SEISMIC REFLECTION STUDIES OF URANIUM BEARING STRATIGRAPHY AT THE BEVERLEY MINE, SOUTH AUSTRALIA

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The Beverley uranium deposit is located in northern South Australia, in the north-west of the Lake Frome Basin. It is thought to be a redox-controlled deposit where mineralisation occurs along depressions, variably referred to as paleochannels, between the Miocene Upper and Lower Namba Formations. Mineralisation occurs in unconsolidated sands that unconformably overlie unconsolidated clays at depths of approximately 85-145 m across the mining lease. The depth and poor physical property contrasts between the host sand and underlying clay renders numerous geophysical techniques as ineffective for direct exploration targeting. Exploration methods that have been previously tested at Beverley include: aeromagnetics, airborne and ground electromagnetics, and detailed gravity surveying which do not successfully image prospective or known depressions. Radiometric surveying is ineffective, as mineralisation occurs below younger sedimentary deposits and shows no surficial footprint. As such, drilling has been the most successful, albeit expensive, technique used for exploration.

Local geology indicates that clays of the Lower Namba Formation are harder (higher sonic velocity) than overlying sands, and as there is no gravity signature, density contrast can be assumed to be small. The prospective contrast in acoustic impedance opens the possibility for application of high-resolution seismic reflection surveying which has been used successfully to image paleochannels at comparable depths in other areas, and should work well for this deposit. In addition, seismic reflection should image faults, which will assist in determining the mechanism of redox controlled mineralisation as a “roll front” mechanism is no-longer favoured (Higgins & Couzens, 2006)

In order to test whether seismic reflection could be used as an exploration tool in the area, three high-resolution lines were shot in areas where paleosurface geometry and mineralisation were accurately known from borehole control. Lines were acquired in a split spread configuration with a total of 123 channels recorded per shot, using 3 vertical stacks with a hammer as source. This was found to be superior to 1 vertical stack using a shotgun charge as a source. Receiver station spacings were 2-3 m, and source intervals were 2-4 m. Data were sampled with a 24 bit A-D converter at 0.5 ms for a total of 750 ms to ensure data fidelity.

Problems encountered during acquisition included rapid attenuation of amplitude and high frequencies due to a surface layer of loose sand and clays with macro-porosity (mud cracking), and the entire interval to target depth (and beyond) is poorly consolidated. High amplitude reverberations were repeated across shot records, which resulted in substantial shingling and severe masking of reflections. These reverberations are believed to have been caused by fast layers in the overburden Willawortina Formation, most likely due to silcrete or gypcrete from paleo-water tables. Poor source and receiver coupling and days of high winds also contributed to the low S/N seen in records.

An apparent absence of reflections and very high amplitude coherent noise on most records rendered data processing a time consuming task. To increase the chance of obtaining real reflections and obtaining as much information as possible from the data, extensive testing of processing techniques was carried out in an iterative approach. Parameter testing was initially performed on individual processes, before combining processes and examining the effects. Combination sometimes allowed refinements to be made to previously determined parameters. Following identification of effective processes, various permutations of these processes were tested to determine an optimised processing flow for each line. Processing routines that made the most significant improvements were found to be: unsmoothed refraction statics from manual first break picks, surface wave noise attenuation, frequency filtering, predictive deconvolution, constant velocity stacking for velocity field determination, radon velocity filtering on selected lines, post-stack time migration (different methods for different lines), and post-stack F-X deconvolution. Extensive data processing resulted in geologically interpretable stacked seismic sections.

The central seismic line was shot across the deepest depression in the interface between the Upper and Lower Namba Formations, and therefore had the greatest chance of resolving a channel-like depression. Depth conversion using the stacking velocity field provided a clear reflector with channel geometry at comparable depth to the known uranium bearing horizon. A strong correlation could be seen between this feature and the modelled surface of interest, with slight discrepancies most likely due to low accuracy static solutions caused by poor first break continuity and gridding errors. This seismic line also images a deeper reflector at depths of approximately 400-450 m, which shows a depression like feature that correlates to a basement low identified with gravity modelling. The deeper reflector does not appear to be a multiple, as it is offset from the earlier reflector.

Faulting is apparent in the section and although there is a chance of this being a migration artefact, faults appear to follow the trend of westerly dipping compressional faulting resulting from subsidence of the Mt Painter Complex to the north-west. Interpreted faulting in the seismic profile appears to occur adjacent to the two identified channel features possibly indicating fault control on sedimentation and mineralisation.

Data processing of the other two lines shows reflectors within the interval of interest, although correlation with known geology is less convincing. Weaker correlation may be the result of lower resolution from using what turned out to be non-optimal sources for the geological setting. Also, the reverberations have been significantly increased and are more difficult to separate out due to the smaller station spacings of 2 m providing smaller offsets in the data for the number of channels used.

Seismic reflection surveying shows strong promise for exploration in this region. Further work is suggested to focus on higher signal strength and higher frequencies that are required to penetrate and resolve layering at and below the target depth. Both of which should be achieved with the use of a mini-vibroseis source and incorporating more channels (>240) at a similar station spacing to provide longer offsets for event separation and higher fold. Before commencing further work, it is suggested that Vertical Seismic Profile (VSP) surveys be conducted in the area to check the origin of reflections and provide more reliable velocity data for improving processing results and more accurate depth conversion.

REFERENCE

HIGGINS J., & COUZENS M. 2006. Back to basics at Beverley, stratigraphy as an exploration tool within the Beverley region: Presented at the *Australian Uranium Conference*, July 2006.

Acknowledgements: The authors acknowledge support from Heathgate Resources Pty Ltd, especially Lachlan Gibbins, John Higgins and Dave McInnes, the Centre of Excellence in High Definition Geophysics, CRC-LEME, and Curtin and Resource Potentials staff who helped in the survey