Project 1:
3D 3C laboratory experiments using laser interferometer to study body and surface waves in anisotropic materials

Co-Supervisors: A/Prof A Bona, A/Prof M Lebedev, A/Prof R Pevzner

Background:
The polarisation of seismic waves is dependent on the elastic properties of the material in which the waves propagate. What can we infer about the properties from the polarisations?

Scope:
To measure the three components (3C) of surface displacements at different points in a grid pattern for different source locations and anisotropy properties of the material. The displacements will be measured by unique Doppler laser interferometer. The materials under study will be transversely isotropic (layered) with two orientations of the layering: parallel and perpendicular to the recording surface. The source of waves will be an S-wave ultrasonic transducer placed both on the recording surface and on the opposite surface to the recording surface.

Desired skills:
Basic MATLAB programming, interest in laboratory work.

Project 2:
Modelling of 3D hard rock environment for seismic interpretation studies

Supervisor: Dr A Squelch
Co-Supervisors: A/Prof M Urosevic, Dr M Madadi, Mr A Dzunic

Background:
The interpretation of seismic data obtained from the complex geological environments applicable to hard rock mineral exploration is notoriously difficult. These difficulties stem from not having a representative and accurate velocity model during the seismic processing and migration stages, and from not being able to interpret the reflection patterns resulting from the interaction between various geological features and structures.

In addition, the ability of the non-geophysics community to interpret and understand the final migrated seismic data is very limited. This could perhaps be addressed by means of exemplar processed 3D seismic data cubes and the associated visualised unambiguous interpretations of the specific feature(s). These models and their interpretations can also be used as teaching aids in various lecture and outreach programs.

Therefore, it is proposed that 3D velocity models are generated for a variety of individual and combinations of hard rock geological structures and features such that the resulting seismic reflection images and cubes can be simulated, visualised and interpretation cues identified.

Scope:
Develop 3D velocity models suitable for numerical simulation to generate synthetic 3D seismic survey data representing mineral exploration hard rock environments (HRE) applicable to DETCRC. Forward model (using FD code), process and migrate synthetic seismic data to produce 3D seismic cubes for visualisation and interpretation studies and teaching or education outreach demonstrations of seismic interpretation and associated geology. Some interpretation techniques can also be applied to illustrate the process.

This project is undertaken within the scope of and supported by DETCRC Project 3.1: 3D Seismic Exploration for Hard Rock Environments.

Desired skills:
Seismic forward modelling, seismic processing, some basic programming skills, and running programs on a supercomputer.
Project 3:
Forward modelling evaluation of a 3D velocity model extrapolated from a borehole in a hard rock environment
Supervisor: Dr A Squelch
Co-Supervisors: A/Prof M Urosevic, Dr M Madadi, Mr A Dzunic

Background:
The migration of seismic data to generate a final result that is amenable to meaningful geological interpretation requires a representative and accurate velocity model. Traditionally in oil & gas seismic processing this is achieved by means of a relatively simple 2D “layered cake” model.

In the case of hard rock mineral exploration surveys this is difficult to achieve and represent in such a simple fashion due to the complex 3D geological environment that exists. The situation can be addressed by building 3D velocity models using data from sonic logs or VSPs carried out in boreholes within the survey area. However, in many cases suitable boreholes (and logs) do not exist at the time of carrying out the seismic survey (one purpose of the survey being to plan the location of the exploration boreholes!).

One possible approach is to use whatever borehole or other geological information is available to correlate reflection horizons in an initially processed seismic time cube with specific geological interfaces and to generate virtual (or synthetic) velocity columns on a grid covering the survey area. Ideally, the rock properties (and any variation with depth) of the major geological units are known and used when assigning velocity values to these virtual velocity columns. These virtual velocity columns are then used to construct a 3D velocity model that is used in the processing of the seismic survey data – with the intention of producing a more accurate migrated seismic cube.

Scope:
It is proposed that a couple of idealised hard rock environment (HRE) geological models are forward modelled to generate synthetic seismic cubes applicable to DETCRC. A synthetic sonic log is then created to represent the velocity column equivalent to a borehole position at the centre of the cube and eight other virtual velocity columns are generated on a grid across the cube following the approach developed by Alicia York in her 2011 Honours project. These velocity columns are then used to generate the 3D velocity model for the seismic processing and migration of the forward modelled data. The success of this approach in reproducing the original input geology model can then be assessed and quantified.

This project is undertaken within the scope of and supported by DETCRC Project 3.1: 3D Seismic Exploration for Hard Rock Environments.

Desired skills:
Seismic forward modelling, seismic processing, some basic programming skills, and running programs on a supercomputer.

Reference:

Project 4:
The nature of ambient noise and its affect on the use of arrays for land seismic acquisition
Co-Supervisors: Dr J C Dupuis and Dr T Dean

Background:
The improvement in signal-to-ambient-noise levels from the use of arrays in land seismic acquisition is typically thought to be proportional the square root of the number of geophones in the array. This assumption is, however, reliant on the idea that the noise being recorded by each geophone is independent of the noise...
being recorded by the surrounding geophones.

The limited number of experiments that have been conducted into the relationship between noise recorded by adjacent geophones indicates that the correlation between geophones drops very rapidly with separation (to around 0.5 in less than 2 m). These experiments have, however, been conducted in flat, dry, featureless terrains. It is likely that the presence of vegetation would increase noise levels (particularly on more windy days).

**Project Objectives:**
The objectives of the project are:
- Determine how the correlation between noise traces varies with different terrains, burying techniques, surface conditions, and wind speed.
- Determine the noise level for seismic recordings, i.e. the noise floor, for different survey conditions.

** Procedure:**
Conduct a brief literature review of (the few) available studies.
Plan a test survey that uses a small network of geophones to satisfy the above objectives.
Acquire the field data.
Analyse the new data, and existing data, to satisfy the objectives of the project.

**Project 5:**
**Joint applications of EM and Seismic methods for minerals exploration**
Supervisors: Dr B Harris, A/Prof M Urosevic

Application of 3D seismic is increasingly common in mineral exploration and mine development. The same volume of rock is usually also covered by EM surveys. The project will focus on establishing the synergies between EM and 3D seismic for mineral exploration and mine development at one or more field sites.

**Project 6:**
**Seismic methods and the hydraulics of sediments**
Supervisor: Dr B Harris

Finding a link between sediment hydraulics and parameters resolved by a seismic reflection survey an important and elusive goal. The link may be indirect, or specific processing may be required to recover the correct information from seismic data sets. Field examples where the sediment hydraulics is well known will be used investigate the link between hydraulic parameters and seismic reflection data (i.e. FWF sonic, VSP and 2D/3D seismic).

**Project 7:**
**Time lapse radar for analysis of rainfall recharge**
Supervisor: Dr B Harris
Associate Supervisors: A/Prof R Pevzner (tentative), Mr E Strobach

The possibility of using radar for time lapse analysis of the way that rainfall recharges groundwater systems exists. The student will investigate existing and new data sets that address this topic.
**Project 8:**
**Finite element analysis of a micro-mechanical model for coal**
Supervisors: Dr Mahyar Madadi, Dr Mark Lwin

**Scope:**
The emergence of the coal seam gas industry has sparked interest in the development of a rock physics model for coal. Coal is different from “traditional” reservoir rock because of a large interaction (adsorption) between pore fluids and its internal surface area. This causes significant swelling of the bulk and shrinkage of pores, even under constant stress. Our goal is to develop the means of linking the amount of fluid adsorbed within coal to seismic attributes that are sensitive to such behavior. To do this the student will use finite element modeling to apply a new poro-elastic theory incorporating the effects of adsorption to different pore geometries. The results will be compared with experimental data obtained by others.

**Skills:**
Interest in rock physics (enrolment in “rock physics course”), Interest in numerical methods. Matlab experience.

**Project 9:**
**Reconciliation of laboratory data to log response of coal seams**
Supervisor: Dr Mark Lwin

**Scope:**
The use of fluid substitution to reconcile laboratory data to log response is a vital step initial step in the workflow for quantitative interpretation. Though standard practice in the petroleum industry it is yet to be applied to coal seam gas. In this project the student will use laboratory data (including fluid content) and rock physics models to attempt to forward model coal seam logs. Through comparison with real logs the goal will be to shine light on the shortcomings of current methodologies applied to this new area of interest.

**Skills:**
Programming skills in Matlab, Knowledge of Hampson Russell or RocDoc (desirable). Interest in rock physics (enrolment in “rock physics course”).

**Project 10:**
**Draggable land seismic array**
Supervisor: Dr J. Christian Dupuis
Associate Supervisor: Assoc Professor Anton Kepic

**Background:**
Seismic methods can provide important structural information for the efficient and economic development of mining infrastructure. It is not routinely used in the mining industry because of its cost. A significant portion of the cost is associated with the personnel needed for the setup of the field acquisition equipment. Thus, the development of draggable seismic arrays would enable a broader use of seismic techniques to unconventional prospects and geotechnical projects.

**Scope:**
The work by Dimech (2010) has demonstrated that, for typical Australian ground conditions, the amplitude and phase response of plated geophones compare very well to traditional spiked geophones. The new phase of this project will be to refine the design of the sensors built by Mohammed-Nour (2011) and build a 24 channel array for trial in the outback.

**Desired skills:**
The student that will undertake this project will require a good understanding of electrical circuits and have a potential to innovate. The student should also be willing to learn to draw mechanical and electrical assemblies and schematics using CAD software.
Project 11:  
*Sonar fault detection*

Supervisor: Dr J. Christian Dupuis  
Associate Supervisor: Assoc Professor Maxim Lebedev

**Background:**  
Faults and unstable ground encountered during drilling can cause significant delays in the drilling program. Exploration boreholes are the most susceptible to being lost to drilling since the hazards in the region may not be well understood. The aim of this project is to develop a tool that will enable drillers to detect unstable ground before they encounter the hazard.

**Scope:**  
This project will conduct a feasibility study on ultrasonic detection of faults ahead of the drill string. This will involve selecting appropriate transducers and determining a transducer configuration that enables fault detection at distances greater than 3 meters.

**Desired skills:**  
The student that will undertake this project will require a good understanding of electrical circuits and have a potential to innovate. The student should also be willing to learn to draw mechanical and electrical assemblies and schematics using CAD software.