurface carbonate systems from Australasia will involve training in seismic

	analysis, facies approaches, petrology and where possible petrophysics to investigate the evolution of a range of carbonate systems and their controlling influences. This topic is also suitable for a 36 pt Master of Science project.

Project:	**Western Australia's coastal deposits as proxies for global climate change**
Majors or Masters:	Geology, Geoscience, Marine Geoscience
Supervisor:	Moyra Wilson moyra.wilson@uwa.edu.au
Description:	Marine and coastal deposits of SW Australia lie at the transition of warm to temperate waters, with the reefal and carbonate deposits acting as sensitive indicators of local to regional environmental and climatic change. A series of projects are available to investigate the impacts of oceanographic, climatic habitat, and eustatic sea level changes on the modern and Plio-Pleistocene coastal and marine deposits of SW Australia. These projects will variably involve training in the study and integration of: modern sediment studies, field outcrop, microscopy and geochemical datasets with fieldwork a possibility. This topic is also suitable for a 36 pt Master of Science project.

Project:	**Testing for tsunami deposits, Australia's Northwest shelf.**
Majors or Masters:	Geology, Geoscience, Geoarchaeology
Supervisor:	Moyra Wilson moyra.wilson@uwa.edu.au, Piers Larcombe piers.larcombe@uwa.edu.au, Ingrid Ward ingrid.ward@uwa.edu.au
Description:	Australia's Northwest continental margin includes large numbers of mass transport deposits, representing massive slope failures. Such failures are likely to have produced many tsunamis in the region over many millions of years. A series of highly unusual cemented deposits have been documented on an island in the region. This project is aimed at testing whether these deposits might represent a paleo-tsunami deposit. As part of testing this hypothesis, the project will detail the microfossils and the mineralogy of the deposits to help indicate the possible origin of the sediments. An opportunity may exist to visit the field site to examine and further document the deposits *in situ*. This project is aimed at Honours or Masters level and will involve training in the study and integration of: outcrop, stratigraphy, microfossil analysis, petrology and geoarchaeology. All results are anticipated to be highly publishable when executed to high standard.

Project:	**Paleoenvironmental records in the Montebello Lagoons**
Majors or Masters:	Geoscience, Geoarchaeology
Supervisor:	Moyra Wilson moyra.wilson@uwa.edu.au, Ingrid Ward ingrid.ward@uwa.edu.au; Piers Larcombe piers.larcombe@uwa.edu.au,
Description:	Marine core samples (totalling 26 m of core) have been collected from several lagoons and mangrove deposits on the Montebello Islands, NW Australia. The nearest equivalent of the lagoons are the drowned evaporite pans of Shark Bay, but the exact formation history of the lagoons remains poorly documented. The lagoons themselves are likely to have preserved records that will reflect sedimentation during Post-Glacial transgression and associated with past cyclonic or even tsunami-related activity. The sediments may form a record of paleo-environmental change. The changing nature of the lagoons with marine inundation may also provide completely new insights into interpretations of the archaeological cave records within the Montebello Is. and Barrow Is. that date back to ~14 ky BP and ~50 ky BP respectively. Focussing on the microfossils contained within the cores, the formation history of the lagoons and the paleoenvironmental record within them will be explored as one or more projects. The work forms a critical part of a broader geoarchaeological study of the Montebello Is. complex. Opportunities to return to Montebello Is. for further fieldwork are possible but not guaranteed. This project will involve training in the study and integration of core, sediment stratigraphy, facies, microfossil analysis and geoarchaeology.

Project	**The origin of the Paroo Station lead carbonate mine: hypogene/ supergene or supergene-only genesis?**
Majors or Masters:	Geology, Geochemistry, Mineral Geoscience, Ore Deposit Geology
Supervisor:	Steffen Hagemann steffen.hagemann@uwa.edu.au; 6488 1517 and Carl Brauhart (CSA Global)
Description:	The unique Paroo Station lead carbonate mine near Wiluna (Western Australia) was discovered in 1991 by Renison Goldfields Corporation. From 2004 to 2015 this mine produced approximately 300,000 tonnes of lead metal in concentrate form (rosslynhillmining.com.au). Cerussite is the main Pb-carbonate ore mineral. It is hosted in 35 metre thick quartz-clay carbonate (including cerrusite), mineralised zones within siltstone. The 'accepted' stratabound, sulphide free supergene ore deposit model has been questioned by various researchers. Fluid inclusions are observed in cerrussite and this projects main objective is to investigate the physico-chemical parameters $P_{ressure}$-$T_{emperature}$-$X_{Composition}$ (P-T-X) of the hydrothermal fluids that were trapped during mineralization and reconstruct the paleohydrothermal system that caused Pb transport and precipitation. Ultimately, the fluid inclusion data will be used to evaluate whether there is a hypogene mineralization event. The carefully petrographically constrained fluid

	inclusions will be analysed using the in house fully automated Linkham heating-freezing stage and laser-Raman spectroscopy. The project is suitable for a 36 pt MSc thesis. Requires knowledge in geochemistry and successful completion of the SEM course early in 2020 (as advertised by the Centre for Microscopy, Characterisation and Analysis at UWA).

Project:	**Garnet and clinopyroxene chemistry of the O'Callaghans polymetallic W-Zn-Pb-Cu skarn, Paterson Orogen, Western Australia: Constraining the physico-chemical conditions of prograde skarn formation**
Majors or Masters:	Geology, Geochemistry, Mineral Geoscience, Ore Deposit Geology
Supervisor:	Steffen Hagemann, steffen.hagemann@uwa.edu.au, 6488-1517 and Laure Martin
Description:	The O'Callaghans polymetallic skarn is located in the Paterson Province in Western Australia and is one of the world's largest W deposit in the world. Garnets and pyroxene are part of the prograde, high temperature hydrothermal silicate alteration which consists of garnet-clinopyroxene-quartz, minor sulphides and scheelite. This investigation will define the garnet and pyroxene species; define intra-garnet and pyroxene zonation and provide P-T estimates based on e.g., the garnet-pyroxene geothermometer. The petrographic and geochemical results of the garnet-pyroxene assemblage will be used to better characterize stage 1 prograde hydrothermal alteration and mineralization at the O'Callaghans skarn deposit and, thereby, further refine the classification of this skarn type. The project is also suitable for a 36 pt MSc thesis. Appropriate prior study and successful completion of the SEM course in early 2020 (as advertised by the Centre for Microscopy, Characterisation and Analysis at UWA).

Project:	**Fluid evolution in the Karouni gold deposit, Guyana, South America**
Majors or Masters:	Geology, Geochemistry, Mineral Geoscience, Ore Deposit Geology
Supervisor:	Steffen Hagemann steffen.hagemann@uwa.edu.au 6488-1517 and Mike Tedeschi.
Description:	The Karouni orogenic gold deposit, located in the Guyana Shield in South America, is Troy Resources flagship gold deposit with production starting in 2015. The key objective of the project is the reconstruction of the paleohydrothermal evolution of this gold system via fluid inclusion and stable isotope investigations. The project involves detailed petrography of quartz veins and breccias, cathodoluminescence of quartz-carbonate crystals and identification of suitable fluid inclusion assemblages. The carefully constrained fluid inclusions will be analysed using the in house fully automated Linkham heating-freezing stage and laser-Raman spectroscopy.

	Oxygen and hydrogen isotopes will be measured on quartz and fluid inclusions, respectively. The results will be used to constrain the characteristics and evolution of the Karouni gold system and aid in the exploration for new, concealed ore bodies in the area. This project is part of the 'to be established' SAXI (South American Exploration Initiative) project, thus the proposed Honours/Masters project provides the candidate with the opportunity to collaborate with a team of national and international researchers. The project is also suitable for a 36 pt MSc thesis. Appropriate prior study and successful completion of the SEM course in early 2020 (as advertised by the Centre for Microscopy, Characterisation and Analysis at UWA).
Project	**Characterisation of proximal to distal alteration footprint of gold deposits in the Yilgarn craton**
Majors or Masters:	Geology, Geochemistry, Ore Deposit Geology
Supervisor:	Nicolas Thébaud, nicolas.thebaud@uwa.edu.au , 6488 7139
Description:	A range of projects are available focusing on gold deposit of the Yilgarn Craton. These projects aim at characterizing the mineral paragenesis and structural contexts and place gold mineralisation within this context. These studies rely on a multi-disciplinary approach combining structural core logging, mineralogy and lithogeochemistry.

Project:	**Tellurium in the lithosphere**
Majors or Masters:	Geology, Geochemistry, Mineral Geoscience, Ore Deposit Geology
Supervisor:	Nico Thébaud, nicolas.thebaud@uwa.edu.au, 6488 7139, Marco Fiorentini and Laure Martin
Description:	Tellurium is an element weakly abundant in the crust (~0.001ppm in the crust) but commonly recognised in mineral systems including ortho-magmatic Ni-PGE deposits but also in orogenic gold deposit. The purpose of this project is to evaluate the nature and abundance of the Te-bearing mineral phases associated with a range of environments including ore deposits, sediments, volcanic complexes and intrusions. This in turn will provide an opportunity to discuss how tellurium may be used to track the metal source within mineralised systems. Accordingly, research methodology will combine petrological investigation and characterisation using optical and electronic microscopy and microprobe analyses deployed on selected samples.

Project:	**P-T conditions associated with gold mineralisation in the Oberon deposit in the Tanami**
Majors or Masters:	Geology, Geochemistry, Mineral Geoscience, Ore Deposit Geology
Supervisor:	Nicolas Thébaud, nicolas.thebaud@uwa.edu.au, 6488 7139, and Andrew Crawford
Description:	This project aims at evaluating the P-T conditions associated with gold mineralisation in the Oberon gold deposit (Tanami). The Oberon deposit is a 4.5 Moz gold deposit hosted in metasedimentary rocks of the Granites-Tanami orogen. Mineralisation is associated with several quartz-albite vein generations. Yet little detailed study of the conditions associated with the mineralisation process has been conducted. This project will endeavour to further the vein paragenesis and constrain the P-T evolution at the time of mineralisation. Methodology for this project involves both field work (one week) and lab work (ore petrology and fluid inclusion study).

Project:	**Structural and mineralogical controls on the relative and absolute timing of gold mineralisation at the Garden Well Gold Deposit, Duketon District, Western Australia.**
Majors or Masters:	Geology, Geochemistry, Mineral Geoscience, Ore Deposit Geology
Supervisor:	Nicolas Thébaud, nicolas.thebaud@uwa.edu.au, 6488 7139
Description:	Using the excellent rock exposure in open pit together with drill-log, geochemistry and petrography, this project aims to integrate the structural and mineralisation history that can be derived from a focussed deposit scale study of the Garden Well deposit into a regional framework. Using a combination of field mapping and exploration diamond drill core, this project aims to: - characterise the structural framework of the Garden Well prospect from open pit and drill core structural analysis; and - establish the mineral paragenetic association related to the mineralisation of the Garden Well deposit in the framework of its structural evolution. This project includes fieldwork (4 to 5 weeks) and lab work (ore petrography).

Project:	**Topological uncertainty propagation –application to mine dewatering**
Majors including:	Hydrogeology, Physics, Engineering, Computer Science
Supervisor:	Guillaume Pirot guillaume.pirot@uwa.edu.au , Mark Jessell mark.jessel@uwa.edu.au
Description:	The objective of this project is to assess the uncertainty of topological constraints (e.g. presence or absence of a fault) on mining activities such as dewatering. Based on real cases reported by industry partners, a large

	ensemble of numerical synthetic models will be tested. It will in particular involve designing and performing a sensitivity analysis of variables describing topological uncertainty as well as other model input variables (e.g. mesh resolution) on the drawdown of the hydraulic head. This project is supported by the MinEx CRC industry and public consortium (https://minexcrc.com.au/program-two-data-from-drilling/project-6-automated-3d-modelling/). The scope is compatible for continuation to a 36 pt Master of Science project. This project would be suitable for students with an interest in 3D geological modelling and statistics. Programming experience would be useful but is not essential.

Project:	**Cost and value analysis of data collection scenarios to reduce geological uncertainty**
Majors including:	Hydrogeology, Geology, Physics, Engineering, Computer Science
Supervisor:	Guillaume Pirot guillaume.pirot@uwa.edu.au , Mark Lindsay
Description:	The objective of this project is to assess the economic efficiency of different data acquisition strategies in a geological characterization context. Based on real cases reported by industry partners, an ensemble of synthetic scenarios will be tested. It will involve 3D geological modelling and integration of surface and borehole geological data observations as well as geophysical measurements. This project is supported by the MinEx CRC industry and public consortium (https://minexcrc.com.au/program-two-data-from-drilling/project-6-automated-3d-modelling/). The scope is compatible for continuation to Masters or PhD level. This project would be suitable for students with an interest in 3D geological modelling and statistics. Programming experience would be a benefit, but is not essential.

Project:	**Assessment of geological uncertainty**
Majors including:	Hydrogeology, Geology, Physics, Engineering, Computer Science
Supervisor:	Guillaume Pirot guillaume.pirot@uwa.edu.au , Mark Lindsay, Jérémie Giraud
Description:	To improve the sustainability of our management and use of subsurface resources (water, energy and minerals), decision makers rely on ensemble of predictions, derived from ensemble of subsurface models. To estimate prediction confidence, it is necessary to characterize properly the uncertainty and diversity of (hydro-) geological or geophysical models. Though several measures can be computed to characterize this geodiversity, the choice of the measures is often subjective. This project will review and benchmark the different indicators in order to formulate some recommendations with respect to the properties of interest. The techniques to be investigated will be defined with the student and can comprise data science concepts, image processing, graph theory, etc.

	This project is supported by the MinEx CRC industry and public consortium (https://minexcrc.com.au/program-two-data-from-drilling/project-6-automated-3d-modelling/). The scope is compatible for continuation to Masters or PhD level. This project would be suitable for students with an interest in 3D geological modelling and statistics. Programming experience would be a benefit, but is not essential.

Project:	**Understanding the drivers of coastal morphodynamics in Western Australia using novel remote sensing techniques**
For majors including:	Marine Science, Marine Geoscience, Geoscience
Supervisors:	Jeff Hansen jeff.hansen@uwa.edu.au, 6488 3724 and Ryan Lowe
Description:	The coastline of Western Australia (WA) is complex due to its geomorphology (e.g. many coral and rocky reef) and is exposed to a unique range of wave and water level conditions. For example, the south of the state is exposed to large waves and small tides with the opposite occurring in the north of the state. This projects aims to develop a more detailed understanding of the coastal dynamics at a particular site or region of WA. Historical (1980s- to present) shorelines will be mapped using a combination of satellite imagery and aerial photography. The variability in the mapped shorelines over time will then be linked to records of waves and water levels to understand the primary drivers of coastal change. For example, during La Niña years, the Leeuwin Current is stronger than normal which causes sea levels to be elevated. Some existing research has suggested the elevated sea level associated with La Niña conditions results in additional beach erosion- but this link needs to be further explored at additional locations. A greater understanding of how the coastline responds to variations in sea level and waves will increase our ability to manage the coast and mitigate the effects of climate change.

Project:	**Measuring the variability of the southwestern Australian coastline from oblique aerial imagery**
For majors including:	Marine Science, Marine Geoscience, Geoscience
Supervisors:	Jeff Hansen jeff.hansen@uwa.edu.au, 6488 3724, Michael Cuttler
Description:	The Western Australian coastline is well known to exhibit seasonal variability in morphology. For example, WA beaches are typically wider in summer and narrower in winter. Typical methods for surveying beach morphology require accessing the beach at multiple times throughout the year. However, WA is one of the most remote and rugged coastlines globally. Thus, there are vast stretches of coastline that have limited access which limit the applicability of typical survey methods. Recently, advancement in photogrammetry techniques have allowed aerial photography to be exploited for measuring coastal morphology with cm-scale accuracy. These advancements now provide an opportunity for measuring stretches of coastline previously unmeasurable with typical surveying techniques.

	UWA has partnered with the Peron-Naturaliste Partnership to capture oblique aerial imagery of the southwestern Australian coastline, from Rockingham to Cape Naturaliste. This project will employ photogrammetry techniques and 4 years of bi-annual oblique aerial photographs to measure coastal morphological change along 250 km of coastline. This large-scale analysis will identify erosion/accretion 'hot spots' and provide value insight into the interannual variability of this coastline.

Project:	**Quantifying coastal morphodynamics through community-sourced imagery**
Majors including:	Marine Science, Marine Geoscience, Geoscience
Supervisor:	Jeff Hansen jeff.hansen@uwa.edu.au, 6488 3724, Michael Cuttler
Description:	With the proliferation of smart phones and social media, capturing and sharing images of the coast has never been easier. A new coastal monitoring program, CoastSnap, has recently been created to analyse community-sourced imagery to provide quantitative data on coastal morphology. CoastSnap was recently established at nine sites along WA's south west (between Rockingham and Busselton, see facebook.com/coastsnapwa). This project will involve analysing the imagery from each of the new CoastSnap WA sites to examine a range of coastal dynamics questions (e.g. magnitude of shoreline change) and social science questions (e.g. who is taking photos, what social media platform is the photo from, etc.).

Project:	**Wave runup and rock fisher safety along the Great Southern coastline**
Majors including:	Marine Science, Marine Geoscience
Supervisor:	Jeff Hansen jeff.hansen@uwa.edu.au, 6488 3724, Michael Cuttler
Description:	The Great Southern region of WA is renowned for its rugged coastline, with common tourist attractions included locations such as 'The Gap and Natural Bridge'. A popular activity amongst locals and visitors to the Great Southern is rock fishing. However, this activity puts fishers in direct contact with the large Southern Ocean swells that are prolific along this coastline. When these large waves break, they cause up-rushes of water (wave runup) that surge over the rock platforms where fishers are located. In the worst cases, anglers can be knocked over, pulled into the sea, and drown. Furthermore, the remoteness of the Great Southern means that most common fishing spots are unpatrolled by lifesavers. Thus, there is a need to better understand the physical processes that drive wave runup along this coastline. This project will use video imagery collected at Salmon Holes (near Albany, WA) to develop a quantitative understanding of wave runup at rocky coastlines that will contribute to the development of a warning system for assessing rock fishing risk.

Project	**Use of artificial reefs for coastal protection: identifying opportunities for WA**
Majors or Masters:	Geology, Geophysics, Marine Science, Environmental Science
Supervisor:	Ryan Lowe, Ryan.Lowe@uwa.edu.au, 6488 2706, Jeff Hansen and Michael Cuttler
Description:	Coastal erosion and flooding due to extreme storms and sea level rise poses a major threat to populations and infrastructure. Traditional strategies to mitigate coastal hazards have focused on use of hard ('grey') infrastructure (e.g. seawalls, breakwaters, etc.), which despite being effective, generally have many negative impacts on coastlines (e.g. degrading coastal ecosystems, losses of coastal amenities, etc.). Alternative nature-based forms of coastal protection are increasingly being considered for future use in coastal mitigation and adaptation strategies, which potentially have additional benefits including, for example, ecosystem services and lack of visibility from the surface. Within WA, coastal erosion has become particularly severe in a number of locations (i.e. erosion hotspots) that require developing new coastal protection strategies. This project will assess the feasibility of use of artificial reefs as potential solutions to WA's coastal erosion problems, including identifying suitable locations, optimum design/placement and assessing likely future shoreline responses.

Project :	**Stream-aquifer interaction – moving beyond the hillslope**
Majors including :	Hydrogeology
Supervisor :	Sarah Bourke sarah.bourke@uwa.edu.au, Department of Water and Environmental Regulation personnel
Description:	It is now widely acknowledged that best-practice water resource management requires a robust understanding of water fluxes between surface water and groundwater. Streamflow is often generated by groundwater outflowing to the surface, while water infiltration from streams forms an important source of aquifer recharge. The majority of studies examining streamflow generation processes have been conducted in the context of hill-slope hydrology, where topography plays is the dominant control on water movement. However, in highly weathered landscapes like WA, subsurface geology can be more important than topography in determining how much water ends in in streams and aquifers. Research project opportunities can include the analysis of existing data sets as well as field data collection to improve our understanding of geological controls on surface water – groundwater interaction and streamflow generation. Field sites may include Preston, Pemberton or sites in northern WA. Research projects will be aligned with current water resource management challenges and the outcomes will be used to inform robust water management decisions.

Project:	**Hydrogeological controls on water quality in remote communities**
For majors including:	Hydrogeology
Supervisors:	Sarah Bourke sarah.bourke@uwa.edu.au
Description:	Communities in rural and remote Australia commonly rely on groundwater for their potable water supply. The potential for adverse health impacts due to poor water quality in remote areas is a current focus of concern for some communities. However, to date there has not been a systematic assessment of water quality in remote communities. The student will collate and interpret existing data from remote communities across Western Australia. Where data gaps are identified additional data collection may be possible. Based on these data the relationships between any water quality issues and the hydrogeology of the source aquifer(s) will be elucidated.

Project :	**Geological structures as controls on groundwater flow in southwest WA**
Majors, Masters	Hydrogeology, Geoscience
Supervisor :	Sarah Bourke (sarah.bourke@uwa.edu.au), Department of Water and Environmental Regulation (DWER) personnel
Description :	Geological structures are a key control on groundwater flow paths and residence times. Robust management of groundwater resources therefore requires an understanding of the presence of faults and folds and their influence on groundwater flow. Research project opportunities are available to work on existing data sets held by DWER to refine our understanding of geological structures in south-west WA. Research will involve the re-interpretation of drill logs, water levels, environmental tracer data and geophysical data sets to refine our understanding of subsurface geological structures and their influence on groundwater flow. Project outcomes will be directly related to current groundwater management issues and will inform robust water resource management decisions.

Project	**Identifying groundwater inflow sources to Gingin Brook**
Majors or Masters:	Hydrogeology
Supervisor:	Jim McCallum (james.mcallum@uwa.edu.au) , Adam Green, Sheryl Ryan (DWER)
Description:	Groundwater and surface water are a joint resource. Understanding the role groundwater plays in sustaining streamflow is essential for the effective management of water resources. Groundwater plays a role in sustaining stream ecosystems, but is also an important resource for human consumption and agriculture. Balancing these two objectives requires high-quality scientific studies. In this project the contribution of groundwater to

	specific reaches of Gingin Brook will be determined using an existing data set. The student will interpret the data to determine which aquifers contribute to Gingin Brook. The aim of the project is to both assess the sources of groundwater, the uncertainty of these sources at discrete locations along Gingin Brook, and how this has changed with time.

Project:	**Assessing fault flow properties using temperature**
Majors or Masters:	Hydrogeology
Supervisor:	Jim McCallum (james.mcallum@uwa.edu.au, JP Pigois, Steve Clohessy (DWER)
Description:	Conceptually, faults can behave as conduits or barriers to groundwater flow. These different conceptual models may significantly impact how aquifers can be utilised. The Badaminna Fault in the Perth Basin causes the two main confined aquifers in the basin (Leederville and Yarragadee) to be juxtaposed. The different fault behaviours (barrier or conduit) could result in significant differences in how the aquifers respond to management strategies. In this project, the student will utilise temperature profiles to assess the movement of water around the Badaminna fault. This data will be utilised to help identify the flow properties of the fault.

Project :	**Hydrogeologic modelling in a changing climate, and an uncertain world**
Majors including :	Hydrogeology
Supervisor :	Adam Siade (adam.siade@uwa.edu.au)
	An important objective of hydrogeological modelling is to make predictions about how aquifer systems respond to anthropogenic influences. Such predictions are predicated on knowledge of aquifer properties, model construction, and future climate evolution, which are often unknown or highly uncertain. For example, the ability for a particular groundwater model to predict the drawdown in a sensitive wetland could be highly uncertain for a number of reasons. Therefore, quantifying this “predictive uncertainty” is paramount for understanding how the natural environment will respond to future anthropogenic influences such as groundwater pumping. Furthermore, reducing this uncertainty can dramatically improve our ability to develop low-risk groundwater management solutions. This project will focus on advanced methods of numerical groundwater modelling, along with the quantification of uncertainty associated with model predictions throughout the Perth region and beyond. Students will gain experience working with the Perth Regional Aquifer Management (PRAMS) modeling framework using the PEST and PEST++ software suites. Analyses may include data-worth, Null-Space monte Carlo, Ensemble Kalman Smoother, etc. Students should have some prior experience with linear algebra and statistics.

Project :	**Quantifying recharge rates using groundwater modelling**
Majors including :	Hydrogeology
Supervisor :	Adam Siade (adam.siade@uwa.edu.au)
Description :	Groundwater models play an important role in water resource management. For example, managers often rely on groundwater model predictions to support/inform important management decisions. Therefore, accurate simulation of key processes, e.g., recharge mechanisms, is critical in order to make reliable predictions. It is also important to consider the spatial and temporal scale of the predictions, as certain processes may or may not be important at different scales. This project will focus on the conceptualization of the processes affecting net recharge rates, and their implementation within a regional-scale groundwater model of the Perth region. Topics could include how the water table elevation affects actual evapotranspiration (AET) rates, estimating AET rates with remote sensing data, addressing flow through the unsaturated zone, how land-use affects net recharge, etc. Students will gain experience working with the Perth Regional Aquifer Management (PRAMS) modeling framework, the primary management tool for groundwater in the Gnangara area. Students will also work alongside the CSIRO scientists tasked with developing new software for simulating net recharge in PRAMS.

Project	**Electrokinetic In Situ Leaching: Towards a greener mining future**
Majors or Masters:	Hydrogeology, Geochemistry
Supervisor:	Henning Prommer (henning.prommer@csiro.au), James Jamieson (james.jamieson@research.uwa.edu.au) and Andy Fourie (Andy.Fourie@uwa.edu.au)
Description:	Electrokinetic In Situ Leaching (EK-ISL) is a novel mining technique that is currently developed. It expands the application of conventional in situ leaching (ISL) to ore deposits that would otherwise be unsuitable due to unfavourable ore characteristics such as low hydraulic permeability. EK-ISL relies on establishing electric fields across ore bodies. It uses those to induce the migration of specific chemical solutions (lixiviants) from a source towards a target reservoir. During its subsurface passage the lixiviant dissolves specific minerals and facilitates the transport of selected metals towards the target reservoir. The in-principle feasibility of this technology has been successfully proven for copper and gold through small-scale experiments. However, the mechanisms that control mineral efficiencies are still poorly understood as well as key parameters that determine the electromigration process. This project aims to better define the key processes and necessary geochemical conditions that allow to maximise mineral recovery rates. Several different thesis projects will be available. Multiple experimental studies will be conducted to explore (i) the application of EK-ISL to a wider range of metals (ii) to explore the application of alternative lixiviants and (iii) to identify the physical and chemical processes that control recovery rates.

Project:	**Groundwater quality dynamics near wastewater infiltration sites**
Majors or Masters:	Hydrogeology
Supervisor:	Henning Prommer (henning.prommer@csiro.au), Clive Hampton (Water Corporation)
Description:	Treated wastewater is increasingly recognised as a valuable resource to supplement existing water supplies. However, specifically in areas where there are important environmental receptors, it is important to understand the response in both groundwater dynamics and groundwater quality to the long-term infiltration of treated wastewater. In this project a portfolio of numerical modelling approaches, i.e., flow, solute transport and reactive transport modelling will be used to (i) accurately delineate the flow path of the infiltrated wastewater using a range of wastewater indicator substances (such as trace organics) and (ii) determine the fate of nutrients and other reactive species within the studied aquifer system. The modelling results will be used to determine the importance and critical factors controlling the physical and biogeochemical attenuation mechanisms in the aquifer systems targeted by wastewater infiltration. Numerical modelling will be undertaken in comparison with previously collected hydrochemical data. The project will assist with clarifying the suitability of each investigated wastewater indicator with respect to constraining the flow and solute transport behaviour at the selected study sites.

Project:	**Modelling the fate of PFAS at selected DoD sites**
Majors or Masters:	Hydrogeology
Supervisor:	Henning Prommer, henning.prommer@uwa.edu.au, Greg Davis (CSIRO)
Description:	Perfluoroalkyl substances (PFASs) contained within aqueous film forming foams (AFFF) have been historically used by the Australian Department of Defence (DoD) in firefighting training from 1970s until the mid-2000s. PFAS compounds in AFFF are emerging contaminants of increasing concern given they are highly persistent, bio-accumulative and potentially toxic to humans and the environment. Understanding the PFAS transport and attenuation behaviour within groundwater systems is an important prerequisite for determining the risks of human exposure and in selecting suitable remediation strategies at sites where an elevated risk is identified. In this project numerical groundwater flow and solute/reactive transport modelling will be used to interpret groundwater quality data from PFAS-affected aquifers with the aim of improving the conceptualisation of the contaminated sites and to quantify contaminant concentrations and mass fluxes. After completion of the model development and calibration stage predictive simulations might be performed to assess remediation time-scales for a range of plume management options.

Project	**Numerical modelling of dipole flow (localised groundwater pumping and reinjection) for a localised groundwater desalination system**
Majors or Masters:	Hydrogeology
Supervisor:	Henning Prommer henning.prommer@uwa.edu.au, Chris Barber, C2 Water
Description:	Decreased rainfall over the last few decades has given rise to increased water stress in agriculture and for water supply generally in Australia and overseas, and there is increased interest in providing local water supplies through desalination of brackish and saline groundwater, using distributed small-scale treatment plants near point-of-use. There is a need to predict impacts of groundwater pumping for treatment and for aquifer reinjection of residual brines (concentrates) produced by the desalination plant. Simultaneous localised pumping of groundwater and reinjection of brines can give rise to dipole flow within the aquifer, where brine return flows increase salinity of feed groundwater for the treatment plant. The latter needs to be minimised to give a constant feed groundwater salinity for optimum treatment. The impacts of brine returns on groundwater quality also need to be assessed, taking account of higher density of these relative to that of ambient groundwater. Based on earlier preliminary results, a more detailed study is now required, based on 3-D modelling of density-dependent flow and transport simulations for a treatment systems producing up to 100,000 L/day of high quality water. Field data for operating sites in WA will be used for model calibration and validation.

Project:	**Remediation of nitrate contamination of groundwater using desalination for local water supply**
Majors or Masters:	Hydrogeology Geochemistry
Supervisor:	Henning Prommer henning.prommer@uwa.edu.au; Chris Barber, C2Water
Description:	Contamination of groundwater by nitrate is common from high use of nitrogenous fertilisers in urban and agricultural areas, from sewage effluent discharge and also from natural accumulation in soils and groundwater in arid regions of Australia and elsewhere. There is consequently a need to remove nitrate for potable water supply. Often the widespread occurrence of contamination makes this difficult. Reverse Osmosis (RO) desalination can remove nitrate from water to below the drinking water standard, where significant amounts of nitrate are rejected by the RO membrane and these remain in residual brines (concentrates) from the RO process, leaving high quality water (permeate) with lower nitrate levels. Reinjection of concentrates back into groundwater can lead to natural denitrification where redox conditions are suitable for this. Alternatively, an appropriate carbon source can be added which promotes in situ denitrification without affecting overall groundwater quality. A better understanding of the efficiencies of RO treatment for removal of nitrate and for natural or amendment-assisted denitrification in groundwater is required, through pilot-scale investigation of the processes and geochemical and/or reactive transport modelling.

Project:	**New approaches to 3D geological modelling- Case study of the Ashburton Basin, Western Australia**
Majors including:	Geology, Geoscience, Physics, Engineering, Computer Science
Supervisor:	Mark Jessell mark.jessell@uwa.edu.au 6488 5803 and Mark Lindsay
Description:	This project will compare two approaches to building 3D geological models of deformed terrains. The aim of the project is to characterise the outcomes of traditional 3D modelling approaches with a new system that extracts the necessary input data directly from digital maps and databases. The test area will be the Ashburton Basin, an arcuate belt of Paleoproterozoic sedimentary and volcanic rocks which forms the northern margin of the Capricorn Orogen, a major orogenic zone between the Pilbara and Yilgarn Cratons. This project would be suitable for students with an interest in 3D geological modelling and GIS. Programming experience would be a benefit, but is not essential.

Project:	**Topological uncertainty in 3D geology**
Majors including:	Geology, Geoscience, Physics, Engineering, Computer Science
Supervisor:	Mark Jessell mark.jessell@uwa.edu.au 6488 5803 and Mark Lindsay
Description:	The geometry of geological models has long been recognised to be an important constraint on the validity of forward process modelling and geophysical inversions, however in many instances the topology of the model is as important if not more so, especially in situations where the continuity of lithologies, or the connectivity of structures controls the outcome, such as in fluid flow or some types of electrical measurements. This project will examine methods to characterise the 3D topology of geological models as a pathway to classifying end-member models that can be used in geophysical inversion schemes. This project is supported by the WA government-funded WA_In3D project, and the scope is compatible for continuation to Masters or PhD level. Computer experience and some maths are required.

Project:	**Geophysical and geological analysis of Monte Carlo-generated collections of structural models**
Majors including:	Geophysics, Geology, Physics, Engineering, Computer Science
Supervisor:	Jeremie Giraud (jeremie.giraud@uwa.edu.au) and Guillaume Pirot (guillaume.pirot@uwa.edu.au) and/or Mark Lindsay and/or Mark Jessell
Description:	The characterization of subsurface properties from geological and geophysical data is challenging because this kind of problem admits numerous possible solutions. To reduce the various risks faced in the

	exploration of natural resources and achieve successful exploration, it becomes critical to identify plausible candidate models. This project will focus on the analysis of a collection of nearly 10,000 structural geological models from two areas in Australia. These models where generated by Monte Carlo sampling of the geological measurements defining the structures observed in the area and all fit the geological measurements within prescribed uncertainty levels. The analysis will be carried out in a quantitative, systematic way from the geophysical and geological point of views. Avenues to be explored comprise geophysical evaluation of the models (gravity and magnetic field responses) together with geological uncertainty, topological variability, image analysis and data science techniques (when applicable). This project is supported by the MinEx CRC industry and public consortium project 6 (https://minexcrc.com.au/program-two-data-from-drilling/project-6-automated-3d-modelling/). This project is be suitable for students with an interest in 3D modelling and statistics. The scope is compatible with a 36 pt Master of Science project.

Project:	**Numerical modelling of basins and synthetic gravity modelling**
Majors or Masters:	Geoscience, Geology, Computer science
Supervisor:	Weronika Gorczyk, weronika.gorczyk@uwa.edu.au, 6488 1516
Description:	Numerical modelling of basin evolution is a great way to understand the processes of basin development. The models generate a full suite of physical properties of evolving crust (e.g. density), which then can be expressed through geophysical inversion tools that are applied to geophysical data sets obtained in the field. Projects are available to apply new technologies to numerical modelling and gravity inversion problems. Work will be completed making full use of Pawsey Centre supercomputer infrastructure and will involve testing new codes, assessing performance and helping to further develop the approach. Software is designed to be used by non-specialists, however, computing experience and reasonable maths ability are desirable.