POSTER ABSTRACTS

SECTION 4

LIST OF POSTERS

All the posters will be displayed for three days: the whole of Monday, Tuesday and Wednesday.

The roster for when the presenters will be available to talk about their posters will be available at the Convention.

No.	Name	Organisation	Paper Title
1	Kirsty Beckett	Curtin University of Technology, CRC LEME	Inferring Soil Chemical and Physical Mobility Using 256-Channel NAI Radiometric Data
2	Andrej Bona	Curtin University of Technology	Obtaining Symmetry Class of Elasticity Tensor in Arbitrary Orientation
3	Miroslav Brajanovski	Curtin University of Technology	Huge Wave Attenuation in Partially Saturated Fractured Reservoirs
4	Astrid Carlton	Geological Survey of NSW	Possible Diatremes, Hay Region, NSW
5	John Cassidy	The University of Auckland	The Northland Basin, New Zealand: Analysis of Gravity and Magnetic Data
6	Carlos Cevallos	NSW Department of Primary Industries	Geophysical Interpretation of the Braidwood Granodiorite on the Braidwood 1 : 100 000 Sheet Area
7	Kalyan Chakraborty	Wafra Joint Operations Company	Improved Seismic Data Processing and Interpretation for Strati-Structural Petroleum Plays in the North of Al-Khafji Area, Middle-East
8	Richard Chopping	Geoscience Australia	Relationship between Physical Properties and Alteration at the St Ives Gold Mine, Western Australia
9	Branko Corner	Remote Exploration Services Pty Ltd	Radon Emanometry in Uranium Exploration using Activated Charcoal: Namibian Case Studies
10	Marina Costelloe	Geoscience Australia	Paterson Airborne Electromagnetic Survey, Onshore Energy and Minerals, Geoscience Australia
11	Tania Dhu	Mineral & Energy Resources, PIRSA	Detailed Radiometric Surveying at Radium Hill, South Australia
12	Bruce Dickson	Dickson Research Pty Ltd	Denoising Aerial Gamma-Ray Survey Data With Non-Linear Dimensionality Reduction
13	Daniel Gray	Mineral & Energy Resources, PIRSA	New South Australian Geophysical Data – Pace Northern G2 Gravity Survey
14	Jonathan Griffin	Geoscience Australia	Correlations Between Earth's Magnetic Field and Climate: The use of Continuous Wavelet Transforms
15	Marcos Grochau	Curtin University of Technology	Core Damage: Can we calibrate Pressure Response with Lab Data?
16	Boris Gurevich	Curtin University of Technology & CSIRO Petroleum	Long Offset Effects in Isotropic and Anisotropic AVO: Experiment Versus Theory
17	Rosemary Hegarty	Geological Survey of NSW	Geophysical-Geological Interpretation of the Cobham Lake and Milparinka 1 : 250 000 Map Sheet Areas, Northwest NSW
18	Baohua Huang	Interpretation Centre of Daqing Well Logging Company	Applications of Cross-Dipole Acoustic Logging for Formation Fracture and Anisotrpic Identifications
19	Hak Soo Hwang	Korea Institute of Geoscience & Mineral Resources	Detection of Sea Water Intrusion caused by using Tidal Action Geophysical Methods
20	Andy Kass	Colorado School of Mines	Efficient Terrain Correction in Airborne and Seaborne Gravity Gradiometry Surveys

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No.	Name	Organisation	Paper Title
21	Richard Kempton	CSIRO Petroleum, ARRC	Calibrated Prediction of Hydrocarbon Fluid Type in Frontier Basins of Australia
22	Kathleen McMahon	Macquarie University	Seismic Reflections from Pycnoclines in the Water Column beneath an Ice Shelf
23	Adrian Merry	Helix RDS	Case History: Arbroath: An Integrated Petrophysical and Seismic Elastic Inversion Process for De-Risking Infill Drilling Targets in a Mature North Sea Oilfield
24	Peter Milligan	Geoscience Australia	Completing the Spectrum of the Australian Digital Magnetic Anomaly Map
25	Bezad Nazari	Oil Exploration Operations Company	Study of the Ghom Hydrocarbon Formation in the Central Iran by using Geophysical Methods
26	Yeong-Sue Park	Korea Inst. Of Geoscience & Mineral Resources	Cavity Mapping and Grout Monitoring: A Microgravity Case History in Korea
27	Peter Petkovic	Geoscience Australia	Preliminary Results from GA302 Over Capel and Faust Basins
28	Murray Richardson	Geoscience Australia	Levelling the National Gamma-Ray Spectrometric Radioelement Database
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30	Andrew Ross	CSIRO Petroleum	Emerging Sensing Technologies for Hydrocarbons and Their Potential use as Exploration Devices
31	Phillip Schmidt	CSIRO Exploration & Mining	Magnetic Anomaly of the Bramfield Iron Formation, South Australia
32	Syed Shabih	LMKR	Understanding the Effect of Stresses on the Productivity of Lower Goru Formation through Rock Physics and Rheological Studies in the Sawan Gas Field – Southern Pakistan
33	Mehrdad Soleimani-Monfared	Shahrood University of Technology	Common Reflection Surface Stack, New Method in Seismic Reflection Data Processing: A Synthetic Data Example
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35	Ken Witherly	Condor Consulting Inc	Modelling of VTEM EM Results over a Base-Precious Metals Target, Western Australia
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37	Valeriya Zadorazhnaya	Council for Geosciences	Fractal Model of Rocks – A Useful Model for the Calculation of Petophysical Parameters
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INFERRING SOIL CHEMICAL AND PHYSICAL MOBILITY USING 256-CHANNEL NAI RADIOMETRIC DATA

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The ^{228}Ac gamma ray decay emission at ~900 keV from the thorium-232 decay series is produced approximately 1.9 years (half-life) before the formation of ^{208}Tl and the 2614 keV (standard thorium) gamma ray decay emission. Because the difference between the daughter products is relatively small, it has been assumed that the two decay energies are in equilibrium. However, when ^{228}Ac gamma ray energy at ~900 keV was isolated from standard 256-channel, high resolution radiometric data using a multispectral processing technique, a difference in the spatial distribution of the ^{228}Ac ~900 keV and ^{208}Tl 2614 keV was observed. This case study describes how the difference between the ^{228}Ac ~900 keV and ^{208}Tl 2614 keV was resolved, and considers how the spatial differences may be used to infer and monitor soil chemical and physical mobility and identify potential radiometric disequilibrium conditions.

OBTAINING SYMMETRY CLASS OF ELASTICITY TENSOR IN ARBITRARY ORIENTATION

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We identify the symmetry of a Hookean continuum and obtain its elastic properties without prior information about the orientations of its symmetry planes or symmetry axes. To do so, we use invariant properties of eigenspaces. Also, we use the strain energy as a measure of difference between a given continuum and any symmetry class to classify any Hookean solid by its symmetry class, taking into account measurements errors.

HUGE WAVE ATTENUATION IN PARTIALLY SATURATED FRACTURED RESERVOIRS

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A conceptually simple superposition model is presented for dispersion and attenuation of compressional waves in fractured porous rocks that are saturated by a mixture of liquid and gas. These two different types of heterogeneities are described by four parameters: the fracture spacing (fracture density) and fracture weakness characterising the fractured medium; the correlation length and degree of saturation characterising the fluid patches that are embedded between the fractures. All four controlling parameters have a clear physical meaning and can be potentially constrained if there is additional information like well-log data. This model is employed to explain the relatively strong *P*-wave velocity dispersion found for a limestone reservoir. The mechanism of wave-induced flow may well explain large *P*-wave dispersion and attenuation in heterogeneous porous media.

POSSIBLE DIATREMES, HAY REGION, NSW

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The *New Frontiers* exploration initiative of the NSW government has implemented the analysis of regional geophysical datasets for the Ana Branch, Pooncarie, Booligal, Balranald, Hay and Deniliquin 1 : 250 000 map sheet areas. The aspiration is to encourage exploration in regional areas by extrapolating the geology beneath covered areas using regional aeromagnetic, gravity, radiometric, Landsat, seismic and borehole stratigraphy datasets.

The Hay 1 : 250 000 map sheet area is the first to be interpreted over the Murray Basin, and was interpreted using TMI and 1VD aeromagnetic data. Outcomes of this interpretation are:

- Diatremes (or volcanic plugs) intrude the basement unit. The cover over modelled diatremes ranges from 300 to 500 m in thickness and no drilling has been conducted to investigate anomalies. Similar clusters of interest are seen in the Balranald 1 : 250 000 map sheet area.
- Silurian–Devonian granodiorite basement ranging from 300 to 700 m deep and contains many NNW–SSE trending dykes.
- Structurally intriguing elongated granites with metamorphic aureoles occur in the south west.
- 300–700 m of poorly consolidated fluvial/alluvial sands, including the Pliocene Loxton–Parilla Sands, contain economic heavy minerals placers. Many are magnetically detectable and clearly visible in the Balranald sheet area with one magnetic strandline occurring within the Hay sheet area.

This study is expected to increase exploration interest in the diatremes in the relatively unexplored Hay region.

THE NORTHLAND BASIN, NEW ZEALAND: ANALYSIS OF GRAVITY AND MAGNETIC DATA

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The offshore Northland Basin, New Zealand, is the northern extension of the petroleum-producing Taranaki Basin. The basin has a complex history involving Mid- to Late-Cretaceous rifting, associated with the separation of the New Zealand micro-continent from the Australian/Antarctic plate, and early-Miocene thrusting and calc-alkaline volcanism, associated with the onset of plate convergence. 2D seismic reflection data show that a sequence of Cretaceous to Recent sedimentary rocks up to 3–4 km thick occurs within the main depocentres. Gravity and magnetic data from the basin are complex and reflect the distribution of basement and volcanic rocks in the basin. Significant positive gravity anomalies, typically sub-circular, are associated with Miocene volcanics, whose upper surfaces are often evident in the

seismic reflection data but whose overall geometries are poorly imaged. More linear, but less pronounced, gravity highs are attributable to up-thrown basement ridges whilst strong gravity lows mark the main depocentres. Strong magnetic anomalies are a characteristic feature of the basin and similarly mark the locations of the Miocene-Pliocene volcanics. In the northern part of the basin especially, more linear magnetic anomalies appear to be associated with structural units in the basement, however the nature of basement rocks in the region is poorly known. Gravity and magnetic data can therefore play a critical role in resolving some important features of basin development.

GEOPHYSICAL INTERPRETATION OF THE BRAIDWOOD GRANODIORITE ON THE BRAIDWOOD 1 : 100 000 SHEET AREA

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Interpretation based on the Total Magnetic Intensity (TMI), gravity, radiometric and digital elevation data acquired as a part of the *Exploration NSW* initiative, focused on the northern part of the Braidwood Granodiorite and its extension to the north of the Shoalhaven River. The use of image processing Sobel filters on the TMI gridded data enhance characteristics such as faults and regional stress fields that would otherwise be very difficult to observe.

Compared to other granites, the Braidwood Granodiorite is unusually magnetic. Palaeomagnetic studies are being conducted along with petrographic work to determine whether the magnetite in the granite is a primary magmatic mineral or the result of secondary alteration.

The Dargues Reef gold deposit lies within the southern part of the Braidwood Granodiorite. It is a member of the intrusion-related gold deposit class that includes Timbarra in NSW and Kidston and Red Dome in Queensland. These four deposits are associated with potassic, oxidised I-type granites that contrast with other overseas intrusion-related gold examples (e.g. Alaska–Yukon), which are reduced and non-magnetic.

IMPROVED SEISMIC DATA PROCESSING AND INTERPRETATION FOR STRATI-STRUCTURAL PETROLEUM PLAYS IN THE NORTH OF AL-KHAFJI AREA, MIDDLE-EAST

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Seismic data with appropriate processing tools, often come to the rescue of interpretation, minimising the ambiguities involved in analysing complex geological situations. Stratigraphic features associated with structure, play critical role in hydrocarbon entrapment within the Middle-Late Cretaceous reservoirs in the Al-Khafji offshore area. A total of 61 km^2 high resolution 3D OBC seismic data were acquired in the North Khafji area, with objectives to explore strati-structural traps and their associated reservoir settings. New petroleum plays are intended to be explored after integrating new 3D seismic vintage with older Al-Khafji seismic data interpretation.

The present study is aimed at comparing seismic datasets that are processed by different companies. Authors examine and identify the relative merits of data attributes that are suitable for structural and strati-structural traps interpretation. The initial interpretation done during 1997, reports a possible carbonate build-up, correlating to the Gudair formation, which is equivalent to a horizon associated with Aruma-Wasia unconformity. A comparative study made between Khafji and north of Khafji main field could not conclusively establish the extension of this carbonate build-up in the North-Khafji area, because of ambiguous nature of structural and stratigraphic anomalies. At places, there is inconsistency among scales of these datasets. However, based on the interpretation of the newly processed seismic data, seismic structure and attributes have been integrated and reinterpreted for scalable anomalies. The present study strongly suggests an exploration potential in the North-Khafji area and recommends pursuing further geological studies, detailing these seismic anomalies and converting them into commercial petroleum plays in the offshore basin.

RELATIONSHIP BETWEEN PHYSICAL PROPERTIES AND ALTERATION AT THE ST IVES GOLD MINE, WESTERN AUSTRALIA

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I use a simple rock physics model, based on linear combinations of the properties of unaltered and altered rocks, to predict the physical properties of altered rocks at the St Ives Gold Mine, WA. Previous studies of mineral systems demonstrated that alteration can produce physical property contrasts with respect to unaltered host rocks and thus produce geophysical signatures in various datasets such as gravity, magnetics and seismic.

When viewed on a scatter plot, the majority of samples at St Ives are within a limited field, representing the properties of unaltered host rocks. Samples plotting outside this field are inferred to be altered. As host rocks have a restricted range of physical properties, there are a range of paths (alteration trajectories) which altered samples can follow on bivariate plots. These trajectories define a cone shaped field, the alteration cone. The open end of the cone encompasses the expected physical properties of unaltered samples, and the focus of the cone lies on the physical properties of the alteration assemblage. Samples plotting inside an alteration cone are inferred to result from alteration of a host lithology and contain some proportion of that alteration assemblage. The distance a sample occurs along the cone is proportional to the amount of alteration the sample has undergone.

This model accounts for the physical properties of samples which are known to be altered, by comparison with HyLogger core logging results and the St Ives drillhole database. This model can also be used to predict alteration within other datasets, e.g. gravity–magnetic inversion results.

RADON EMANOMETRY IN URANIUM EXPLORATION USING ACTIVATED CHARCOAL: NAMIBIAN CASE STUDIES

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In this study the implementation and refinement of the Radon-on-Activated-Charcoal (ROAC) technique, developed by the South African Atomic Energy Corporation in the 1970s, is discussed. Case study results are presented from two areas in Namibia.

Radon, contained in ground air, migrates to surface as a result of the pumping action of diurnal pressure variations. It is adsorbed onto activated charcoal contained in a cartridge, fitted into the base of an inverted cup and buried in the ground. The technique (here termed *RadonX*) differs from alpha-sensitive systems in that it measures gamma radiation arising from the ^{214}Bi and ^{214}Pb daughter products of the adsorbed radon. Thoron (^{220}Rn), arising from thorium that may be present, is not measured due to its very short half-life. The case study data are derived from an orientation survey over a known buried palaeo-channel of duricrust-hosted uranium, and from an exploration area potentially hosting uraniferous granites at depth. The *RadonX* surveys show:

- Improved sensitivity compared to a previous alpha-detection survey.
- Good repeatability. Some loss of sensitivity, due to possible large temperature variations between initial and fill-in surveys, is easily corrected for by repeat measurements.
- Improved resolution with detailed grids, allowing accurate mapping of uranium mineralisation and positioning of boreholes.
- Excellent penetration through residual or transported surficial cover. Given favourable porosity conditions, a depth of penetration of 80m or more has been achieved.
- Deployment is rapid and cost effective.

PATERSON AIRBORNE ELECTROMAGNETIC SURVEY, ONSHORE ENERGY AND MINERALS, GEOSCIENCE AUSTRALIA

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The Paterson Airborne Electromagnetic (AEM) survey is a major component of the Northern Western Australia (WA) regional project in the Onshore Energy Security Program (OESP) at Geoscience Australia. During 2007, Geoscience Australia, through Fugro Airborne Surveys, will acquire a TEMPEST survey with broad line spacings (up to 2 km) in the Paterson Province, WA. The area to be covered comprises sections of the Yarrie, Nullagine, Paterson Range, Balfour Downs, Rudall, Tabletop, Gunanya and Runton 1 : 250 000 map sheets. The survey results will help to improve our understanding of the area's geology and mineral potential by mapping the conductivities of different geological and hydrogeological units under cover. The dataset will contribute to interpretations regarding the presence of graphitic units in the Rudall Complex; the location of major structures; and the extent of Permian palaeovalleys and other regolith features. This poster outlines the survey specifications and objectives, and describes some of the geophysical modelling and processing methods being developed by Geoscience Australia.

DETAILED RADIOMETRIC SURVEYING AT RADIUM HILL, SOUTH AUSTRALIA

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In June 2007, a ground radiometric survey utilising quad bikes was conducted over the Radium Hill townsite, former minesite area and processing plant. An eight litre crystal pack was used along with an Exploranium GR-320 gamma ray spectrometer set to continuous (streaming) mode. A total of 148.8 line-km of radiometric data were collected over NS lines spaced at 100 m intervals. Average ground speeds of 10 km/h combined with the large crystal pack enabled good quality, highly detailed data to be collected on the ground over rough terrains. Data were continuously sampled at one second intervals and the entire survey was conducted in 10 days including mobilisation and demobilisation. The terrain was not suitable for large vehicles due to the danger of below surface mine adits, hence, the only alternative to surveying on quad bikes would be to survey on foot. It is estimated both that to get the same quality of data over this size survey area would require two operators 60 days, and also the use of such a large crystal pack would result in detailed data comparable with that derived from airborne surveys.

DENOISING AERIAL GAMMA-RAY SURVEY DATA WITH NON-LINEAR DIMENSIONALITY REDUCTION

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Denoising aerial gamma-ray surveying makes possible the extraction of previously hidden detail. Conventional methods for denoising spectral data make strong assumptions about the levels and type of noise which reduces their efficiency. The proposed methodology cast the problem as manifold learning followed by non-linear regression. Non-linear dimensionality reduction (NLDR) is employed to compute the underlying structure of the data. By calculating the intrinsic dimensionality of the spectra, the algorithm selects dimensions that are more representative of the data while eliminating dimensions with noise. The most representative dimensions are employed to learn a mixture of linear models through Expectation Maximisation. Non-linear regression is then performed using these mixtures to recover the denoised spectra from the low dimensional representation. Thus, the model makes no assumptions about the level and type of noise.

Tests performed with a synthetic survey demonstrate that data denoised with NLDR show much clearer detail in images involving uranium but only slight improvements for K and Th channel data. This has been confirmed with real surveys where subtle features involving U has been found using NLDR denoising. The NLDR method offers particular advantages in the search for uranium where combinations such as U*U/Th can be used to highlight areas of coincident high U and high U/Th ratios if cleaned data is available.

NEW SOUTH AUSTRALIAN GEOPHYSICAL DATA – PACE NORTHERN G2 GRAVITY SURVEY

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A combined heli-borne ground gravity acquisition program of approximately 17 000 gravity stations was acquired over the Northern G2 region within South Australia, as part of The Plan for Accelerating Exploration (PACE) program. The resolution of the

gravity data was dramatically enhanced from the existing gravity coverage with a station spacing of approximately 7 km to a 1.5 km grid within the PACE survey. There have been several discoveries in the south of this region, leading to this area becoming a focus for data acquisition. Acquisition of geophysical data, especially gravity on a regional scale is a key strategy of the PACE program. It is expected that the new gravity data will provide exploration companies with many geophysical targets ready to drill.

CORRELATIONS BETWEEN EARTH'S MAGNETIC FIELD AND CLIMATE: THE USE OF CONTINUOUS WAVELET TRANSFORMS

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Recently there have been suggestions that changes in the earth's magnetic field may influence climate on millennial, centennial and decadal scales. Continuous wavelet transforms are used to compare time series of geomagnetic and climatic variables.

Continuous wavelet transforms resolve a time series into its time and frequency components, meaning temporal variation in signal power at a particular frequency can be detected. This allows both continuous and intermittent periodic correlations to be found.

Continuous geomagnetic field monitoring in Australia began in 1840 at the Rossbank observatory. Since then the observatory has been re-located to Melbourne, Toolangi and finally Canberra, with all data corrected to the Canberra reference. In this study monthly mean geomagnetic data for the period 1949–2006 were compared using wavelet transforms with temperature and rainfall data recorded at Canberra Airport and cloud data from Sydney Airport. Sunspot number data were also compared.

Wavelet analysis shows peaks in geomagnetic power at annual, 9–14-year and 45-year periods. Temperature, rainfall and cloudiness results show high power annually, at 2–5 years and at 10–15 years. Cloud and magnetic data both show a spike in annual power at 1990. Sunspot power is dominant at 11 years.

Annual variations are seasonal, while 9–15-year variations appear to be related to the 11 year sunspot cycle. The link between magnetic field variations and sunspot activity is well established. Current research suggests that solar activity may also affect climate, perhaps modulated by the Earth's magnetic field. Other correlations are not currently explained and do not necessarily imply causality.

CORE DAMAGE: CAN WE CALIBRATE PRESSURE RESPONSE WITH LAB DATA?

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Time-lapse (4D) seismic quantitative interpretation is based mainly on measurements of how saturation and pressure changes affect seismic velocities. The effects of saturation can be modelled using Gassmann equations. The pressure effect is usually obtained by laboratory measurements, which can be affected by core damage. In order to assess the adequacy of the core measurements to the properties of the intact reservoir rocks, it is necessary to compare them to *in situ* measurements. We present a study to assess the adequacy of ultrasonic measurements on core samples by comparing measured ultrasonic velocities at reservoir pressures with sonic log data from two wells located in an oil field in Campos Basin, offshore Brazil. The analysis is performed for these densely cored wells: more than 50 samples were extracted from a turbidite reservoir. We use Gassmann fluid substitution to obtain low-frequency saturated velocities from dry core measurements (thus mitigating the dispersion effects) taken at reservoir pressure. Comparisons of these computed velocities with sonic logs measurements show very good agreement. This confirms that for those particular regions the effect of core damage on ultrasonic measurements is below the measurement error. Consequently, stress sensitivity of elastic properties as obtained from ultrasonic measurements is adequate for quantitative interpretation of time-lapse seismic data.

LONG OFFSET EFFECTS IN ISOTROPIC AND ANISOTROPIC AVO: EXPERIMENT VERSUS THEORY

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A spherical wave AVO response is investigated by measuring ultrasonic reflection amplitudes from a water/Plexiglas interface. The experimental results show substantial deviation from the plane-wave reflection coefficients at large angles. However there is an excellent agreement between experimental data and full-wave numerical simulations performed with the reflectivity algorithm. By comparing the spherical-wave AVO response, modelled with different frequencies, to the plane-wave response, we show that the differences between the two are of such magnitude that three-term AVO inversion based on the AVA curvature can be erroneous. We then propose an alternative approach to use critical angle information extracted from AVA curves, and show that this leads to a significant improvement of the estimation of elastic parameters. Azimuthal variation of the AVO response of a vertically fractured model also shows good agreement with anisotropic reflectivity simulations, especially in terms of extracted critical angles.

GEOPHYSICAL–GEOLOGICAL INTERPRETATION OF THE COBHAM LAKE AND MILPARINKA 1 : 250 000 MAP SHEET AREAS, NORTHWEST NSW

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As part of the *New Frontiers* exploration initiative, a new series of geophysical–geological interpretation of 1 : 250 000 map sheet areas is being completed. Interpretation of the Cobham Lake and Milparinka map sheets in the far northwest of NSW has been completed and highlights and extends the following major domains:

- Proterozoic units of the eastern Curnamona Province are present in the west of Cobham Lake sheet where rock types

exposed in the Broken Hill area extend northward under relatively thin cover.
- The Bancannia Trough (thick sequences of Cambrian to Devonian age) and Quinyambie Trough (Cretaceous sediments) share a northwesterly trend.
- The Koonenberry Belt comprises a complex structural zone where Neoproterozoic to Cambro-Ordovician units have been affected by a series of orogenic events.
- Intrusions of Silurian age (such as the Tibooburra Granodiorite), possible Cambro-Ordovician age, and Permian diatremes are interpreted.
- The contact zone is drawn between the Koonenberry Belt and the western extent of the Thomson Orogen.

Aeromagnetic data (1VD and TMI imagery) were used to create a framework plot of anomaly sources, assisting recognition of discontinuities, fractures, and textural domains. Previous interpretations, gravity data, mapping, drilling, seismic, and regional studies were integrated to allocate appropriate stratigraphy. Accompanying reports document aspects such as unit characteristics, major structures, magnetic susceptibility data, anomalous features, mineralisation, and depth to basement information. The Cobham Lake and Milparinka map sheets both have extensive cover of Cretaceous, Tertiary and Quaternary sediments and sedimentary rocks but offer exploration targets at shallow depths.

APPLICATIONS OF CROSS-DIPOLE ACOUSTIC LOGGING FOR FORMATION FRACTURE AND ANISOTROPIC IDENTIFICATIONS

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Cross-dipole borehole acoustic logging has been used for identifying vertical or deviated fractures, evaluating formation stresses, and monitoring hydraulic fracturing effects. In principle, cross-dipole borehole acoustic tool is able to predict horizontal transverse isotropy of a formation that apparently generates shear wave separation. This characteristic is used for identifying formation anisotropy distributions near the borehole, so that formation stress and fracture in a real formation can be evaluated. However, in practice, because of complicated logging environments, such as formation variations, borehole condition variations, and sometimes there existing abnormal formation, it has a restricted applications. Therefore, a comprehensive procedure may be used for detailed data interpretation, with the help of the other logging data.

In this work, firstly, a 3D staggered finite–difference method is used to simulate borehole acoustic wave propagation excited by a cross-dipole source in a pre-stressed formation. The wave equations of motion are based on nonlinear acousto-elastic theory. The effects of formation pre-stress on borehole flexural modes are discussed. Then, based on the numerical modelling results, the cross-dipole acoustic logging data in 400 wells from the Daqing Oilfield of China are used for fracture identifications in deep formations with complex lithology. Also, the metamorphic formations outside of the main area in Daqing Oilfield are studied. Hydraulic fracturing efficiency, formation stress distributions in a damaged casing area are investigated together with other well logging. Finally, the results are validated indirectly with other local formation stress detections, deformed casing analysis, and water injection fracturing data.

DETECTION OF SEA WATER INTRUSION CAUSED BY TIDAL ACTION USING GEOPHYSICAL METHODS

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The 1 km^2 studied area is located in Sukchun-ri, Hwasung-koon, the southern part of the Kyeonggi Province of Korea. In order to determine the extent of seawater contamination and a preferred channel of the seawater intrusion, DC resistivity and TEM surveys were performed. According to the resistivity map obtained from geophysical surveys, the study area is divided into two districts as relatively low (less than 30 Ωm) and high (more than 30 Ωm) areas. The distribution of the low resistive area is consistent with the distribution of the layer of composed pf clay minerals, and the resistivity of the clay miner layer decreases slowly as approaching to the old seashore. Hydrogeological analysis shows that the clay layer within a distance of about 200 m from the seashore has been already contaminated by sea water, and its electric conductivity is 8 times higher than that of the sand layer covered by the clay layer. According to the results of the 2D DC resistivity surveys with a dipole–dipole array, there are two preferred channels of seawater intrusions in the site, and both channels are in NW–SE direction from the old seashore. The DC resistivity and TEM recordings were carried out along the preferred channel which has low resistivity zone extended to a depth of 80 m. The time series measured by those two methods fluctuates with a period of 12 hours. These observations show that the sea water intrusion caused by tidal action is still in progress along the preferred channel interpreted by the geophysical surveys.

EFFICIENT TERRAIN CORRECTION IN AIRBORNE AND SEABORNE GRAVITY GRADIOMETRY SURVEYS

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Gravity gradiometry has proven an invaluable tool for both mineral and petroleum large-scale exploration. Airborne and seaborne systems allow extremely accurate surveys to cover large areas quickly and efficiently. Unfortunately, the five independent components of the gradient tensor result in a large amount of data that must be reduced. Terrain corrections are often the most difficult phase of this process due to severe computation time, but are also the most critical – the predominant signal in unprocessed gravity gradiometry data is a result of the terrain, as the gradient field decays as inverse distance-cubed.

Industry standard practices do not optimise the terrain correction process – often a nominal digital elevation model (DEM) size and resolution are used. However, due to uni-directional low-pass filters which are almost invariably applied to the data during or immediately after acquisition, the required resolution of the DEM is often significantly reduced. In addition, the

frequency content of the terrain to be modelled allows for calculation of the required spatial extent of the DEM. Quantifying this allowable reduction in resolution greatly reduces computation time without sacrificing accuracy. In the same vein, quantifying the required spatial extents of the DEM for terrain correction allows greater reduction of computation time and storage requirements by half or more relative to industry-standard practices. We study and quantify the required resolution of DEMs as well as their spatial extents for the improvement of efficiency in both gravity gradiometry forward modelling as well as terrain corrections.

CALIBRATED PREDICTION OF HYDROCARBON FLUID TYPE IN FRONTIER BASINS OF AUSTRALIA

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There is potential for a new oil province in Australia's expansive EEZ with a value to the nation measured in billions of dollars. To screen this large area requires appropriate technologies to detect petroleum systems. A common risk is that hydrocarbon charge and petroleum systems are not proven. Inclusions of oil in sedimentary grains detect migratory oil and can be used to deduce key parameters of petroleum systems that are critical for predicting the fluid type.

Methods will be developed to extract attributes of inclusion oil by spectral measurement of individual fluid inclusions in samples of reservoir rock and to calibrate models of oil generation and migration. Fluorescence spectra of oil inclusions broadly correlate with API gravity. Spectra in the blue part of the visible spectrum are associated with about 45 degrees API gravity oil while those in the yellow part of the spectrum are associated with about 30 degrees API gravity oil.

Methods for predicting the characteristics of source rocks, the generation of hydrocarbons and phase behavior during the migration of oil from source to reservoir will be modified and augmented to predict attributes that can be compared with those measured from inclusion oil.

Algorithms will be formulated that enable the observational data and predictions to be used in an iterative way to constrain key parameters of petroleum systems that are critical for predicting the fluid type and to forecast the value to be expected from future production in a region or prospect.

SEISMIC REFLECTIONS FROM PYCNOCLINES IN THE WATER COLUMN BENEATH AN ICE SHELF

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Pycnoclines (layers within ocean waters defined by a rapid change in density, either due to a change in temperature and/or salinity) have been found to produce reflections that appear in seismic data collected on the Amery Ice Shelf (AIS), East Antarctica. The pycnoclines, present due to an ice pump mechanism under the AIS, are clearly visible within the ocean water column beneath the ice shelf. This is evidenced in a 3 km common depth point reflection survey undertaken on the eastern side of the AIS. The reflections are unmistakably primary in nature, producing their own multiples in the seismic record. Further processing of other AIS seismic data also reveals reflections at similar arrival times in the ocean water column. While the reflection coefficient (RC) of the ice-water and water-seafloor boundaries are approximately 600 times greater in magnitude than that of these pycnoclines, the pycnocline RCs are 40 times greater in magnitude than the surrounding ocean waters – sufficient to produce a reflection. The pycnocline reflections correlate well to changes at density interfaces observed by *in situ* CTD (conductivity-temperature-depth) data collected under the AIS through a borehole in the ice. Seismic surveys carried out over different field seasons, spanning three years, and observed at different times during the summer seem to indicate that there is a variation in the depth and thickness of the pycnocline layers. One possible reason for this variation is the presence of internal waves at the interface between the density layers.

CASE HISTORY: ARBROATH – AN INTEGRATED PETROPHYSICAL AND SEISMIC ELASTIC INVERSION PROCESS FOR DE-RISKING INFILL DRILLING TARGETS IN A MATURE NORTH SEA OILFIELD

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The Arbroath Field is located in UKCS block 22/17 and produces 38º API oil from the Forties Sandstone turbidite reservoir at approximately 2500 m TVDSS. Production began in 1990 and the field still produces significant oil volumes today. In 2006, a re-appraisal of 1993 and 2000 vintage 4D seismic data over the field was initiated to de-risk infill drilling targets. This included a petrophysical and petroacoustic review and 4D seismic re-processing:

- Petrophysical log database QC and repair, facies modelling and shear log prediction using clustering to provide a quality log set for all key wells.
- Quantifying the seismic response to reservoir sand presence and fluid fill. Quantifying the dynamic seismic response associated with changes in OWC, oil saturation and fluid pressure due to continued production using seismic forward modelling techniques. Selecting optimum seismic elastic inversion products to highlight produced zones.
- Improved 4D seismic images by using state-of-the-art time lapse processing technology.
- Applying enhanced seismic processing to improve signal levels in seismic AVO volumes, leading to improved relative fluid impedance volumes for better delineation of by-passed oil.
- Predicting continuous rock strength profiles along infill well paths, performing sand stability and *in-situ* stress analysis to optimise preferred perforation placement and orientation.

This poster presents the integrated progression from seismic data review with petrophysical and petroacoustic analysis leading to identification of unswept oil, and assisting infill well placement and design. We highlight the innovative technology used during each of the stages.

COMPLETING THE SPECTRUM OF THE AUSTRALIAN DIGITAL MAGNETIC ANOMALY MAP

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Continental-scale merges of Australian airborne magnetic data are only accurate for wavelengths ≤100 km, due to limitations of survey size and data processing. Wavelengths >400 km are available from satellite data; thus, there is a 'gap' in the spectrum for wavelengths between 100 km and 400 km. Geoscience Australia is filling this gap by acquiring new airborne magnetic data as part of the Australian Government's new Onshore Energy Security Program. Intermediate wavelengths are important, for example, to better define sedimentary basins for petroleum prospectivity evaluation, to interpret depths to bottom of magnetic sources in attempts to define the Curie point isotherm, and for regional removal in modelling. The AWAGS2 project (Australia-wide Airborne Geophysical Survey) is collecting both gamma-ray spectrometric and total-field magnetic data across Australia with long north-south lines spaced 75 km apart and 80 m terrain clearance. Accurate spatial crustal magnetic data depend upon accurate removal of time variations of Earth's magnetic field. These are recorded at pairs of ground sites, concurrently with the airborne acquisition, and supplemented by geomagnetic observatory and other data. Routine airborne magnetic surveys rarely use more than one base magnetometer and the long lines of AWAGS2 present a challenge. It cannot be assumed that time variations are spatially uniform (e.g. induction in the oceans and crust creates spatial non-uniformities). Removal of time variations depends on interpolation of data recorded at ground sites and knowledge of induction effects. Using the AWAGS2 corrected traverses will improve the accuracy of intermediate wavelengths in the Australian Digital Magnetic Anomaly Map.

STUDY OF THE GHOM HYDROCARBON FORMATION IN THE CENTRAL IRAN BY USING GEOPHYSICAL METHODS

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Within exploration studies for oil in the Central Iran, the first seismic survey led to Zavareh 1 exploratory well (3900 meters deep), which turned out to be a dry well. In this research, we have tried to conduct an integrated geological and geophysical study for identifying major geological structures in order to better locate exploratory wells. For this purpose, firstly, the geology of the Zavareh–Ardestan area was carefully studied and the relevant hydrocarbon horizon was identified. Then, by using gravity, magnetic and seismic methods the important geological structures including anticlines A, B and C were mapped. By reprocessing and interpreting a number of seismic lines and specially the one intersecting Zavareh 1 exploratory well, we concluded that the drilled well had not reached the target horizon. Based on this study, we suggested the Ghom Formation as the oil producing horizon and anticline C as a suitable target for future exploratory drilling. In addition, we recommended that the National Iranian Oil Company conduct denser gravity, magnetic and 3D seismic surveys in order to more precisely determine the new position of the well.

CAVITY MAPPING AND GROUT MONITORING: A MICROGRAVITY CASE HISTORY IN KOREA

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Muan has suffered from subsidence, thought to be related to cavities developed in Paleozoic limestone. Microgravity survey was executed at a rice field in Muan for subsurface cavity mapping. The data were collected using a Scintrex CG-3 gravimeter at about 800 stations at 5-m intervals along paddy paths, which provided a semi-grid data set.

The residual gravity anomaly was interpreted by Euler deconvolution, and 2D and 3D inversion. The density distribution of the profiles was drawn by two dimensional inversion based on the minimum support stabilising functional, which generated better focused images of density discontinuities. Three-dimensional density distribution was imaged by growing body inversion. We devised an inversion scheme utilising Euler deconvolution as a priori information in order to reduce the inherent non-uniqueness of gravity inversion. The essential point of the scheme is to restrict the model space with help of Euler deconvolution, which pointed plausible locations of anomaly sources. The three-dimensional density image showed that the cavities were dissolved, enlarged and connected into a cavity network system. It was generally coincided with the result of resistivity survey and supported by drill-hole logs.

A time-lapse microgravity survey on a newly widen road passing through the site for monitoring the change of the density distribution before and after grouting. The comparison of density distributions imaged by minimum support inversion showed the change and development of density structure during the lapsed time, which implies the effects of grouting.

PRELIMINARY RESULTS FROM GA302 OVER CAPEL AND FAUST BASINS

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Data from 50 sonobuoys were recorded over the Capel and Faust Basins, 800 km to the east of Australia's eastern margin in water depths ranging from 1500 to 2000 m, during a 2006 seismic survey (GA302) for Geoscience Australia's Big New Oil program. These data were interpreted and forward modelled by ray-tracing to provide an estimate of P-wave velocities in the upper sedimentary section, and hence constrain estimates of sediment thickness. Also recorded were gravity and magnetic anomaly data which, in conjunction with the very high quality seismic reflection data, provided additional constraints upon the velocity models. Typical ranges in four model layers below water were: 1.9, 2.3–3.0, 3.6–4.7, 5–5.3 km/s. Gravity models based on these results were compared to features identified on depth converted seismic reflection lines and indicate that sediment thickness at densities approximating 2.3 gm/cm^3 may reach 5 km in several localities.

LEVELLING THE NATIONAL GAMMA-RAY SPECTROMETRIC RADIOELEMENT DATABASE

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The individual surveys that comprise the national gamma-ray spectrometric radioelement database are not all registered to the same datum. Older survey results are presented in units of counts/sec, which depend on factors such as survey flying height and detector volume. Even recent surveys can have a significant mismatch along common borders due to limitations in spectrometer calibration and data processing procedures, as well as environmental effects that result in temporal changes in the gamma-radiation fluence rate at the earth's surface. To solve these problems, Geoscience Australia is currently flying (under contract) an Australia-wide airborne geophysical (magnetic and radiometric) tie-line survey (AWAGS2) that will be used to bring all of the surveys in the national database to a common datum. The AWAGS2 survey is being funded under the Australian Government's Onshore Energy Security Program and is due for completion early in 2008. The data are being acquired and processed according to international standards, and the final estimates of radioelement concentrations along the AWAGS2 tie-lines will be consistent with the International Atomic Energy Agency's (IAEA) radioelement datum. The national database is being levelled by estimating survey correction factors that, once applied, minimise both the differences in radioelement estimates between surveys (where these surveys overlap) and the differences between the surveys and the AWAGS2 traverses. This effectively levels the surveys to the IAEA datum, and significantly enhances the value of a database that is essential for informed decision-making about Australia's onshore energy resources, mineral exploration and environmental protection.

INTEGRATED INTERPRETATION OF MICROGRAVITY DATA USING ANALYTIC SIGNAL AND EULER DECONVOLUTION TO DELINEATE CAVITIES

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In this paper, we propose a new interpretation method of gravity data by means of combining the analytic signal and Euler deconvolution. Euler deconvolution is widely used to analyse potential data without any prior information. However, since Euler deconvolution tends to make so many spurious solutions, it is hard to pick up real solutions. Avoiding these ambiguous problems, we utilised a combined method between the analytic signal and Euler deconvolution. Analytic signal can give us horizontal information of isolated anomalous bodies. We carried out Euler deconvolution not only gravity data but also analytic signal of gravity data. It gives us clearer solutions than using Euler deconvolution only. We verified the proposed method by synthetic data and applied it for microgravity data. We carried out gravity survey using Scintrex CG3, CG5, and ZLS Burris meter. The target area is a small urban area nearby coal mines. This area has some cases of subsidence problem due to cavities in limestone bedrock. We set up 10 profiles and measured every 4 m. And the some part of area was collected by scattered points because it is impossible to make a profile due to existence of buildings. We gathered totally about 1100 points. Low Bouguer anomaly zones coincided well with drill logs. We applied integrated interpretation method to microgravity data of limestone area by means of analytic signal and Euler deconvolution simultaneously. Results from the combined method showed indications of cavities.

EMERGING SENSING TECHNOLOGIES FOR HYDROCARBONS AND THEIR POTENTIAL USE AS EXPLORATION DEVICES

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Australian waters contain a number of under-explored offshore sedimentary basins, which have or could have significant hydrocarbon accumulations. Current exploration strategies are based primarily upon seismic data acquisition, with other data type acquisition, (e.g. geochemical sampling) requiring further survey cruises. This multiple survey strategy significantly increases exploration costs leading to tough decisions being made upon which surveys to perform when exploration budgets are tight. The attraction of using a single cruise to achieve multiple surveys is therefore of interest in reducing costs and increasing the impact of each exploration dollar.

New chemical-physical sensing devices offer potential for useful new technology to explore large areas of offshore basins to detect microseeps and provide molecular information that is indicative of fluid type. These sensors when mounted on current survey platforms could be run continuously in marine surveys to obtain profiles of hydrocarbons in water that can be mapped in a similar way to seismic, electromagnetic, and magnetic data.

This paper reviews currently available technologies and presents the collaborative research being conducted by CSIRO Divisions of Petroleum and Industrial Physics, Curtin University, and University of Western Australia. This research is focusing upon the two essential parts of chemical sensing systems, the nanochemical molecular binding element that is often a surface designed to be specific for certain classes of molecule, and a transduction element that provides a physical signal that binding has taken place. These elements will then be integrated into a robust marine deployable sensor system that can be used for hydrocarbon exploration.

MAGNETIC ANOMALY OF THE BRAMFIELD IRON FORMATION, SOUTH AUSTRALIA

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Lynch Mining holds numerous exploration licences on the Eyre Peninsula, South Australia, where there is very little outcrop although the average cover is only a few tens of metres. Clearly

geophysical methods are crucial in these circumstances. Early drilling of a large (7000 nT) magnetic anomaly, ~2500–3000 m ×350 m in areal extent, intersected east dipping (60°–80°) iron formation and associated forsterite-magnetite marbles and calcsilicates. A 38 m zone between 87 m and 125 m assayed at 40% Fe with low (<900 ppm) phosphorus and ~ 3000 ppm manganese. From the size and areal extent of the magnetic anomaly a large iron ore resource was inferred. Initial magnetic modelling indicated a broad vertically dipping body. However, subsequent drilling, while intersecting lens-like bodies sporadically, failed to intersect a thick uniform iron-rich body commensurate with the initial magnetic modelling.

Magnetic property measurements (k 1.0 SI) suggest that the magnetic susceptibility value used in the initial modelling (0.5 SI) was too low by a factor of two. Moreover, the remanence is soft and probably in the same direction as the induced magnetisation, i.e. a viscous remanent magnetisation, so the effective susceptibility may be 2.0 SI. Self-demagnetisation constrains the magnetisation to be aligned along the bodies, deflected away from the geomagnetic field direction. This means that no matter whether the bodies dip to the west, the east or are vertical, the anomaly will be symmetric. The causative bodies appear to be dispersed magnetite-rich lenticular pods giving a combined anomaly that simulates a uniform body.

UNDERSTANDING THE EFFECT OF STRESSES ON THE PRODUCTIVITY OF THE LOWER GORU FORMATION THROUGH ROCK PHYSICS AND RHEOLOGICAL STUDIES IN THE SAWAN GAS FIELD – SOUTHERN PAKISTAN

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The aim of this study is to verify that the low impedance and over-pressured petroleum systems (gas reservoirs) in the vicinity of high stresses are unproductive with the hydrocarbons. The study has been conducted in and around the Sawan Gas Field, located in Southern Pakistan. Rock Physics Parameters (Poison's Ratio, Vp/Vs Ratio) are calculated in this area. The behaviour of these properties resembles a low impedance and over-pressured gas reservoir, which in this case is the Lower Goru Sands. Sequence stratigraphic studies were carried out to comprehend the depositional model of sand and shale. Conformity has been established between this model and the pattern achieved from detailed rock physics investigations, which further helped in the identification of the anomalous gas zones for the reservoir.

Next, it needs to be confirmed, whether or not these anomalous zones can be productive? This goal is achieved by the following rheological studies.

- Finding the longitudinal and shear strain around the interpreted faults.
- Converting this strain into the stresses.
- Contouring the stress and strain values.

These contour maps give a complete picture of where the reservoir falls in the high stress zones. In these areas it is not productive. On the other hand, we can predict its productivity in areas of low stresses. These scenarios can be demonstrated by examples of some productive and failed wells in the field.

COMMON REFLECTION SURFACE STACK, NEW METHOD IN SEISMIC REFLECTION DATA PROCESSING: A SYNTHETIC DATA EXAMPLE

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The NMO/DMO/stack method is a traditional and well-known method in the oil industry that needs an accurate macro velocity model to image the subsurface structures. Making such a macro velocity model is a time consuming process that is error prone. New introduced common-reflection-surface (CRS) stack is a data driven method which is independent of velocity information apart from the surface velocity. It comes from common reflection point (CRP) trajectory concept for finite offset. In NMO/DMO/stack the stacked data are obtained from a summation over a curve along the offset coordinate but the principal of CRS stack is to sum along a surface of specular contributions from a segment of a reflector instead of reflection point. The summation over a segment of a coherent reflector drastically improves the signal/noise (S/N) ratio as the stacked data will show. An important aspect of the method is that the estimated parameters provide us with significant information on the subsurface structure. These are three new parameters called kinematic wavefield attributes α, R_N and R_{NIP}. The parameter α is the emergence angle of normal-ray which will be later for a normal-ray map migration. R_N is the curvature of the exploding reflector wavefield measured at the surface and R_{NIP} is the curvature of normal-incidence-point wave which could be used later to yield information on the propagation velocity and inversion NIP tomography. Here we processed a synthetic data to derive zero offset or CRS stacked section with high S/N ration and better continuity on the reflection events.

GEOPHYSICAL MODELLING COMPARISON AT VARYING SATURATION AND PRESSURE: CO_2 SEQUESTRATION PILOT PROJECT IN THE OTWAY BASIN

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The Otway Basin CO_2 sequestration pilot project aims to demonstrate that CO_2 can be safely stored in a depleted gas field and that an appropriate monitoring strategy can be deployed to verify its containment. The advantage of injecting CO_2 into a depleted gas field is having access to well-established infrastructure, pre-existing geophysical exploration data, and production wells. On the downside, the geological complexity of the Naylor gas field, which is relatively deep and of a small size (0.5 km^2), presents challenges for detailed geophysical and geological characterisation and consequently makes the design of a geophysical monitoring program much more difficult. Uncertainty of the location of paleo and current gas–water contacts poses additional difficulty for positioning of the injection well. These factors call for further analysis of all available geophysical data.

One such task is the investigation and examination of the elastic properties changes at varying saturation and pressure in time-

lapse and their effect on seismic response before and after CO_2 injection at the existing Naylor-1 well (monitoring well). The result from modelling shows that the density is more sensitive than velocity. Consequently, model-based prediction suggests the changes in elastic properties and the effect in seismic response is very subtle. Attempt to relate the seismic attributes computed from pre-stack and post-stack 3D seismic and VSP to the changes in elastic properties will help further refine the geophysical analysis.

Using the same methodology, the modelling of the new injection well is compared with Naylor-1 model. The outcome will be discussed in this paper.

MODELLING OF VTEM EM RESULTS OVER A BASE-PRECIOUS METALS TARGET, WESTERN AUSTRALIA

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A VTEM airborne EM and magnetic survey was flown over the previously located and drilled base and precious metals prospects located near Manjimup, Western Australia. These data have been modelling with a layered earth inversion program and a discrete plate program. These outcomes have then been compared with pre-existing airborne and ground geophysical results as well as drilling.

A MAGNETIC GRADIOMETRIC METHOD AS AN ADJUNCT FOR MARINE CSEM

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The marine Controlled-Source Electromagnetic (CSEM) method has proven itself an invaluable adjunct to the seismic method in petroleum exploration in the last few years. The problem is that it is not easily adapted to the Australian scene because most of Australia's petroleum deposits are in relatively shallow waters where CSEM does not work very well. Depending on the target, depths up to 500 m can be considered shallow water for CSEM. CSEM surveys in shallow water can have problems with the airwave dominating the received CSEM signal and also with electromagnetic noise induced by ocean waves. We have been developing an auxiliary magnetic gradiometric method that will help overcome these problems. This poster will present the results from preliminary field trials conducted off Sydney's coast, in water depths up to 60 m, with the aim to detect the presence of the magnetic signal induced by ocean waves. Approaches for using magnetic gradient measurements as an adjunct to marine CSEM data will also be described.

FRACTAL MODEL OF ROCKS – A USEFUL MODEL FOR THE CALCULATION OF PETOPHYSICAL PARAMETERS

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There are numerous experimental works intending to find the dependence between the porosity and resistivity of sediments of different types and ages. Traditionally for many years the empirical Archie's law has been used for interpreting EM data. It allows for the estimation of the porosity of sediments if the dependence between resistivity and porosity (at least the structural index of porosity) is known. This model does not take into account the influence of double electrical layers which are responsible for induced polarisation effects, which arise in the sediments due to applied electrical current. However there is not enough application of these theoretical considerations to the interpretation of electromagnetic data as well as physical modelling of data. Most scientists try to find empirical relations between petrophysical parameters.

Mathematical modelling of petrophysical properties can be done using matrix (fractal) models. A fractal model containing n-series of spheres with corresponding radii and surrounded by a thin film of adsorbed water (DEL) has been used. This model is more suitable for real sedimentary rocks. Using the parameters of the fractal model several petrophysical parameters can be calculated namely: effective and dynamic porosity, permeability, diffusion coefficient, volume of matrix, thickness of adsorbed water which characterises electro-osmosis polarisability and decay constant, and the most important – the resistivity of two component (matrix/fluid or matrix/fluid and gas) and three component (matrix/clay/fluid and matrix/clay/fluid and gas) rocks. This model has been used for interpreting geophysical data for many years and for different tasks.

IMPROVING PETROPHYSICAL INTERPRETATION THROUGH STATISTICAL LOG ANALYSIS AND ROCK PHYSICS MODELLING

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Uncertainties in the quantitative interpretation of well log data are often unquantified and ignored. Uncertainties are always present to some degree and have many underlying causes such as quality of log data, lack of calibration data, choice of petrophysical model, choice of model parameters. Understanding the nature of reducing the uncertainties is important if the petrophysical results are to be used for reservoir characterisation, reservoir modelling or risk analysis.

Statistical petrophysical techniques provide a means to assess the sensitivity of the interpretation to model and model parameter choice and to include known or assumed uncertainties in the measured data. To reduce uncertainty additional information must be introduced such as multiple well data or rock physics constraints. Parallel interpretation of multiple wells can increase the signal to noise ratio of the interpretation and at least ensures greater consistency of interpretation between the wells. Rock physics provides a link between the standard petrophysical properties and any measured elastic properties of the formation and therefore can provide an additional constraint on the petrophysical interpretation. An extra advantage of integrating a rock physics model is that, since elastic properties can be estimated from seismic data, the petrophysical interpretation can be interpolated between wells more accurately using seismic data as a guide.

This paper highlights how statistical log analysis, parallel interpretation of multiple wells and the integration of rock physics constraints can reduce uncertainty in petrophysical interpretation in cases of bad hole and complex lithology.

VELOCITY REVERSAL AS A DIRECT HYDROCARBON INDICATOR IN THE ANOMALOUS HIGH TEMPERATURED AND OVER PRESSURED DF1-1 GAS FIELD BELOW 2100 M IN THE YINGGEHAI BASIN, SOUTH CHINA SEA

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In the DF1-1 Gas Field in the Yinggehai Basin, South China Sea, the velocity-depth plot and velocity spectra show significant variations from the classic linear trend, exhibiting a universal reversal phenomenon. Velocity parameters derived from velocity spectral analyses of the seismic data and sonic logs indicate that the 'interval velocity' universally reverses below 2100 m, corresponding to the starting depth of overpressure in the field. There is a distinct difference between the gas-bearing sandstones and the surrounding rocks in the shallow strata with depths <2100 m; however, such a difference becomes less apparent beyond 2100 m in the middle-deep strata.

In the shallow strata of the DF1-1 Gas Field, the gas-bearing sandstones can be effectively recognised prior to exploration drilling using the DHI (Direct Hydrocarbon Indicator) techniques. However, these DHI models developed for the shallow strata were found to be ineffective for the middle-deep strata for direct exploration target recognition due to the velocity reversal.

To effectively identify DHIs in the middle to deep depth strata under velocity inversion, we used an integrative approach to detect the 'integrated hydrocarbon indicators' and tested the applicability of Differential Interformation Velocity Analysis (DIVA) as a DHI in the DF1-1 Gas Field. The results indicate that the "DIVA" technique can be effectively used as a DHI in both the shallow and the middle-deep strata in the study area with the shallow strata characterised by Type I DIVA anomaly and the middle-deep strata characterised by the Type II DIVA anomaly.