SECTION 4
POSTER ABSTRACTS

POSTERS WILL BE ON DISPLAY FROM SUNDAY 22ND AUGUST, 1600 HOURS IN THE EXHIBITION HALL 5

Poster Presenters will be asked to stand by their posters at the following nominated times.

Poster Session 1

Monday 23rd August 1300–1330

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5	Enhancing the radiometric map of Australia ***Brian Minty***
8	A magnetic survey at Histria Necropolis ***Sorin Anghel***
11	Study of apparent resistivity of a sphere buried in a horizontal layered structure ***Alireza Safari***
16	The generation of starting models for refraction inversion from multi-fold seismic data with the GRM ***Derecke Palmer***
17	The computation of attributes from seismic refraction data ***Derecke Palmer***
18	Non-uniqueness with refraction inversion – The Mt Bulga shear zone ***Derecke Palmer***
23	A potential field approach to defining the margins of the West Australian Craton ***Brenton L. Crawford***
29	Two-dimensional regularization inversion of magnetotelluric data for deeper mineral exploration: An example from the Sanjiang River copper deposit ***Liu Jian-Xin***
32	Radiometric anomalies of South Australia ***Stephen Petrie***
35	Streaming: Vehicle-borne radiometric surveying in SA - past, present and future ***Gary Reed***
38	The magnetic anomaly map of Australia, 5th edition, 2010 ***Peter R. Milligan***
41	Magnetic moments of fine particles from micromagnetic surveys ***Phil Schmidt***
44	Approximation to macro anisotropy of conductivity for CSAMT exploration ***Yixian Xu***
47	Ground-truthing proposed slab window formation beneath Sundaland using seismic tomography ***Theresa Fabian***
50	Reprocessing strategy to obtain quantitative early time data from historic VTEM surveys ***James Macnae***
56	Passive seismic spectroscopy ***Erik H. Saenger***
59	Transformation of coincident loop data to a surrogate potential response ***Lachlan Hennessy***
62	Time frequency spectral decomposition for determination of bottom simulating reflector (BSR) of gas hydrate seismic data ***Doan Huy Hien***
65	Pit(wells)-ground controlled source electromagnetic signal transmitter ***Wang Meng***
68	A method suited to survey of shallow high resolution survey and survey in busy streets of a city – Landsoner ***Zhong Shihang***
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Poster Session 2

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3	Prospect of natural gas industry in Iran ***Hedayat Omidvar***
6	Applications of Gamma-ray transport modeling to improving borehole logging for Uranium ***Bruce L. Dickson***
9	Complete bouguer anomalies for the Australian national gravity database ***Ray Tracey***
12	Fault shadow distortions on 3D seismic data and their removal by depth processing ***Sergey Birdus***
14	Marine seismic profiling and shallow marine sand resistivity investigations in Jervis Bay, NSW Australia ***Julian Vrbancich***
21	Is VIRT an efficacious strategy for refraction inversion? ***Derecke Palmer***
22	Imaging the base of the weathering by stacking shot records ***Derecke Palmer***
24	Multiattribute analysis of East Java Basin carbonate reef built-up ***Roy Barus***
27	A geological interpretation of the Tallaringa and Ooldea Magnetic surveys ***Philip Heath***
30	Regularized equidimension inversion of gravity data ***Guibin Zhang***
33	Bayesian stochastic inversion (a case study from an Iranian oil field) ***Hosseinzadeh Abdolsamad***
36	The latest geological/geophysical interpretation of the NSW Murray Basin basement ***Astrid Carlton***
39	Automatic velocity model building technology ***Wu Peng***
42	Quantitative appraisal of heliborne and ground-based time domain electromagnetic surveys for uranium exploration – A case study from Rajasthan, India ***Anand Kumar Chaturvedi***
45	Paraguay: stopped at the border ***Bill Lodwick***

Poster #	Title and authors
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51	High resolution seismic for sequence stratigraphy interpretation of shallow sediments in the Continental Shelf of Vietnam ***Mai Thanh Tan***
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Poster Session 3

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7	Pine Creek airborne electromagnetic survey results ***Marina Costelloe***
10	A new automated method to determine depth to magnetic basement – the Gawler Craton depth to basement map ***Tony Meixner***
13	Migration of duplex waves for coal-bed methane prediction ***Naum Marmalevskyi***
15	Marine seismic profiling and shallow marine sand resistivity investigations in Broken Bay, NSW Australia ***Julian Vrbancich***
19	Detailed refractor imaging with the RCS ***Derecke Palmer***
20	Non-uniqueness with refraction inversion – a syncline model study ***Derecke Palmer***
25	Links between catchment erosion and climate investigated with uranium series isotopes ***PO Suresh***
28	Application of SoPC in high-precision geoelectric data acquisition system ***Zhang Qisheng***
31	Geophysical characterization and monitoring of subsurface drip irrigation water, Powder River Basin, Wyoming, USA **Burke Minsley**
34	Computation of porosity using sand and carbonate rock physics models in an Iranian oil field ***Hosseinzadeh Abdolsamad***
37	What can potential field data really tell us about Continent-Ocean transitions? ***Simon Williams***
40	Short and long wavelength geophysical features reflecting geology and structure in the Doradilla Tin–Copper–Nickel District, approximately 45 KM south-east of Bourke, NSW ***Rosemary Hegarty***
43	Isostatic residual gravity anomaly grid of onshore Australia ***Aki Nakamura***
46	Acquisition and processing of seismic reflection, refraction and magneto-telluric data: Northern Eyre Peninsula, Gawler Craton ***Aki Nakamura***
49	Lineament analysis as a tool for hydrocarbon and mineral exploration: a Canadian case study ***Madeline Lee***
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POSTER ABSTRACTS

2. MAGNETOTELLURIC SURVEY ACROSS THE CENTRAL EYRE PENINSULA

Stephan Thiel[1]*, *Graham Heinson*[1], *Peter Milligan*[2], *Goran Boren*[1] *and Jingming Duan*[2]
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Magnetotelluric (MT) measurements were undertaken at 40 broadband (0.01 s–500 s) and 12 long-period (10 s–10000 s) stations across the central-eastern Eyre Peninsula, South Australia, using Auscope MT equipment. Typical site spacing is of the order of 15 km in between sites for the long-period stations and and 3–10 km for the broadband stations. This ensures sufficient coverage to map the upper crustal to upper mantle structures underneath central Eyre Peninsula.

The profile extends south of the Gawler Range Volcanics and crosses the Archaean Sleaford Complex, the Hutchinson Group and the Donington Suite from west to east. The 2D MT profile also crosses the location of the postulated Eyre Peninsula Anomaly (White and Milligan, 1984, Kusi et al., 1998, Thiel et al., 2005) as well as the Kalinjala Shear Zone in the eastern part of the profile (Vassallo and Wilson, 2002, Thiel et al., 2005).

Dimensionality analysis and strike determination has been carried out using phase tensor analysis (Caldwell et al., 2004). Subsequently, data influenced by 3D effects could be discarded and the remaining data were inverted for 2D structure using a code by Rodi and Mackie (2001). 2D inverse modelling of the broadband and long-period data indicates a resistive crust in the

western part of the profile representing the Archaean Sleaford Complex. Along its eastern margin extends a major conductive crustal boundary in the central part of the profile.

3. PROSPECT OF NATURAL GAS INDUSTRY IN IRAN

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Iran holds the second largest gas reserves in the word with over 27.5 trillion cubic meters (TCM) of natural gas. Due to lack of geological surveys in certain geographical regions in Iran, It is likely to explore further reserves in the future.

Hence, for utilizing this energy carrier, it is essential to have comprehensive and explicit planning knowledge. The study of gas industry development policies is indicative of certain barriers in utilizing prospective opportunities. Iran is one of the largest gas rich countries in the word that production capacity exceeds domestic consumption and gas injection requirements. Gas can be utilized as feed stock in petrochemical plants and refineries or exported through pipeline or LNG. Through re-injection of gas to oil reservoirs, while increasing the oil recovery ratios, the produced gasses from fields shared with other countries could be stored in to domestic gas fields.

Gas consumption in domestic markets and its substitution with oil products, in addition to providing environmental benefits, will also result in optimum consumption of these products and relieving the government from the heavy burden of existing and heavy expenditures of importing these products in to country.

4. INTEGRATED MT/GRAVITY GEOTHERMAL EXPLORATION IN HUNGARY: A SUCCESS STORY

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Hungary is promising for utilization of low temperature (<150°C) geothermal energy because of its high thermal gradient, reaching almost 50°C/km over most of the country. This high gradient is mainly caused by a relatively thin layer of the Earth's crust in that area and partly due to the non permeable lower Pannonian sediment layer that covers a large part of the country. Our geothermal evaluation project in Hungary has, since 2007, yielded over 30 possible well sites for geothermal energy production and utilization. The first drilled well was recently successful.

The correlation between resistivity and temperature is associated with the local degree of hydrothermal alteration. Most high-temperature hydrothermal systems are indicated by a low resistivity layer over the geothermal reservoir which is caused by clay mineral alteration.

Electrical methods provide information about rock properties, temperature, and the degree of hydrothermal alteration. This information can be used to determine the geometry of hydrothermal reservoirs, its depth, location of fracture zones, and the permeability distribution.

To complement the electromagnetic method of choice (magnetotellurics or MT), gravity surveys were acquired along the MT survey lines with higher density spacing to assist in detecting fault systems. Gravity data may be used to interpret the subsurface and to aid in locating prospective heat sources. Integrating the MT and gravity data reduces the ambiguity of either dataset and produces a more robust interpretation.

The distribution characteristics of the fault zones with relatively low resistivity and with boundaries outlined by cooperative constrained inversion of MT and gravity data indicate that the prospective zones for potential geothermal reservoirs in the survey area are along the midnorthern part of the AMT/MT survey line 1 and the middle part of AMT/MT survey line 2.

Based on integrated processing and interpretation of electromagnetic, gravimetric and seismic combined with stratigraphic information; the position of the first geothermal well site was selected and drilled in the Szentlőrinc survey area. Hot water with temperatures in excess of 85°C, estimated to have a peak heating capacity of 4 MW, was found at depths of 1620 to 1790 meters. This discovery was possible due to the utilization of different geophysical and geological methods to determine the best well location.

The integrated approach which uses different datasets has proven to be a very effective method for locating the most promising areas for geothermal exploration. Utilizing this method in Hungary, with the goal of supplying 700 000 homes with geothermal energy within the next decade, is readily possible.

5. ENHANCING THE RADIOMETRIC MAP OF AUSTRALIA

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The Radiometric Map of Australia shows the distribution of potassium (% K), uranium (ppm eU) and thorium (ppm eTh) over Australia. A suite of image enhancement and data integration techniques can be used to enhance the value of these data for both mineral exploration and environmental mapping. Gradient-enhanced ternary and pseudo-colour image enhancements are now routinely used for the presentation and interpretation of gridded radioelement data. Where digital elevation data are available, these colour representations can be draped over the elevation data to form 3D perspective views, or hillshaded derivatives of the DEM can be embedded into the ternary imagery as an intensity component. These are useful because the radioelement response can then be interpreted within the context of the relative position of anomalous features in the landscape. However, subtle variations in the concentrations of K, U, and Th are best interpreted using the ratios of the radioelements. The U/Th and U^2/Th ratios are important indicators of uranium mineralization. The Th/K ratio is widely used for the detection of several styles of mineralization associated with K alteration. For the interpretation of map data, classification/clustering methods can be used to assist pattern recognition and are useful for the rapid assessment of large multivariate datasets. Automatic edge detection procedures can be used to speed up the annotation of unit boundaries. Residual modeling or normalising techniques can be used to highlight potential anomalies in the data.

6. APPLICATIONS OF GAMMA-RAY TRANSPORT MODELING TO IMPROVING BOREHOLE LOGGING FOR URANIUM

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Borehole logging for uranium was much studied in the late 1970s–early 1980s and required building large concrete calibration pits. Codes for Monte-Carlo, gamma-ray transport modeling were then the specialty of large nuclear research institutions. Today, building concrete pits is difficult but sophisticated modeling codes are freely available. For example the GEANT code, used in this study, is available from CERN and gamma-ray problems can be evaluated by modeling rather than experiment and this paper illustrates three examples of recent applications of the modeling approach.

Firstly, in the early 1980s, deconvolution methods were developed to remove the effects of an uncollimated detector from borehole data. However, because fast-Fourier Transform software was not available, this work relied on equivalent space-domain filters. Recent work to reevaluate the method has required the response of a thin-bed source calculated out to distances not possible with concrete models, something easily achievable with the software.

A second recent study examined the effect of very high U grades (up to 50%) on the response of total count tools. Uranium self-adsorbs low energy radiation (the so-called Z-effect) but modeling revealed an intriguing response that at high U grades, the response of a detector actually rose as the amount of casing and water in the borehole increased. This was a consequence of increased scatter to low energies being measured by the total count instrument.

Finally a new detector-type has been recently introduced made from cerium-doped, lanthanum bromide. These BrilLanCe detectors offer higher resolution than other room-temperature detectors but modeling confirmed that the resolution was still not sufficient to allow direct U logging by looking at the 1.00 MeV peak from 234 mPa.

7. PINE CREEK AIRBORNE ELECTROMAGNETIC SURVEY RESULTS

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In 2008–2009 Geoscience Australia, contracted Fugro Airborne Surveys and Geotech Airborne Geophysical Surveys, to respectively acquire TEMPEST and VTEM airborne electromagnetic (AEM) data with broad line spacings (up to 5 km) covering more than 71 000 km^2 in the Pine Creek region, Northern Territory. The Pine Creek survey is the second regional AEM survey funded by the Onshore Energy Security Program (OESP) at Geoscience Australia. To facilitate interpretation, subsurface electrical conductivity predictions using a layered earth inversion (sample by sample) algorithm developed by Geoscience Australia (GA-LEI) were derived from the AEM survey data. Products derived from the model-dependent earth conductivity predictions include: conductivity distribution point located data; conductivity depth sections; conductivity depth slices and conductance distribution grids and images. The inversion results have contributed to the improved understanding of the area's geology and mineral potential by mapping the conductivities of different geological and hydrogeological units under cover, in particular the interpreted presence of conductive units in the Pine Creek Orogen; depth to the unconformity between the Pine Creek Orogen and the Kombolgie Subgroup and depth and extent of the Woolner Granite and Koolpinyah Dolomite. This poster outlines the survey specifications, objectives, and describes the geophysical results at a regional scale.

8. A MAGNETIC SURVEY AT HISTRIA NECROPULIS

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Near surface geophysical methods are used in archaeology to estimate the distribution, depth, form and physical properties of the buried features before digging. For studying the burial mounds from the Histria necropolis was chosen the micromagnetic method conducted with a proton procession magnetometer in rectangular panels with a sampler interval of 2 m, resulting 16 profiles for each mound.

Histria necropolis is located north-west from Histria citadel and is formed from elevated burial mounds with different characteristics and structures. Previous archaeological studies encountered several burial rites, including pyre incineration. These studies revealed even metallic remains of the actual pyre and a burnt shaly horizon with an increased magnetic susceptibility.

The magnetic maps of the two studied burial mounds indicate a very complex archaeological situation, also distinguished in the actual archaeological diggings. There are some anomalous aspects that could correspond to some ceramic fragments, to greenshists used to mound building and to some metallic objects such as shields or darts. The presence of metallic objects and ceramics within the burial mounds was strongly connected to afterlife belief.

Archaeological remains usually generate small local magnetic anomalies in the range of 1–20 nT. Among the archaeological features, more magnetic are ferrous objects and structures that exhibit remanent magnetization or have great magnetic susceptibilities. Remanent magnetization is associated with ancient burned structures and objects such as ceramics, hearths, fire pits, fire-altered soils.

9. COMPLETE BOUGUER ANOMALIES FOR THE AUSTRALIAN NATIONAL GRAVITY DATABASE

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The Australian National Gravity Database (ANGD) contains over 1.8 million gravity observations from over 2000 surveys conducted in Australia over the last 80 years. Three processes are required to correct these observations for the effects of the surrounding topography: firstly a Bouguer correction (Bullard A), which approximates the topography as an infinite horizontal slab; secondly a correction to that horizontal slab for the curvature of the Earth (Bullard B); and thirdly a terrain correction (Bullard C), which accounts for the undulations

in the surrounding topography. These three corrections together produce complete bouguer anomalies.

The spherical cap bouguer anomaly calculation that is applied to data extracted from the ANGD since February 2008 applies the Bullard A and Bullard B corrections. Terrain corrections, Bullard C, have now been calculated for all terrestrial gravity observations in the ANGD allowing the calculation of complete bouguer anomalies. The terrain corrections were calculated using the Shuttle Radar Topography Mission 3 arc-second digital elevation data to a radius of 166.7 km. This radius corresponds to that of the spherical cap used for the bouguer correction.

The complete bouguer anomalies calculated for the ANGD provide users of the data with a more accurate representation of crustal density variations through the application of a more accurate earth model to the gravity observations.

10. A NEW AUTOMATED METHOD TO DETERMINE DEPTH TO MAGNETIC BASEMENT – THE GAWLER CRATON DEPTH TO BASEMENT MAP

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A new method has been developed to determine the depth to magnetic basement. This method uses an efficient automated approach that produces depth estimates via inverse modelling the azimuthally averaged log of the power spectra of gridded airborne magnetic data. The model consists of a horizontal slab possessing band limited fractal magnetisation. The sensitivity and uncertainty of the depth estimates were analysed based on the magnetic slab's fractal property using Bayesian analysis via Markov chain Monte Carlo and Jeffery's prior. A sliding window technique with an appropriate amount of overlap to the adjacent data window has been applied to a magnetic grid of the Gawler Craton region. The window size selected was optimised to produce depth estimates for relatively shallow magnetic sources due to the relatively thin cover material in the region. The resulting depth estimates were combined with drill-hole data and seismic data and then gridded using the minimum curvature technique to produce a depth to basement map of the region. The new automated depth method was developed within Geoscience Australia's Geodynamic Framework Project, part of the Onshore Energy Security Program.

11. STUDY OF APPARENT RESISTIVITY OF A SPHERE BURIED IN A HORIZONTAL LAYERED STRUCTURE

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Detecting of spherical anomalies is an important case in exploration of some mineral bulks and cavity exploration in runways. The effect of a spherical anomaly, located in a half space is studied by different authors.

In this paper, the potential of a sphere buried in two layered earth is obtained by theoretical calculation as a forward modeling. Both of layers are assumed homogeneous and isotropic and the sphere is located into the first layer. Two current electrodes are positioned in far distance with the anomaly in a symmetric array. The electric flux, produce a uniform electric field into the earth.

The electric field polarize the buried sphere as induced electric charges situate in two sides of sphere and orient opposite the primary uniform field. In practice the electrical charges on two sides of sphere will be equivalent with an electric dipole. The potential of a buried sphere into a half space earth is obtained by solving the Laplace equation with applying boundary conditions and considering an electrical image of sphere in relation to the earth's surface.

Using these calculation and considering large number of electrical images, yield an explicit expression for total potential. Desired potential in various situations with parametric variations of problem is calculated by computer programming as a numerical analysis. At last apparent resistivity of structure is computed in different conditions and compared with each other in plotting modes.

12. FAULT SHADOW DISTORTIONS ON 3D SEISMIC DATA AND THEIR REMOVAL BY DEPTH PROCESSING

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In many areas so-called Fault shadows manifest a serious challenge to seismic imaging. The major part of this problem is caused by velocity variations associated with the faults. Pre-stack depth migration with sufficiently accurate velocity model successfully resolves this problem and the high resolution tomographic depth-velocity modeling is the most important component of the solution.

It was noticed during depth processing on a number of real 3D seismic datasets affected by the Fault shadows from Australia and other regions that:

- the appearance of the image distortions below the faults and the convergence speed of the tomographic velocity inversion depend on the acquisition direction;
- sometimes, tomographic modeling produces depth-velocity models that closely follow geology, but in other areas, the models contain non-geologically looking anomalies; in both cases the depth migration delivers distortion free images;
- if anisotropy is present in faulted areas, it creates additional image distortions and requires extra efforts to solve them.

In order to examine these effects and optimize our depth-processing workflow we created several 3D synthetic seismic datasets for different types of velocity anomalies associated with the faults in isotropic and anisotropic media and different acquisition directions.

On synthetic and real data we illustrate different types of Fault shadows and show how they can be solved depending on the acquisition direction. We show that some types of the Fault shadows require multi-azimuth illumination to guarantee their successful removal.

13. MIGRATION OF DUPLEX WAVES FOR COAL-BED METHANE PREDICTION

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The coal fields can as well be the methane reservoirs. In many regions of the world (USA, Canada, Australia and others) methane production at coal fields is commercially viable. The most important condition for gas migration from gas-produced rocks like coal or organic deposits of enclosing it rocks is natural fracturing.

Basic seismic exploration techniques aimed at prospecting for fractured zones are based on study of azimuthal anisotropy of reflected wave velocities and amplitudes. 3D seismic exploration techniques are efficient in the case of pronounced HTI-environment that leads to effective azimuthally-dependent anisotropy. However, in case when coal gas saturates some fractured zones (the thickness of which does not exceed several tens of meters) isolated by non-disturbed rocks, azimuthal anisotropy does not practically manifest itself.

This paper focuses on the opportunity of imaging near-vertical reflecting objects responsible for zones of gas-saturated fracturing. For this purpose we use duplex wave Kirchhoff depth migration. The term duplex wave describes propagation paths with a double reflection involving a reflecting base boundary and a near vertical feature. By means of these waves images of sub-vertical boundaries can be obtained.

A case study of imaging gas-saturated fractured zones is based on 3D seismic exploration data obtained in the Donets Coal Basin (Ukraine). It is shown that joint analysis of structural interpretation data, seismic facies studies and the results of duplex wave migration allows to expect improving efficiency of coal methane prediction.

14. MARINE SEISMIC PROFILING AND SHALLOW MARINE SAND RESISTIVITY INVESTIGATIONS IN JERVIS BAY, NSW, AUSTRALIA

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A marine continuous seismic profiling (CSP) study and a resistivity study of Vibrocore samples of shallow marine sands were undertaken in Jervis Bay, NSW, Australia, to characterise the seabed. The CSP study also included Crookhaven Bight adjacent to Jervis Bay facing north-east to the ocean. The results of the CSP studies show variable geological conditions below the seabed, indicating very dense sands and variably weathered sandstones. The bedrock surface was also highly irregular in places suggesting cyclic erosional pulses under rapidly falling sea levels at various times in the past. Bedrock was found to form the seafloor in some locations and deeply incised paleochannels extending to –62 m AHD in the Crookhaven Bight area. The surveyed areas in Crookhaven Bight and entrance to the bay demonstrate the highest variability of overlying sediment thickness. The sampled sands had very low magnetic susceptibilities, thus corroborating the visual impression of low clay content. However, a variety of grainsizes, grainshapes, colours and cohesions were noted. These factors, together with variations in inferred porosity, gave rise to a range of resistivities, which, when temperature corrected, plotted with some scatter about appropriate Archie Equation curves. Initial direct tests on the parent PVC core tubes, were deemed unreliable owing to the possibility of unseen voids and channels which shunt current in parallel. Resistivity measurements on subsamples in four electrode cells were deemed generally satisfactory for the purposes of the study. Resistivity values recorded ranged from 1.2 to 0.8 Ωm (20°C) for 32 samples obtained from 11 sites.

15. MARINE SEISMIC PROFILING AND SHALLOW MARINE SAND RESISTIVITY INVESTIGATIONS IN BROKEN BAY, NSW, AUSTRALIA

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A marine continuous seismic (CSP) profiling study and a resistivity study of Vibrocore samples of shallow marine sands were undertaken in Broken Bay, NSW, Australia, to characterise the seabed. The acoustic impedance contrast between deeper sediments and the anticipated sandstone, as observed in the CSP study, was variable suggesting very dense sands, evident as layered sediments owing to regression/transgression of sea level, and variably weathered sandstones.

The bedrock surface was highly irregular indicating significant erosional pulses under rapidly falling sea levels at various times in the past. Interpreted bedrock levels vary considerably across the survey area.

A broad deep channel representing a high-energy paleo-fluvial drainage system in the Hawkesbury outreaches is identified, extending to ~–80 m AHD. Another area is indentified as a drowned river valley with a dentritic fluvial pattern extending to ~–70 m AHD. A moderately narrow paleovalley extending to –90 m AHD either side of the Palm Beach tombolo is clearly identified. The sampled sands had very low magnetic susceptibilities, thus corroborating the visual impression of low clay content. However, a variety of grainsizes, grainshapes, colours and cohesions were noted. These factors, together with variations in inferred porosity, gave rise to a range of resistivities, which, when temperature corrected, plotted with some scatter about appropriate Archie Equation curves. Initial direct tests on the parent PVC core tubes, were deemed unreliable owing to the possibility of unseen voids and channels which shunt current in parallel. Resistivity measurements on subsamples in four electrode cells were deemed generally satisfactory for the purposes of the study. Resistivity values recorded ranged from 1.3 to 0.7 Ωm (20°C) for 64 samples obtained from 17 sites.

16. THE GENERATION OF STARTING MODELS FOR REFRACTION INVERSION FROM MULTI-FOLD SEISMIC DATA WITH THE GRM

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The tau-p algorithm is widely used to generate starting models for most computer programs which employ refraction tomography. However, model and case studies demonstrate that

this algorithm frequently generates artifacts in both seismic velocities and depths.

The shortcomings of the tau-p algorithm are directly related to its inability to determine true seismic velocities from downdip and updip apparent seismic velocities. In near-surface seismic refraction investigations there can often be significant lateral variations in depths and seismic velocities over relatively short distances, and in some cases, the apparent seismic velocities can even be negative. It can be concluded that the tau-p algorithm is not suitable for the majority of applications of near-surface seismic refraction methods to geotechnical and environmental investigations.

The shortcomings of the tau-p algorithm are readily addressed with inversion algorithms which explicitly identify forward and reverse traveltimes, within the algorithms, such as the generalized reciprocal method (GRM). This study presents novel adaptations of the standard GRM algorithms, for generating quite detailed models of the seismic velocities and time models of the near-surface, using multi-fold data. These modified GRM algorithms generate a single value at each station for a given source separation. By employing a systematic increase in the source separation, deeper refractors, as well as vertical velocity gradients within individual refractors are mapped. The results are suitable for the quality control of traditional refraction inversion methods, or for use as starting models for refraction tomographic inversion.

The modified GRM algorithms are well suited to rapidly and efficiently processing large volumes of data, such as that obtained with routine multi-fold roll-through seismic reflection acquisition operations, but not the data acquired with static spreads routinely employed in geotechnical investigations. The approach is illustrated with two case studies, each of which consists of more than 250 000 individual traveltimes.

17. THE COMPUTATION OF ATTRIBUTES FROM SEISMIC REFRACTION DATA

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The reconciliation of geophysical results with bore hole data represents an ongoing challenge to the useful integration of geosciences with engineering in geotechnical site characterization. Anecdotal evidence emphasizes the regrettable lack of effective communication between the two professions (Danbom, S. H., 2005, Special challenges associated with the near surface, in Near-surface geophysics, Dwain K. Butler (ed.) Investigations in geophysics no. 13, 7–29, SEG).

By contrast, the effective integration of bore hole data with its superior vertical resolution with seismic data with its superior spatial resolution is routine with petroleum exploration and production applications. In particular, multi-attribute transforms are employed to predict petrophysical properties measured in bore holes from the seismic data (Hampson, D. P., Schuelke, J. S., and Quirein, J. A., 2001, Use of multiattribute transforms to predict log properties from seismic data. *Geophysics* **66**, 220–236; Russell, B., 2007, Integrating multiple maps for reservoir prediction, http://www.cggveritas.com/technicalDocuments/443_Emerge_Geostats.pdf).

A seismic attribute is any measure that helps to better visualize or quantify features of interest in seismic data, and they comprise morphological attributes and reflectivity attributes (Chopra, S., and Marfurt, K. J., 2007, Seismic Attributes for Prospect Identification and Reservoir Characterization. Geophysical Developments 11, Society of Exploration Geophysicists). This study presents attributes, which are derived from seismic refraction data using the generalized reciprocal method and the refraction convolution section, such as detailed seismic velocities in the refractor, head wave amplitudes, the optimum XY value, and various combinations and transforms of these attributes. These refraction attributes are sensitive to important petrophysical parameters, such as rock strength and depth of weathering.

18. NON-UNIQUENESS WITH REFRACTION INVERSION – THE MT BULGA SHEAR ZONE

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The tau-p inversion algorithm is widely employed to generate starting models with many computer programs which implement refraction tomography. However, this algorithm can frequently fail to detect even major lateral variations in seismic velocities, such as a 50 m wide shear zone which is the subject of this study.

By contrast, the shear zone is successfully defined with the inversion algorithms of the generalized reciprocal method (GRM). The shear zone is confirmed with a 2D analysis of the head wave amplitudes, a spectral analysis of the refraction convolution section, and with numerous closely spaced orthogonal seismic profiles recorded for a later 3D refraction investigation.

Further improvements in the lateral resolution of the seismic velocities, which facilitate the definition of additional zones with moderate reductions in seismic velocity, are achieved with the use of the Hilbert transform. However, the recognition of these additional zones is also dependent upon the determination of the optimum XY value as well as the use of a lower average vertical seismic velocity which accommodates a probable velocity reversal in the weathering. By contrast, the major shear zone is readily detected with non-optimum XY values.

Although all of the tomograms are consistent with the traveltime data, the resolution of each tomogram is comparable only with that of the starting model. Therefore, it is essential to employ inversion algorithms which can generate detailed starting models.

Non-uniqueness can often be readily resolved with head wave amplitudes, attribute processing of the refraction convolution section and additional seismic traverses, prior to the acquisition of any borehole data. It is concluded that, unless specific measures are taken to address non-uniqueness, the production of a single refraction tomogram which fits the traveltime data to sufficient accuracy does not necessarily demonstrate that the result is either correct, or even the most probable.

19. DETAILED REFRACTOR IMAGING WITH THE RCS

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The refraction convolution section (RCS), which is generated with the convolution of forward and reverse traces at each

station, can image a substantial region both above and below the interface defined with scalar traveltimes and standard refraction inversion methods. The vertical extent of the imaged region, which is consistent with the refraction Fresnel zone, can be many tens of metres.

In addition to relic weathered structures within the saprolite, dipping structures within the sub-weathering can also be recognized. While the features imaged in the RCS can also be seen in the stacked reflection sections, the advantage of the RCS is that it also images the base of the weathering, whereas the stacked reflection section usually does not.

This study applies standard methods of attribute analyses to the RCS, in order to detect structures within the RCS which have more subtle expressions. It is demonstrated that processes, such as flattening and instantaneous phase, can reveal faults and dipping structures within the refractor. None of these features can be detected with traditional methods of refraction inversion, including refraction tomography, which employ scalar traveltimes.

The RCS images facilitate more useful geological interpretations for mineral exploration, geotechnical site characterization and investigations of contaminant flow in fractured bedrock.

20. NON-UNIQUENESS WITH REFRACTION INVERSION – A SYNCLINE MODEL STUDY

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Non-uniqueness occurs with the 1D parameterization of refraction traveltime graphs in the vertical dimension and with the 2D lateral resolution of individual layers in the horizontal dimension. The most common source of non-uniqueness is the inversion algorithm used to generate the starting model. This study applies 1D, 1.5D and 2D inversion algorithms to traveltime data for a syncline (2D) model, in order to generate starting models for wavepath eikonal traveltime (WET) tomography.

The 1D tau-p algorithm produced a tomogram with an anticline rather than a syncline and an artifact with a high seismic velocity. The 2D generalized reciprocal method (GRM) generated tomograms which accurately reproduced the syncline, together with narrow regions at the thalweg with seismic velocities that are less than and greater than the true seismic velocities as well as the true values.

The determination of vertical velocity functions within individual layers is also subject to non-uniqueness. Depths computed with vertical velocity gradients, which are the default with many tomography programs, are generally 50% greater than those computed with constant velocities for the same traveltime data. The average vertical velocity provides a more accurate measure of depth estimates, where it can be derived.

Non-uniqueness is a fundamental reality with the inversion of all near-surface seismic refraction data. Unless specific measures are taken to explicitly address non-uniqueness, then the production of a single refraction tomogram, which fits the traveltime data to sufficient accuracy, does not necessarily demonstrate that the result is either ‘correct’ or the most probable.

21. IS VIRT AN EFFICACIOUS STRATEGY FOR REFRACTION INVERSION?

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Visual interactive ray trace (VIRT) inversion is a manual approach to refraction tomography. Refraction tomograms produced with wavepath eikonal traveltime (WET) tomography using smoothed and detailed starting models generated with the generalized reciprocal method (GRM) have smaller errors than tomograms obtained with VIRT tomography and with WET tomograms generated with VIRT starting models.

The VIRT tomograms neither detect nor define a major 50 m wide shear zone with a low seismic velocity at Mt Bulga. This failure is attributed to the probable use of a low resolution starting model, specifically the tau-p WET tomogram, for the VIRT inversion. Alternatively, the conventional reciprocal method has been used to generate a starting model, in which the existence of the low velocity region is unambiguous. In this case, confirmation bias has been employed to remove any expression of the low velocity region in the VIRT tomogram.

VIRT tomography generates complex velocity models of the weathering from relatively small numbers of traveltimes, indicating that the inversion process is poorly constrained and even unstable. The extensive use of vertical interfaces across which there are large contrasts in seismic velocities is not consistent with standard models of normal weathering profiles.

VIRT neither improves the accuracy nor the geological verisimilitude of refraction tomograms. Furthermore, VIRT is time consuming, subject to confirmation bias, and in the final analysis, outdated. While it can be concluded that technically, VIRT is efficacious, the alternatives of automatic refraction tomography are more practical, more accurate, and generate more useful tomograms.

22. IMAGING THE BASE OF THE WEATHERING BY STACKING SHOT RECORDS

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The generation of a time model of the weathering for statics corrections for the processing of seismic reflection data is critically dependent upon the signal to noise ratio of the first break refraction data. In arid areas, the signal-to-noise ratios can be very low, often because of the common occurrence of sand dunes. In other areas, biogenic gas generation can result in significant gas saturation in porous formations, which strongly attenuate all seismic energy.

This study presents a new method for stacking shot records. A comparison shows that the improvements in the signal-to-noise ratios can be quite significant, even with relatively low fold of stacking.

Although the stacking of shot records is a more effective strategy for improving signal-to-noise ratios than stacking the refraction convolution section, it is not able to image geological structures within the saprolite or below the base of the weathering.

23. A POTENTIAL FIELD APPROACH TO DEFINING THE MARGINS OF THE WEST AUSTRALIAN CRATON

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The margins of the West Australian craton (WAC) have been largely identified from magnetic and gravity datasets. However, the nature of these boundaries at depth and their associated structural architecture are poorly understood.

During the lateral accretion of material to the margins of the WAC in the Proterozoic, major lithospheric structures would have developed due to the significant amounts of strain associated with collision, and rheological heterogeneity between the craton margin and the crustal material being accreted.

These boundaries may have been favoured sites for mineralisation because they are likely to reflect ancient plate margins that are characterised by elevated heat flow and lithospheric penetrating faults systems able to tap the deep crust and mantle lithosphere. Significantly, these boundaries may have occupied the position of ancient arcs, which on the modern Earth have been shown to favour the development of mineral districts.

Major lithospheric structures associated with craton margins are investigated using potential field data. Aeromagnetic and gravity data are used to map and characterise major upper crustal structures. Gravity inversions of lithospheric scale 3D models are used to identify steps in Moho topography associated with mantle penetrating craton margin structures.

Linking upper crustal features with those identified at Moho depths allows the mapping and definition of these major boundaries in the lithosphere that may be host to significant economic deposits.

24. MULTIATTRIBUTE ANALYSIS OF EAST JAVA BASIN CARBONATE REEF BUILT-UP

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The use of three-dimensional (3-D) seismic attributes to predict reservoir properties is becoming widespread in much area, one of the most underutilized aspects of the methodology is that the property prediction maps can help geoscientists understand depositional and post depositional controls on reservoir development.

Seismic data are built by various seismic attributes such as amplitude, frequency, phase, time and their derivative. Multiattribute analysis is a technique using geostatistics approach to define log properties from seismic data. In simple way seismic attribute shape is used to estimate the nature of log properties shape such as porosity, density and other well logs properties.

We illustrate this point via a case study that examines an Early Miocened-aged carbonate built-up of Tuban Formation in East Java Basin. In the first attempt, seismic analysis is carried out to characterize carbonate facies by utilizing seismic attributes such as Instantaneous Frequency and Reflection then made positive average maps for 200 ms above and below interpreted Turban Carbonate interval. This approach is carried out for 3-D Sukowati Seismic.

The target log of this multiattributes study is porosity log in order to construct porosity cube controlled by nine wells log data which then utilized for reservoir mapping based on the distribution of carbonate reef built-up.

25. LINKS BETWEEN CATCHMENT EROSION AND CLIMATE INVESTIGATED WITH URANIUM SERIES ISOTOPES

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To understand how our environment responds to climate change and to human activity, we need to constrain the rates of processes that shape the Earth's surface. Some of these processes are the production of soils by physical and chemical weathering of rocks and the transport of sediments from source areas (often soils in elevated upper areas) to oceans. These processes are controlled either directly or indirectly by climate change. Studying the history of the sediments deposited throughout the river and its palaeochannels can give insight to the history of climate change occurred.

A new approach using uranium series isotopes has been devised and being used recently to address the questions presented above (DePaolo et al., 2006). The decay of ^{238}U causes recoil on the daughter product (^{234}Th, which rapidly decays into ^{234}U) to be displaced from its original position (Kigoshi, 1971). If the decay is occurring within the recoil range at the surface of the grain (30 nm), the daughter product will be lost. This creates a depletion of ^{234}U in the surface of the grain. This depletion causes disequilibrium in the ($^{234}U/^{238}U$) activity ratio and is detectable in grains of size ~50 μm or less. During physical weathering, fine grains of these sizes are generated and these grains can be analyzed to measure the disequilibrium ($^{234}U/^{238}U$) activity ratio, which in turn marks the age since production. Sediments are transported by rivers and deposited at lowlands. The time since the grains started losing ^{234}U, defined as 'comminution age' represents the amount of time elapsed since production from the bedrock by physical weathering.

Cosmogenic isotope data of denudation rates of the upper catchment area (Frogs Hollow) of the Murrumbidgee River has been reported by Heimsath et al. (2001). However, storage time of the sediments in weathering profile is the same as the comminution age of the grains in the weathering profile. We will report the soil production rate at Frogs Hollow we obtained from the disequilibrium of uranium isotopes caused by recoil loss.

Under the existing equipments and interpretation technologies, the vertical resolution of CSAMT achieves about 10% to 20% of the exploration depth. In fact the structure consists of thin laminated layers can only be identified as a macroscopic electric layer. With the concept of average function in mathematics, three equivalent methods named geometry-harmonic mean, arithmetic-harmonic mean, and square-harmonic mean are defined to equivalence between the thin laminated layers model

and transverse isotropic one. Through numerical calculation and comparison the CSAMT responses in the near-field zone, transition zone and far-field zone, the approximate accuracies of these three equivalent models are discussed in detail.

27. A GEOLOGICAL INTERPRETATION OF THE TALLARINGA AND OOLDEA MAGNETIC SURVEYS

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Two magnetic surveys (Tallaringa and Ooldea) were flown for PIRSA and GA over 2005–2006. Grids of the two surveys have been stitched together to produce a TMI RTP image and a 1VD AGC image. These, combined with the gravity over the area, have been used to produce a geological model of the basement of the area. The predominant geological units appear to be the Moondarah Gneiss (Proterozoic), three other unknown Proterozoic units, the Mulgathing complex (Archaen) and two other unknown Archaen units.

The lack of outcrop in the area means that all geological information comes from drillhole data. However, with only 11 drillholes actually intersecting basement, the choice of geological units are largely based upon similarities in geophysical signatures. The cover is largely Quaternary, Tertiary and Cambrian sediments, none of which are considered crystalline basement. The only Post-Cambrian feature shown on the map is the One Tree Anomaly; shown as a series of short magnetic highs. This feature is not very well understood and the two leading theories suggest that it may be a paeleochannel or the contact between two geological units. I have adopted the theory that it is a paeleochannel based on the fact that the geophysical response either side of the anomaly is largely similar. A possible extension of the Karari shear zone is interpreted to be constituted of the Moondarah Gneiss.

28. APPLICATION OF SOPC IN HIGH-PRECISION GEOELECTRIC DATA ACQUISITION SYSTEM

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SoPC technology based on FPGA is a flexible and efficient countermeasure for system-on-chip, which provides a new way to develop high-precision geoelectric data acquisition devices. This paper introduces the application of SoPC technology to research and design of an A/D conversion Controller which complies with the time sequence of CS5372, a module converting the serial data to parallel one. A resampling FIR digital filter using Matlab and DSP Bulider, a NIOS II Soft IP Core integrated by Quartus Ⅱ and a PC software designed with LabVIEW. Under the application of equipments mentioned above, Cyclone chip, which replaces expensive CS5376, can be used to realize the acquisition of the high-precision geoelectric data. As the result shown, the use of the technology of SoPC can greatly improve the cost-effectiveness of high-precision geoelectric data acquisition devices and also can integrate the digital parts of geoelectric data acquisition devices into a chip, which also provide an effective way to solve problems under the complex geoelectric conditions.

29. TWO-DIMENSIONAL REGULARIZATION INVERSION OF MAGNETOTELLURIC DATA FOR DEEPER MINERAL EXPLORATION: AN EXAMPLE FROM THE SANJIANG RIVER COPPER DEPOSIT

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As near-surface ore bodies are depleted, the exploration for economic minerals requires information from deeper depths. The magnetotelluric method has the necessary depth capability, unlike many of the controlled-source electromagnetic prospecting techniques traditionally used. The geological setting of ore deposits is usually complex, requiring two-dimensional or three-dimensional Earth models for their representation. An example of the applicability of two-dimensional inversion of magnetotelluric data to mineral exploration is presented here. The magnetotelluric inverse problem is ill-posed and the inverse results are unstable and non-unique. It means that different geo-electrical model could fit the observed data with the same accuracy. A stable solution of the ill-posed inverse problem can be obtained by utilizing the regularization methods in the objective function. Solving large scale linear equation of inverse problem, the damped Gauss-Newton algorithm was adopted, which can improve local convergence of Gauss-Newton method. On the one hand, inversion of TE-mode data is more sensitive for the low abnormal body and has poor resolution for the high abnormal body. On the other hand, inversion of TM-mode data has better resolution for the high abnormal body. Jointed two-mode data inversion is able to achieve better model and stack quality in considerably fewer iterations. In order to better inversion results, TE- and TM-mode magnetotelluric data are jointed. Through two-dimensional regularization inversion of the field data, the Sanjiang River copper deposit is located.

30. REGULARIZED EQUIDIMENSION INVERSION OF GRAVITY DATA

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The inversion of gravity data is to recover a 3-D distribution of density contrast based on the gravity observation data. In reality, we can merely utilize the limited and discrete gravity data known only on the surface in the inversion. That causes the inherent non-uniqueness and low depth resolution of the gravity data inversion results. In this paper, we developed a new method of the regularized equidimension inversion (REI), which achieved the inversion of the 3-D gravity anomaly model with 3-D gravity anomaly data. We combined the BG theory and Tikhonov regularization method, developed the regularized inversion of the potential field data. The character of equidimension inversion is to inverse the subsurface model utilizing the 3-D anomaly data. The 3-D anomaly is including the anomaly data of several height planes besides the 2-D anomaly data of the surface.

Steady and higher accuracy inversion results can be obtained by utilizing the regularization even the observation data with errors. The accuracy of the 3-D REI of gravity data is better than the accuracy of the current inversion which is utilizing the singular gravity anomaly data on the surface, and this new application is a powerful way for the improving of the depth resolution. The accuracy of the inversion and the improvement of the depth resolution are better as the increasing of the number of data layers on the height because the data in different heights contain the information of the subsurface anomaly orebody in different depth.

31. GEOPHYSICAL CHARACTERIZATION AND MONITORING OF SUBSURFACE DRIP IRRIGATION WATER, POWDER RIVER BASIN, WYOMING, USA

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Subsurface drip irrigation (SDI) has recently been implemented as a means for beneficially disposing of water co-produced with coal bed methane in the Powder River Basin (PRB), Wyoming. Because of the sodic and moderately saline nature of the PRB water, careful application is needed in order to prevent damage to the near-surface soil structure or salinization of the soils and deeper groundwater system. Repeated electromagnetic (EM) geophysical surveys have been carried out at one SDI site to characterize baseline conditions and monitor changes in subsurface properties over time. The GEM-2, a multi-frequency electromagnetic instrument that is primarily sensitive to the subsurface electrical conductivity structure, was towed along 20 m spaced survey lines over multiple irrigation fields covering approximately 1.4 km^2.

The EM geophysical data can be utilized to help monitor the fate of the SDI water because changes in subsurface electrical conductivity (EC) can be attributed to changes in saturation and/or salinity. Properly quantifying these subsurface changes in terms of meaningful EC values and their spatiotemporal distribution requires survey procedures and data processing strategies that reduce systematic instrument errors (drift and calibration) as well as random noise. We present strategies for filtering, calibrating, and inverting the multi-frequency EM data that are specifically designed to preserve important spectral relationships within the data that are lost when using traditional processing methods. The data collection and processing methods presented here result in frequency domain electromagnetic data that are inverted to recover models that can be quantitatively interpreted both in time and space.

32. RADIOMETRIC ANOMALIES OF SOUTH AUSTRALIA

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Analysis of airborne radiometric surveys across South Australia has identified a number of regions with anomalously high radiometric responses. These anomalies occur across the State including east of Lake Frome, SAEI A3 anomaly east of Ceduna and Lake Gairdner. The anomalies range in size from small playa lakes to nearly a hundred kilometres long and analysis of survey data shows high responses occurring across multiple flight lines indicating that the response is geologically motivated, rather than related to instrumentation.

Several geological scenarios are proposed as the source of the anomalies from palaeochannel uranium mineralisation to radon concentration. Individual anomalies were assessed via an integrated geophysical and geological approach to determine their genesis. Ground gamma ray spectrometry surveys were collected along with X-ray diffraction analysis of rock formations in the field using a Nitron handheld XRF. Samples were collected for more complete geochemical lab analyses and the region was mapped geomorphologically to determine possible transport systems for the anomaly. These different datasets combine to give a more complete picture of the sources for radiometric anomalies enhancing our understanding of geology and potential mineral systems.

33. BAYESIAN STOCHASTIC INVERSION (A CASE STUDY FROM AN IRANIAN OIL FIELD)

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We have implemented an estimation procedure whereby wireline data can be extrapolated away from existing well using geostatistical inversion of post-stack 3D seismic data. This procedure works directly in a fine-scale stratigraphic grid, and is conditioned by well data and seismic stack. It uses a Bayesian framework and a linearized, weak contrast approximation of the Zoeppritz equation to construct a joint log-Gaussian posterior distribution for P- wave impedances. Variograms are also estimated from well-log, seismic data and acoustic inversion results that define the expected degree of lateral smoothness away from the well. A sequential Gaussian Simulation algorithm is applied to sample the posterior PDF and generates multiple, high-resolution realizations of the acoustic impedance which can be utilized to generate stochastic realizations of petrophysical variables that not only honor the well-log data, but most importantly, that fully honor the 3D seismic.

Sensitivity analysis was also performed to find the optimum values for S/N ratio, Variogram ranges and prior standard deviation. We had just one well in the area and proffered to keep it to perform quality control of the inversion results. Without constraining with well, geostatistical inversion still can be used to estimate acceptable static reservoir model for the subsequent simulation and planning of in-fill drilling and/or enhanced-oil-recovery operations.

34. COMPUTATION OF POROSITY USING SAND AND CARBONATE ROCK PHYSICS MODELS IN AN IRANIAN OIL FIELD

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In this case study, we have employed post stack inversion, guided by rock physics, to estimate reservoir porosity in an Iranian oil field. The reservoir, based on the lithology and porosity information can be divided into 8 zones and 19 subzones with lithologies comprised of shale, sand and carbonates. Among them, three zones above WOC are carbonate and sandstone. We use different rock physics model to estimate

porosity from wire line data and seismic data. The procedure uses stack and estimated wavelet to determine the elastic parameters: P-wave impedance. Different rock physics model were applied to relate acoustic impedance (AI) to porosity. This allowed performing rock physics analysis, not only on well log data, but also on seismic data (post stack inversion results). The poststack inversion of AI within the target zone was projected onto the template to generate porosity volume. One of the most important issues in carbonate rock physics is fracture distribution. Petrophysical analysis in carbonate sections of the reservoir shows that the fracture distribution is limited and production is mostly from matrix porosity. Fractures in the carbonate zone are mostly joints with 0.5 mm opening and 15 cm in length, so the isotropic medium assumption can be made. The results show that Nur-Dvorkin (1996) model and Raymer-Greenberg-Castagna (1997) are appropriate for predicting porosity in sandstone and carbonate zone of the reservoir respectively and predict porosity up to 30% which shows good agreement with the porosity values measured from well log data.

35. STREAMING: VEHICLE-BORNE RADIOMETRIC SURVEYING IN SA – PAST, PRESENT AND FUTURE

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Compilation of the first State radiometric image was commenced almost a decade ago. Preparation was hampered by vastly differing ages and quality of data. To overcome this, a back calibration method was adopted that derives the true ground concentrations of the three radio elements, U, TH and K.

One major setback of this method however, was the significant time required to back calibrate each individual survey. In order to dramatically speed up the process, a vehicular-mounted streaming calibration system has been utilised that allows radiometric data to be recorded continuously whilst driving.

In recent years, use of this method has progressed to successfully undertake ground based exploration procedures. Numerous quality tests have been completed, including a direct comparison with airborne data near Peterborough, a ground based grid near Quorn, dose rate monitoring at Radium Hill, and several dirt versus bitumen tests.

Recently Geoscience Australia completed the Australia Wide Airborne Geophysical Survey (AWAGS2). This survey consisted of a number of magnetic and radiometric tie-lines over the Australian continent, and around the coast. The results from both the State streaming and national AWAGS2 surveys compare favourably.

Future uses of this method will tend towards regional and detailed surveys as an aid to mapping over project areas.

36. THE LATEST GEOLOGICAL/GEOPHYSICAL INTERPRETATION OF THE NSW MURRAY BASIN BASEMENT

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The *New Frontiers* exploration initiative of the NSW government has commenced the interpretation of regional geophysical datasets for the Ana Branch, Pooncarie, Booligal, Balranald, Hay and Deniliquin 1 : 250 000 map sheet areas. The aim is to encourage exploration to frontier areas of NSW by extrapolating the geology beneath covered areas using regional aeromagnetic, gravity, radiometric, Landsat7, seismic and borehole stratigraphy datasets.

The Pooncarie and Balranald 1 : 250 000 map sheet areas, which were predominantly interpreted using total magnetic intensity (TMI) data, 1VD TMI imagery, Bouguer gravity imagery and 1VD Bouguer gravity imagery, are the latest areas to be interpreted over the Murray Basin. Outcomes of this interpretation are:

- Pipe-like, magnetically susceptible sources that intrude the basement. They have an inferred age of late–Permian and may be indicative of a deep-mantle heat pulse.
- The Hay–Booligal Zone, interpreted as a micro-continent that broke off from the Australian continent, that then rolled back. It consists of Silurian–Devonian sediments overlying an interpreted early-Palaeozoic or Proterozoic basement of crystalline rocks.
- A suture zone of S-type granites along the western border of the Hay–Booligal Zone. The eastern side is bounded by the Boothegandra Fault.
- Curvi-linear magnetic trends, of the Stawell Zone in NSW, that wrap around the Hay–Booligal Zone, were tilted into place by the collision of the Hay–Booligal Zone.

Results of this study provide a greater tectonic understanding of the basement geology in the Murray Basin and postulate deep mantle plume activity in the Permian.

37. WHAT CAN POTENTIAL FIELD DATA REALLY TELL US ABOUT CONTINENT–OCEAN TRANSITIONS?

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Defining the extent of continental and oceanic crust at passive rifted margins is of great importance for hydrocarbon exploration – and also notoriously difficult. A number of methods have been used to estimate continent–ocean boundary (COB) positions on a regional scale; using isobaths; gravity anomalies and gradient maps; gravity inversion magnetic anomalies and spreading rates, and continental stretching factors.

Further complicating matters, many passive continental margins may not exhibit a clear transition from continental to oceanic crust. Seismic refraction profiles across continental margins often define zones of anomalously high velocity crust within or adjacent to the interpreted continent–ocean transition, interpreted variously as magmatic underplating, zones of heavily intruded continental crust, or exhumed and serpentinized continental mantle. In any case, the zones of high velocity crust imply corresponding density variations, which must be taken into account when studying the gravity field over continental margins.

We investigate the ability of gravity and magnetic derivative maps to define the distribution of crustal types at continental margins. Studying these maps where they are to some extent 'ground-truthed' by seismic refraction data, allows us to develop a better understanding of gravity signatures due to crustal

thinning and density variations within the crust – including those of Australian margins with very different characters, the non-volcanic southern margin and the volcanic western margin. We can then evaluate different approaches to the interpretation of Continent–Ocean transitions from potential field data, and determine the level of uncertainty in COTs interpreted from these data where seismic data are sparse.

38. THE MAGNETIC ANOMALY MAP OF AUSTRALIA, 5TH EDITION, 2010

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The 5th edition of the Magnetic Anomaly Map of Australia provides significant improvements to data quality, coverage and resolution over previous editions. Since the 4th edition was published in late 2004, many new high-resolution airborne magnetic surveys have been flown by State and Territory governments. In addition, significant numbers of surveys acquired by companies have now been released as open file. Grids of these new data have been added to the Magnetic Anomaly Grid Database of Australia held by Geoscience Australia, and a new composite grid of the Australian continent produced with a cell resolution of 80 m.

During 2007 a special airborne magnetic and radiometric calibration survey was flown across continental Australia with a north-south line spacing of ~75 km and an east-west tie spacing of ~400 km. This survey was undertaken as part of the Australian Government's energy security initiative. From the magnetic perspective, the aim of this survey was to provide accurate coverage of the intermediate wavelengths (150 km to 400 km) of the Earth's crustal magnetic anomaly field, and these data have been used to constrain the merging of ~800 separate survey grids into the 80 m composite grid.

A new hardcopy map at 1 : 5 000 000 scale will be published in March 2010, along with the release of the 80 m composite grid and various other derivative products to aid interpretations of the data.

39. AUTOMATIC VELOCITY MODEL BUILDING TECHNOLOGY

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The automatic velocity model building technology is a new velocity model building method researched all by ourselves, it had been supported by China Ministry of Geology and Mineral Resources and SinoPec petroleum corporation from 1992 to 2004. We have got Chinese Patent in 2004 after over ten years study. After that, we applied this technology successfully in several work areas of China with different geology conditions, such as foothill complex surface and subsurface structure in the southern part of Tianshan Mountain carbonate platform edge in Tahe area and marine carbonate rock in southern China etc.

This technology includes two main procedures: High Density CDR Velocity Analysis and Constrained Interval Velocity Inversion. High density CDR velocity analysis uses ray parameters at shot and receiver, and the corresponding traveltime to calculate the seismic velocity trace-by-trace at peak times. Its basic procedures include:

(1) Perform time-variant stacking on CMP gather, and automatically pick the traveltimes, amplitudes frequencies wavefield coherences, and ray parameters at shots and receivers for the regular waves.
(2) Calculate the reflection velocities at peak times of trace for each offset using ray parameters at shots and receivers traveltimes as well as the coordinates of the shots and receivers.
(3) Improve velocity accuracy via space-variant time-variant velocity filtering, frequency filtering or dip filtering.

Then we obtain a high dense rms-velocity model in each CMP Gathers.

Constrained interval velocity inversion is a stable inversion method to create a geologically constrained instantaneous velocities from rms-velocity model. The inversion includes five steps: (1) Building a global initial instantaneous velocity trend function; (2) Calculating the rms-velocity by Dix-equation; (3) Performing a constrained least-squares inversion; (4) Modifying the initial velocity and repeat 2 and 3 steps; (5) Interval velocity model establishing. Finally we obtain a smooth interval velocity model for time migration and initial macromodels for depth migration or tomography.

40. SHORT AND LONG WAVELENGTH GEOPHYSICAL FEATURES REFLECTING GEOLOGY AND STRUCTURE IN THE DORADILLA TIN–COPPER–NICKEL DISTRICT, APPROXIMATELY 45 KM SOUTH-EAST OF BOURKE, NSW

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Alteration and intrusion effects in the vicinity of the Doradilla mineral district near Bourke are highlighted by aeromagnetic, gravity and radiometric data. This region is characterised by very flat terrain, a well developed regolith layer, and scarce outcrop. Aeromagnetic data show complex patterns of short wavelength anomalies indicating near-surface lithologies and structures. These are superimposed on a major longer wavelength magnetic feature which is interpreted as intrusion-related magnetism at depth in excess of 1 km. A zone of low density in gravity data is consistent with the intrusion being a granitic body.

The Doradilla area is noted for varied styles of mineralisation: copper mining from the 1900s, skarn-hosted tin mineralisation discovered in the 1970s, and recent identification of a nickel sulphide resource in serpentinite. Two enigmatic geological features are the extensive (>15 km), but narrow (50–80 m), linear calc-silicate horizon which hosts cassiterite-bearing skarn, and the unexpectedly young Triassic age obtained from SHRIMP dating of a porphyry dyke swarm and a single granite stock in outcrop.

Radioelement information from airborne and ground gamma-ray spectrometry provides useful indications of intrusive and/or alteration distribution at the surface. Lithologies and magnetic susceptibilities for interpreted aeromagnetic units are determined on the basis of outcrop and drillhole information: these units and

structures are modelled for the intrusive centre. The tectonic boundary between the Thomson and Lachlan orogens exists in this region, and deep-seated structures are investigated using edge detection contours to analyse crustal gradients in the regional gravity data.

41. MAGNETIC MOMENTS OF FINE PARTICLES FROM MICROMAGNETIC SURVEYS

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A new scanning magnetic microscope to image magnetic fields with micrometric resolution has been constructed based on a giant magnetoresistance (GMR) sensor. Operating in zero-field, the GMR sensor is sensitive to the components of the magnetic field arising from the remanent magnetisation parallel to the plane of the cut rock surface. The field component perpendicular to the surface therefore has to be calculated using FFT relationships. The spatial resolution of the system is 20 µm, and its peak-to-peak noise during operation is 250 nT. Its high spatial resolution and a minimum sensor- to-sample distance of only 30 µm compensate for its rather modest field sensitivity.

Once all three components of the field are known it is possible to determine the magnetic moments of individual fine particles. The individual moments of fine particles can be combined vectorially and the total magnetic moment per volume (i.e. the magnetic intensity) can be estimated and compared with macroscopic measurements, either on standard samples or through ground- or aero-magnetic surveys.

This procedure has been performed on a hemo-ilmenite – magnetite norite sample from the 930 Ma Bjerkreim-Sokndal (BKS) layered intrusion of south Norway. The BKS is a 7 km-thick norite to quartz mangerite layered intrusion, part of the early Neoproterozoic Rogaland Anorthosite Province. The sample with a strong lattice preferred orientation (LPO) of orthopyroxene and moderately strong LPO of hemo-ilmenite, has an NRM of 53–60 A/m inclined at ~65° to the polished surface. Highly variable magnetisation in the BKS, caused by progressive magmatic crystallization giving rise to differing combinations of opaque minerals, highlights some of the possibilities to be considered in evaluating crustal magnetic anomalies.

42. QUANTITATIVE APPRAISAL OF HELIBORNE AND GROUND-BASED TIME DOMAIN ELECTROMAGNETIC SURVEYS FOR URANIUM EXPLORATION – A CASE STUDY FROM RAJASTHAN, INDIA

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Uranium deposits are known to occur in soda-metasomatised rocks and metasediments at several places in the world constituting 18% of the world's uranium production. Uraniferous metasomatites/albitites are identified at several locations along the 320 km long albitite zone in the environs of North and South Delhi Fold Belts of Rajasthan, India. A multi disciplinary geoscientific approach followed over the last few decades, led to the discovery of a uranium deposit along the albitite line. Fracture controlled uranium mineralisation is associated with weak to moderate albitisation and pyroxenisation of metasediments, as well as with metallic sulphides and carbonaceous phyllites. Mineralisation is mainly in the form of uraninite associated with copper, molybdenum and sulphides. The low resistivity of the fractures associated with metallic minerals produces a significant contrast with the host rock, which can be located with electromagnetic methods. High-resolution heliborne geophysical surveys were conducted to identify deposits in the albitite zone. This paper demonstrates the results of heliborne and ground follow-up geophysical surveys to prioritise targets for uranium exploration.

Analysis and integrated interpretation of the heliborne high-resolution multiparameter magnetic, transient electromagnetic (VTEM) and gamma ray spectrometric surveys conducted in Archaean–Proterozoic metallogenic province of North Delhi Fold Belt, Rajasthan has delineated several targets for uranium exploration. A ground based Time Domain Electromagnetic survey employing Geonics make EM37 system were conducted over one of the target area. Interpreted results from ground data correlate well with the spatial locations of the EM conductors delineated from heliborne surveys. Modelling of both heliborne and ground based EM data revealed the presence of subsurface conducting bodies with comparable model parameters. Plate models generated from both the data sets provided useful input to ongoing exploration programme.

43. ISOSTATIC RESIDUAL GRAVITY ANOMALY GRID OF ONSHORE AUSTRALIA

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Gravity anomalies from geological features in the upper crust are masked by large amplitude long wavelength gravity variations from isostatic roots. We have produced an isostatically corrected gravity anomaly grid of onshore Australia which has these long wavelength features removed. This gravity map reveals more clearly the density distributions of geological interest within the upper crust.

The principle of isostasy states that loads on the earth's surface in the form of topographic features are compensated at depth by mass deficiencies. These mass deficiencies are modelled as a thickening of the lithosphere or crust and are referred to as isostatic roots. The tendency toward isostatic balance causes Bouguer gravity anomalies to be substantially negative over mountains and substantially positive over oceanic regions. Hence there is an inverse correlation of Bouguer gravity values with surface elevation.

The depth to mantle model and subsequent isostatic corrections were produced using a modified version of the USGS program AIRYROOT provided by Intrepid Geophysics. Geoscience Australia's 2009 Bathymetry and Topography Grid was used

to calculate the depth to crustal bottom following the Airy-Heiskanen crustal-root model. The isostatic corrections were then applied to the complete Bouguer anomalies to produce the Isostatic Residual Gravity Anomaly Grid of Australia.

44. APPROXIMATION TO MACRO ANISOTROPY OF CONDUCTIVITY FOR CSAMT EXPLORATION

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Under the existing equipments and interpretation technologies, the vertical resolution of CSAMT achieves about 10% to 20% of the exploration depth. In fact the structure consists of thin laminated layers can only be identified as a macroscopic electric layer. With the concept of average function in mathematics, three equivalent methods named geometry-harmonic mean, arithmetic-harmonic mean, and square-harmonic mean are defined to equivalence between the thin laminated layers model and transverse isotropic one. Through numerical calculation and comparison the CSAMT responses in the near-field zone, transition zone and far-field zone, the approximate accuracies of these three equivalent models are discussed in detail.

45. PARAGUAY: STOPPED AT THE BORDER

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This paper summarises, and discusses the prospectivity of, the petroleum basins of Paraguay based on data collected from the Paraguayan government in 2008. Analyses of these data suggest that the sedimentary basins are under-explored and have potential for exploration success.

Paraguay is a landlocked country in central South America with no oil or gas production. It has three sedimentary basins covering over 200 000 sq km that are prospective for oil and gas. The Argentine Northwest Basin, which extends into Paraguay (where is it called the Pirity Basin) has producing fields almost up to the Paraguayan border. Bolivia has production from the Chaco basin west of its border with Paraguay. The Parana basin which extends north, east and south into Brasil, Uruguay and Argentina, respectively, has no producing oil or gas fields. A fourth basin, the Pilar, has only one well and evaluation of its prospectivity (or lack of it) is highly speculative. Since Union Oil first explored Paraguay in 1946, only 48 exploration wells have been drilled. Many have reported oil or gas shows.

The Paraguayan government oil and gas dataset contains an incomplete record of oil exploration activities since 1946 to a total of 24 gigabytes in nearly 10 000 files. The SEGY data contained in the package has no digital navigation. Shotpoint locations have been digitised from scanned maps. Seismic lines were mostly in image formats and have been converted to SEGY and loaded into an interpretation workstation for interpretation. Well data is also incomplete but most wells have some information which has also been loaded to a workstation.

46. ACQUISITION AND PROCESSING OF SEISMIC REFLECTION, REFRACTION AND MAGNETO-TELLURIC DATA: NORTHERN EYRE PENINSULA, GAWLER CRATON

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In 2008 Geoscience Australia acquired high quality regional seismic reflection data along a 253 km east-west line across northern Eyre Peninsula in South Australia as part of the Australian Government's energy security program. Coincident refraction/wide-angle reflection and magnetotelluric (MT) data were also collected along the line. Together these datasets provide complimentary information on the crustal architecture and evolution of this section of the Gawler Craton.

The refraction/wide-angle reflection experiment focused on the central part of the line, and measurements were made simultaneously with the reflection acquisition by using the same vibroseis sources.

The major aim of the seismic reflection method is imaging crustal reflectivity, whereas refraction/wide-angle reflection data supplement these images by providing velocity information for the upper crust and also enable a comparative study of near-vertical and wide-angle seismic trace recordings. Knowledge of the acquisition parameters and processing steps for these two techniques helps to resolve differences in these seismic datasets and also helps to understand their advantages and limitations.

MT data were acquired at 40 broadband and 12 long period sites along the seismic reflection line using AuScope equipment in a collaborative project between Geoscience Australia and the University of Adelaide. The long period data were acquired with a site spacing of 20 km, and the broadband data with a spacing of 10 km, with some 5 km infill. The MT method uses natural time variations of the Earth's magnetic and electric fields to measure electrical conductivity with depth and provides information from the near-surface to well into the mantle. Success of analysis and modelling of MT data is very dependent upon the selection of acquisition and processing parameters, and the dimensionality and complexity of Earth conductive structures within the survey.

An understanding of the acquisition, processing, analysis and modelling technologies for these different methods will improve the quality of the geological interpretation of data over the Gawler Craton.

47. GROUND-TRUTHING PROPOSED SLAB WINDOW FORMATION BENEATH SUNDALAND USING SEISMIC TOMOGRAPHY

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Based on tectonic reconstructions, Whittaker et al. (2007) proposed that a slab window formed beneath Sundaland, due to subduction of the Wharton Ridge, between 70–43 Ma. They

suggest that extension in the Java Sea region at this time was exacerbated as a result of upwelling asthenosphere associated with the slab window. Active ridge subduction and subsequent slab window formation can severely affect basin formation, heatflow and petroleum systems on the overidding margin. A slab window forms between the diverging plates when a mid ocean ridge is subducted leading to anomalous thermal effects like increased mantle temperatures and thermal gradients in the overlying curst. Whittaker et al. (2007) kinematic reconstructions rely on restoring now subducted lithosphere based on preserved ocean crust, but the inherent uncertainties in this process call for an independent evaluation of this model. Mantle seismic tomography models provide qualitative boundary conditions for modeled tectonic histories. We compare seismic tomography models with the model of Whittaker et al. (2007) at a range of mantle depths to confirm the existence of a slab window, and obtain bounds for its maximum regional extent. We identify a break in the high velocity, high-velocity, down-going Indian-Australian Slab at depths between 950–1350 km and longitudes between 85° and 110°, supporting the presence of a slab window. However, we find that the window is located approximately 5° further north and 10°–15° further west than previously proposed, implying that the assumed orientation and/or geometry of the Wharton Ridge may not be correct.

48. PROFILING OF AEROMAGNETIC DATA INTERPRETATION USING THE EYE TRACKER

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Interpretation of geoscientific data is a difficult and sometimes an impossible task as it has to deal with problems such as: incompleteness and poor resolution of observations; the lack of experimental control to understand the phenomenon; and great spans of time and complex events taken for the observed geological phenomenon to take place. Thus the interpretation process involves the interplay between what are obviously or objectively noticeable phenomenon in observations and what interpreters bring (i.e. subjectivity) to the interpretation in regards to presuppositions and expectations.

As a first step towards understanding the subjectivity and human biases in interpretation, our study focuses on quantitative profiling the behaviour of interpreters while the data is being observed by using the eye tracker that captures eye gaze information associated with the visualization of the data. The specific aims of this study include the analysis of: (1) target spotting accuracy and efficiency between interpreters from varying training backgrounds and level of interpretation experience; (2) the impact of commonly used enhancement tools for data interpretation. A preliminary experiment was conducted using an aeromagnetic dataset from Ontario, Canada, and the 1st order vertical derivatives (1VD) of the corresponding data, to profile the observation patterns in free viewing and target spotting accuracy for specific geological features (faults, granitoid intrusions, kimberlite pipes). The results showed: some distinct observation patterns between experience and inexperienced interpreters; characteristics of easy/hard-to-detect features for interpreters; and the impact of the 1VD enhanced data in interpretation.

The study outcomes may impact on a wide range of geoscientific communities including: risk managements in decision making for the mining industry; education and training of geoscientists; and the development of enhancement tools for geoscientific data.

49. LINEAMENT ANALYSIS AS A TOOL FOR HYDROCARBON AND MINERAL EXPLORATION: A CANADIAN CASE STUDY

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An understanding of the geological framework and localized structural constraints are critical to hydrocarbon and mineral deposit exploration. As such, lineament tectonics has been used successfully to delineate oil and ore deposits around the world. Lineament analysis is completed on various geoscientific data: aerial photography, topography, and geophysics. There are various approaches to extract lineament information. While a visual approach is most common; the method is subjective and time consuming especially when applied to large data sets. Therefore, automated routines are important to promote efficiency. Within geophysics, possible numerical approaches include source edge detection routines and the Hough transform. We suggest an alternative approach, which is to implement a methodology commonly applied to topographic data – 'stream flow analysis'. Stream flow analysis delineates stream locations, flow impact, and flow direction by identifying localized low points and their continuity on a topographic surface. In this study, we apply stream flow analysis to a 'topographic' surface defined by aeromagnetic data, where faults and fractures are revealed since they are represented by magnetic lows. Conversely, magnetically high features, such as dykes, are delineated by changing the data set background value causing highs to be represented by lows. Furthermore, by constraining the dimensions of the 'watershed' we are able to isolate linear features at multiple scales. Further analysis of stream segments involves direction/length studies, linearity analysis, and stream intersection points. This methodology is applied to a study area in the Northwest Territories, Canada which has been shown to have high mineral potential and similar IOCG-type deposits as Olympic Dam in Australia.

50. REPROCESSING STRATEGY TO OBTAIN QUANTITATIVE EARLY TIME DATA FROM HISTORIC VTEM SURVEYS

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While data in AEM systems such as VTEM is continuously sampled at 5 or 10 ms, conventional processing steps in the past have not provided useful data close to transmitter current turnoff. In historic VTEM data for example, delivered data usually starts many tens or even a hundred microseconds or so after turnoff. Experiments in deconvolution of early time data at high altitude identified that the symptoms of 'problem' early-time data were that the underlying cause had a linear phase response, resulting in a consistent 'system' exponential response

in time-domain. This unwanted or spurious response is experimentally determined to be of variable amplitude, and of either sign, usually reducing the data at early delays, but occasionally enhancing the combined response. A change in processing strategy to specifically identify and subtract this additive spurious response from a valid earth response has led to the extraction of quantitative AEM data at early delays in the 10 to 20 ms range. The process can be applied to historic data. System bandwidth limitations do of course provide a limit to the accurate sampling of the earth response at extremely early delays. More recently, hardware changes have increased the system bandwidth and reduced the need for software corrections to acquired data.

51. HIGH RESOLUTION SEISMIC FOR SEQUENCE STRATIGRAPHY INTERPRETATION OF SHALLOW SEDIMENTS IN THE CONTINENTAL SHELF OF VIETNAM

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High resolution seismic (HRS) method is useful for interpreting and understanding shallow geological characteristics, modern dynamic activities, and evaluating potential mineral resources or geological hazard. In this paper, the authors will present seismic stratigraphy interpretation of sequence stratigraphy on shallow sediments of continental shelf of Vietnam, using HRS, determining the sedimentary system tracts and sequences in 4th or 5th order, the relationship between sedimentary cycles, sea level change and tectonic movement, facial – paleogeographic characteristics and geological development history of Pliocene-Quaternary of the area. These sequences relates with sea level changes from glacial periods and melting periods Dunai (Pliocene), Gunz, Mindel, Riss, Wurm 1, Wurm 2 (Pleistocene), progradation Flandrian (Holocene). Seismic faces analysis, based on seismic reflection patterns allow to study channels, submarine canyons, carbonate reefs, volcanic rocks. The interpreted seismic stratigraphic features were contributed to defining the gross depositional environments, the relative sea level changes, shale/sand ratios, and locations of carbonate reefs and igneous rocks in the area.

52. YULE RIVER BOREFIELD TEMPEST SURVEY

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The Yule River borefield is a major source of water for the City of Port Hedland in the Pilbara Region of Western Australia. As such it is a significant resource supporting Australian mineral exports. TEMPEST airborne electromagnetic (AEM) and magnetic data, were acquired over the area surrounding the borefield.

In addition to the acquired survey data (airborne electromagnetics, magnetics and DTM) and client supplied data (borehole logs, isohaline map and downhole induction logs) publically available datasets (regional magnetics and radiometrics, Landsat 7ETM+, SRTM and geological maps) were acquired and incorporated into the interpretation.

Results of the interpretation provided:

- an updated interpretation of the basement geology, focussing on structures that control hydrogeology in regolith aquifers
- an interpreted relative porosity map showing the vertical and horizontal extent of various units identified from changes in conductivity
- basement surfaces, both weathered and competent, that mark the base of the regolith groundwater system in areas where there are no borehole logs
- a number of targets for possible groundwater extraction.

In total, 5 target zones for possible groundwater extraction were identified and ranked based on both the lateral and vertical extent of the potential reservoirs and their recharge potential.

54. DISCOVER BROADBAND TOWED STREAMER ACQUISITION

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The effect of the sea surface ghost on marine seismic acquisition is well understood. Shallow tow geometries recover high frequencies at the expense of attenuating low frequencies and deep tow geometries recover low frequencies at the expense of attenuating high frequencies. In recent years two dual streamer tow depth solutions (Over-Under and Sparse-Under) have been deployed, both of which use two streamers which are towed at two different depths.

A 2D survey was acquired offshore China, in August 2009, utilizing three separate streamer depths (5, 17 and 23 m). This three streamer depth configuration allows for the benefits of the two broadband solutions to be evaluated against each other and against a shallow streamer single depth seismic measurement. This paper will review the theory behind the two combination techniques, compare the seismic datasets, and finalize with some conclusions on the relative benefits both in terms of seismic imaging and acquisition efficiency.

55. AUSTRALIA-WIDE HIGH- PASSED RADIOMETRIC IMAGE

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A standard Australia-wide image of the recently-calibrated airborne radiometrics is demonstrated. Filters are applied to the data so that a sufficient dynamic range to cover equalisation is achieved over the smallest and largest scales. A high pass filter of broad roll off if necessary to avoid artefacts.

The resulting image is explored on screen. Familiar areas from all states are zoomed into, showing their details in full, without need for a local equalisation.

An Australia-wide TIFF version has been placed on GADDS. Because the image is ready to go at all scales, an adequate image of almost any area can be cookie cut directly from GADDS.

56. PASSIVE SEISMIC SPECTROSCOPY

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Passive seismic low-frequency (from approximately 1–6 Hz) data have been acquired at several locations around the world. Spectra calculated from these data, acquired over fields with known hydrocarbon accumulations, show common spectral anomalies. Verification of whether these anomalies are common to only a few, many, or all hydrocarbon reservoirs can be provided only if more and detailed results are reported. Several hydrocarbon reservoir-related spectral attributes are suggested and mapped attributes were compared with known hydrocarbon-bearing intervals.

We review available survey data from several case studies in Europe, North America and the Middle East to put recent findings in the correct perspective. Data preprocessing (e.g. filtering, cleaning, stacking etc.) and possible near surface effects are important aspects in this evaluation. Time Reverse Modeling and techniques based on sensor arrays are applied to localize noise sources as well as to localize the origin of observed anomalies. Performing statistical classification and/or pattern recognition (e.g. neural networks) to the passive seismic attributes will be used to interpret the results.

A preliminary model was developed to explain the source mechanism of those microtremors. Poroelastic effects caused by wave-induced fluid flow and oscillations of different fluid phases are significant processes in the low-frequency range that can modify the omnipresent seismic background spectrum. These processes only occur in partially saturated rocks. We assume that hydrocarbon reservoirs are partially saturated, whereas the surrounding rocks are fully saturated. Real data observations are consistent with this conceptual model.

57. THE PNG HIGHLANDS SURVEY – RADIOMETRICS CHALLENGES AND UNEXPECTED SUCCESSES

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Magnetic and radiometric data were acquired in the PNG highlands survey over an area of 62 000 square kilometres. Despite the weather, rugged terrain, dense vegetation and highly variable mositure levels the radiometric data map geology and show features previously unrecognised in mapping. In the Porgera region, conicident magnetic and potassium anomalies similar to those over Porgera present potential targets for further exploration. A sub-volcanic complex was identifed in the Mt Meri area due to coincident potassium anomalies.

Perhaps the most surprising result was the presence of uranium anomalies over the Hides Gas field. The model for radiometric anomalies over oil and gas fields has been seen before and proposed as due to the microbial consumption of microseeping light hydrocarbons. Our investigations suggest disequilibirum effects in uranium distribution. Seepage of oil and gas results in strong reducing conditions around seepage areas and deposition of uranium decay products. Work is continuing on development of these concepts.

58. 3D COMBINED GRAVITY AND MAGNETICS INVERSION MODELLING AS A GUIDE TO TARGET HAEMATITIC IRON ORES – AN EXAMPLE FROM THE KOOLANOOKA SOUTH (WA) PROSPECT

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The aim of this paper is to present an innovative method to help delineate potential target volumes for Haematite-Goethite mineralisation as opposed to more magnetic ores. This is achieved through interpretation and modelling (2.5D and 3D inversions) of ground magnetics and gravity surveys over the Koolanooka South prospect in WA. The targets are assumed to be dense and weakly magnetic and hosted within banded iron formation (BIF) horizons.

Geophysical interpretation (2D map) was performed using a variety of processed magnetic and gravity images to determine the distribution of lithologies, to understand the structural architecture and to map out any anomalous areas of excess density (possibly indicating goethite alteration). The created geological map is used to build geological cross-sections (geometrically consistent) that were modelled (in 2.5D) against both potential field datasets. The cross-sections are consequently used as the framework to build a 3D geological model. The model defines 3D volumes of rocks including several BIF horizons. The distribution of densities and magnetic susceptibilities of the BIF's is inverted within the Gocad-VPmg environment to reduce the misfit between the response of the model and the observed gravity and magnetics. By combining the results of both petrophysical property distribution it is possible to map out (using classical GIS type queries in 3D) volumes of higher density and lower magnetic susceptibility.

59. TRANSFORMATION OF COINCIDENT LOOP DATA TO A SURROGATE POTENTIAL RESPONSE

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A transformation of coincident loop EM data to an equivalent fixed source potential field response is a novel approach to the inversion of EM data. We call this transformed data the surrogate potential. Various choices for potential field inversion exist, of which Euler deconvolution is accurate and efficient at estimating depth and location of any source. The procedure is an improvement on EM interpretation using stitched 1D inversion's which overestimates the depth of a small body.

Forward modelling shows that the square of a zero sum magnetic potential field is equal the coincident loop EM response. By inference the square root of the EM data is then a potential field with sign ambiguity. Since the transmitter and receiver of the EM system are concentric, the response at each delay time is proportional to the square of a magnetostatic scalar potential field with distinct wavenumber contents.

The variable amplitude of current at a fixed delay time due to coupling change is corrected through the square root procedure to a constant. Under the quasi-static approximation at each instant a 'ring' of induced current will be the 'fixed' source of a surrogate potential field whose variable amplitude is corrected

through the square root procedure. Processing includes inspecting data and resolving the sign ambiguity. The surrogate potential is useful for horizontal and steeply dipping plates that are relatively small in size. Any background such as conductive overburden will introduce a 'DC offset' which must be subtracted prior to taking the square root.

As Euler deconvolution is performed on the surrogate potential fields target location and depth delimitation is accomplished with efficiency. Matlab code has been written in order to optimize the results for our application since the spatial wavenumber contents are different to that expected in commercial magnetic inversion code.

60. PLANE-WAVE MIGRATION FOR STEEP REFLECTORS IMAGING

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The application of plane-wave migration for the steep reflectors imaging is investigated. Due to the limited aperture, a single common shot migration based on the one-way wave equation is not effective for the dipping structures imaging. Plane-wave migration, which can produce equal or higher quality images with much less computation cost than conventional shot migration, doesn't suffer from the aperture problems of common-shot records since their recording aperture is the length of the seismic survey. We have found that the corresponding relation between the angle of dipping reflectors and the surface ray parameters P can be estimated from the initial velocity information. On one hand, we improve the wavefield extrapolation accuracy only for common P sections corresponding the selected steep targets, in which way, the imaging accuracy of the selected targets can be improved; on the other hand, the plane-wave integrals can be pruned to concentrate the image on the selected targets, in which way, the computation time can be further reduced.

Synthetic left salt body dataset from the BP 2004 velocity benchmark and VTI synthetic dataset from Amerada Hess are used to demonstrate the methods respectively for the isotropic and anisotropic case. Then we extend it to real data of Luzong area in China for steep structures imaging. Synthetic and real data examples show that plane-wave migration generates high-quality images of steeply dipping reflectors with very low computation cost.

61. 3D PRESTACK DEPTH MIGRATION WITH COMPENSATION FOR FREQUENCY DEPENDENT ABSORPTION AND DISPERSION

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Spatial variations in the transmission properties of the overburden cause seismic amplitude attenuation, wavelet phase distortion and seismic resolution reduction on deeper horizons. The absorption effect is spatially varying, offset dependent and frequency dependent. This poses challenging problems for interpretation, tying of migration images with well-log data, CIG picking for tomographic velocity inversion in dim zones, and AVO analysis. In this abstract, we describe our prestack depth migration approach that compensates for the frequency dependent dissipation effects during the migration process. A ray-based prestack depth Q migration is formulated by using the correspondence principle in which traveltimes become complex and frequency dependent. A naïve implementation in the frequency domain would increase the computational cost by a factor equal to the number of frequencies. We put forward an efficient ray-based prestack depth Q migration method to compensate for the Q anomaly effect and successfully applied the method to both real and synthetic examples. We show that the method mitigates the frequency dependent dissipation effects caused by transmission anomalies and should be considered as one of the processes for amplitude preserving processing that is important for AVO analysis when transmission anomalies are present. Furthermore, our method also enables better and more reliable CIG pickings in the dim zone due to absorption anomaly for better velocity model building when incorporated in the iteration of tomographic velocity inversion.

62. TIME FREQUENCY SPECTRAL DECOMPOSITION FOR DETERMINATION OF BOTTOM SIMULATING REFLECTOR (BSR) OF GAS HYDRATE SEISMIC DATA

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Gas hydrate, a complex compound, formed in the special condition of low temperature and high pressure, has been paid much attention to study due to i) high potential of new energy resources; ii) one of reasons of marine slope stability and iii) a factor of climate changing.

Bottom simulating reflector (BSR), defined as the boundary between gashydrate and free gas zone, is considered as the most important indicator for the gashydrate exploration by seismic reflectivity method. The seismic characteristics of BSR has been found out high amplitude, parallel and phase reversal to the sea floor reflector. Additionally, the location of BSR can help to estimate the thermo-dynamic parameters for gas hydrate stability zone. Spectral decomposition methods such as STFT (Short Time Fourier Transform), CWT (Continuous Wavelet Transform) and MPD (Marching Pursuit Decomposition) for seismic data has been proposed and applied in the various rock reservoirs to characterize hydrocarbon indicators as possitive anomalies in the spectrum. Because BSR has several specific characteristics that create strong reflectivity pattern in the seismic section, the time-frequency decomposition could be used to distinguish this boundary in the gas hydrate seismic data by taking the high energy position at the frequency gather slice. The output of seismic data processing for gas hydrate exploration in the Ulleung Basin, Korea, will be used for time-frequency analysis to locate the BSR in seismic data. These results showed the high energy position at the time of 0.25–0.30 s below the sea floor reflector at the frequency gather slice of 75 Hz that would indicate to the position of BSR. Based on this determination, the empirically estimating thermal gradient by the depth of BSR is about 70º/km.

63. ATTENUATION OF SPATIAL ALIASING BY MEANS OF STATIONARY-WAVELET AND SLANT-STACK TRANSFORMS

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Spatial aliasing is inevitable in some seismic data has grave effects on the performance of multichannel data processing and migration. There are many methods for removing this subject which they produce distortion of the signal through the removal of high-frequency information; In addition, their performances are very similar to high-cut filters. In contrast, this new method, attenuation of spatial aliasing by means of stationary-wavelet and slant-stack transforms, pruduces an unaliased estimate f the signal at all frequencies present in the original traces in time domain.

This new algorithm for attenuation of spatial aliasing is developed by exploiting the properties of seismic wavefields in the stationary-wavelet and slant-stack transforms. Slant-stack domain, specifically exhibits the overlap of information between wavelet scales at the same frequency.

This paper introduces a new and effective method for attenuation of spatial aliasing of seismic data that is adequately sampled in time but undersampled in space. This method is a restoration of energy at high frequencies that would be aliased at high ray-parameter or slowness. High-cut filtering would merely remove those high frequencies and disturb the signal. The new dealiasing method exploits the properties of seismic data as expressed in the joint stationary-wavelet and slantstack domains. The effectiveness of this method is demonstrated through the processing of synthetic data.

65. PIT(WELLS) – GROUND CONTROLLED SOURCE ELECTROMAGNETIC SIGNAL TRANSMITTER

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View of the current geophysical electromagnetic exploration of metal ores shallow depth, low accuracy and resolution, poor anti-interference ability problems, making use of the existing mine tunnels, the electromagnetic transmitter on the ground and the recorders on the underground (pits, wells) or ground (prefecture) compose of quasi-three-dimensional arrangement of measurement technology. This combination method of ground incentiving and underground receiving can be observed from different directions to obtain subsurface electrical conductivity of the large amounts of information, and conduct quasi-three-dimensional imaging, which are likely to increase detection depth and resolution, and to reduce the data interpretation of the non-uniqueness and provide a new exploration for metallic ore exploration method and technique. High-power single-frequency transmitter Studied can provide a single or multi-frequency inverter square wave, launching the signal frequency from DC to 9600 Hz; the maximum emission voltage of 700 V, power supply current of 60 A; by the use of the GPS clock and real-time clock (RTC) module to ensure to launch scheduled frequencies; make use of wireless Bluetooth and serial communication interface to control transmitting operation and edit the control parameter file; observe a variety of supplementary status information. The experiment proved that the equipment is stable and reliable to meet conventional electromagnetic exploration and the requirement of 'Tapping the deep and blind exploration' for the crisis mine substitutable resources.

66. PIT (WELL) – GROUND CONTROLLED-SOURCE ELECTROMAGNETIC SIGNAL RECORDER

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As a high-tech electrical prospecting pit (well) – ground controlled-source electromagnetic imaging methods aimed at improving the detection depth of metal mines while increase resolution appropriately, and require the signal recording instrument into the ground, underground (pit, well) quasi-three-dimensional receiver. From 0.1 Hz to 20 KHz Signal Bandwidth, N * 10nV – N * 100 mV amplitude range of natural field source and the controlled source signal, using ARM + LINUX embedded technology, low-noise high-precision technology, GPS synchronization and low drift technology, low-power technology, NET technology, high-capacity storage technology, has developed a large dynamic range of broadband pit (well) – ground controlled-source electromagnetic recorder. Field survey data indicate that the signal recorder normal and stable work, and various aspects of index has reached the expected results.

67. CONVERTED-WAVE ELASTIC IMPEDANCE AND FLUID IDENTIFICATION FACTOR IN FRACTURED RESERVIORS

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Identification and prediction of fracture and its developmental zone is meaningful to reservoir exploration and development. According to solid mechanics, fracture strata is anisotropic media. Previous formulation for S-wave elastic impedance neglects seismic anisotropic. In order to incorporate anisotropic, we use an approximation of converted PS-wave reflection coefficients to deduce converted wave elastic impedance in weakly anisotropic media for the first time. Through numerical simulation, the effect of Thomsen parameter, incident angle and azimuthal angle on the formulation are described in detail. At the same time, we analyze the precision of new approximation formulation and compare the hydrocarbon detection effect of PP wave and converted wave elastic impedance. The future work is to select the newest nonlinear inversion algorithm and realize elastic impedance inversion in anisotropic media.

On the basis of sensitive fluid identification factor in isotropic media, we construct the new fluid identification factor in weakly anisotropic media, which is composed of PP wave and converted wave elastic impedance. The advantage of new fluid identification factor is to allow investigating AVO anomalies with the effect of anisotropic parameters. Then, we can analyze the difference of fluid identification factor with azimuthal angle and anisotropic parameters in 3D space. Adding Thomsen parameter to the 25 formation models gived by Castagna and Smith, we analyze the identification effect. Numerical simulation results show that the new fluid factor can identify the gas sand and brine sand effectively.

68. A METHOD SUITED TO SURVEY OF SHALLOW HIGH RESOLUTION SURVEY AND SURVEY IN BUSY STREETS OF A CITY – LANDSONER

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Landsoner is the abbreviation of extremely elastic reflection wave recording continues profiling with extremely small offset and vary wide band frequency. It has following characteristics: (a) Small-offset single is used; (b) Under situation of using hammer source can be excited and be received reflection wave with frequency 10 Hz–4000 Hz of depth of 1~200 m; (c) It is unnecessary that the geophones fixed on the ground. On this characteristics the wave with different frequency band can be got that can greatly rise resolution, and can keep away from the noise of acoustic wave, direct wave, reflected wave, surface wave, specially can keep away from the noise of vibration of pedestrians, cars and the other machines on a city. When using landsoner method survey line with broken line can be used. There is no need to statics in mountainous region for this method. On the time-section of figure of Landsoner a karst cave can clearly be reflected. Landsoner method has been successfully used in shallow high resolution survey in mountainous region or in a busy city, in survey karst caves, in geological prediction forward from working face in a tunnel construction and in examining quality of concrete structures.

70. PRESTACK DEPTH MIGRATION USING SEISMIC VIRTUAL SOURCE GATHERS

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Prestack depth migration is used to image for complex geological structure. In this case, it is widely used the surface reflection data as an input data. However, the surface reflection data have problems to image the subsalt and the salt flank due to the complex wavefields and multiples which come from overburden. For overcoming the defect of the surface reflection data, we used the virtual sources in terms of seismic interferometry to image the subsurface. We developed inhomogeneous velocity models for this and generated virtual source gathers through ocean bottom seismic numerical modeling. We decided a reference trace, and generated cross-correlation gathers by cross-correlation of all sources. The virtual source gathers were made by integration at the stationary phase interval.

Numerical modeling showed that the virtual source gathers integrated at the stationary phase interval are more superior that of all sources. For the application to image the subsurface, we conducted prestack depth migration using virtual source gathers. The results of the prestack depth migration using virtual source gathers and velocity model below receivers produced similar geological interfaces. Especially artificial interfaces by multiples were suppressed without applying any other data processing. The results of imaging obtained from inhomogeneous velocity model below receivers showed that the artificial geological interfaces were suppressed than that of the homogeneous velocity models below receivers.

71. AEM GO-MAP FOR THE PATERSON REGION, WA AND PINE CREEK, NT

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Geoscience Australia (GA) has recently completed two regional-scale Airborne Electromagnetic (AEM) surveys: one in the Paterson Region, WA; and the other in the Pine Creek region, NT. These surveys provide AEM data at line spacings of 200 m to 6 km covering an area greater than 110 000 km^2. The surveys were designed to promote more detailed investigations by the mineral exploration industry. An inherent risk in using AEM surveys is that the depth of penetration of the primary electromagnetic field is highly variable. Although forward modelling is undertaken before the AEM campaign, the depth to which we can reliably invert the AEM signal to generate conductivity models is not known until after the survey is flown. In order to estimate the penetration depth of the AEM surveys, we calculate the depth of investigation (DOI) based on the GA layered-earth inversion algorithm, which is influenced by both conductivity measurements and reference model assumptions. We define the DOI as the maximum depth at which the inversion is influenced more by the conductivity data than the reference model. We present the DOI as a 2D grid across both the Paterson and Pine Creek AEM surveys. Labelled the 'AEM go-map', the DOI grid helps to promote AEM exploration by decreasing risk when industry undertakes follow-up surveys within these regions.