Passive Microseismic in the Canning Basin – Direct Hydrocarbon sensing

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SUMMARY

A method for directly detecting hydrocarbons with minimal environmental impact is presented here with deployment examples from a recent Canning Basin project.

To maintain their social license to operate oil and gas explorers and producers must seek to reduce their environmental footprint and regulatory authorities are required to reduce impact to an acceptable and as low as reasonably practical level. This creates a window of opportunity for advanced, disruptive technologies, which avoid dry holes and shorten the appraisal and development timeframe, while minimising the impact on the environment. Low-frequency seismic (LFS) is such a technology and here we describe its onshore application.

Passive microseismic surveys are well known in engineering geology and seismology; however, in oil and gas industry it is a relatively new geophysical area and their usage is increasing every year. Passive microseismic surveys are a solution both for exploration, de-risking near-field step-outs and siting infill wells in oil and gas accumulations.

During August-September 2021 passive seismic data was acquired in the Canning Basin of Western Australia for Buru Energy Ltd and its joint venture partner Origin Energy West Pty Ltd . The author was on site for the deployment and shares here details of the successes and challenges of data acquisition in the remote desert regions of Australia.

Between February – August 2022 the passive data was processed by TenzorGEO, and the results of this processing are presented.

Key words: Passive seismic, microseismic, LFS, Canning Basin, low impact.

INTRODUCTION

When exporing an area with only 2D or vintage 3D seismic data available, it is often not possible to de-risk the prospects to a level needed for a drilling decision without additional data. Often the default position then is to suggest acquiring a new active seismic survey. This might be to overshoot a 2D survey with 3D, or to remedy some perceived failing of the vintage 3D, such as cable lengths insufficient for AVO work, or a non-optimum shooting azimuth etc.

However vintage active seismic data combined with a new passive survey acquisition can reduce prospect or fielduncertainty equally as well, or better than the proposed active survey.

Public concern about the environmental impact of active source geophysical seismic surveying has increased in recent years. In 2020/21 an Australian Senate Inquiry into the 'Impact of seismic testing on fisheries and the marine environment.' was published. Equally, onshore, resistance to line clearing has made the planning of active surveys challenging, often limiting new acquisition to the use of existing tracks. Both operators and regulators are seeking geophysical data acquisition techniques that minimise their environmental impact.

Onshore, for an active seismic survey, heavy equipment such as vibroseis trucks (weighing up to 40 tonnes) must be moved across farmland and bushland. This requires negotiation with land managers and traditional owners about access and vegetation clearance to create source transit lines across the survey area. In a passive survey, there is no source and no requirement for line clearing as receiver nodes require no external cables or power sources. The nodes can be placed from a standard utility vehicle, and in sensitive areas the final placement can be done on foot. There is little to no impact of the acquisition to cropping land or the in-place flora and fauna.

This low impact onshore deployment with no heavy machinery, no disturbance to normal activity in the survey area and minimal environmental footprint creates the possibility of greater acceptance of oil and gas activity by the wider community.

Finally, in a step-change to the efficiency of data acquisition during an active source onshore seismic survey, three component sensors can be deployed alongside the active source/receiver array. Passive data is acquired when the active source is not active (i.e. at night). This type of deployment minimises the number of entries to the survey area and does not require any additional permitting over and above those already required for the active survey.

BACKGROUND

In general, one of the main tasks of geological exploration and development is selecting a location for exploratory and producing wells. Presence of a structure does not guarantee the presence of hydrocarbons. Conventional seismic surveys are aimed, for the most part, at studying geometry of the trap and evaluation of formation properties and do not often definitively answer the question of presence of hydrocarbons in the traps to be drilled. An LFS passive micro-seismic survey is designed to detect the presence of hydrocarbons. Combining the active acquisition with the LFS survey reduces the risk of drilling a dry well.

The LFS method is based on analysing spectral properties of low-frequency (0.5-10 Hz) natural seismic background, changing above hydrocarbon accumulations. The effect of change in the low-frequency range of natural microseismic background above petroleum accumulations has been known since the 1990s (Grafov et al 1996) and it has been observed in multiple hydrocarbon provinces.

In 2006, the authors of the LFS method suggested a hypothesis (Birialtsev 2006) that abnormal spectral maxima are of resonant nature. Any stratified geological medium has its own frequency property, while hydrocarbons introduce additional contrast in the cross-section that causes changes in the structure of the spectral maxima (Ryzhov 2013). The reason for the change is related to the fact that hydrocarbon deposit is a matter which causes abnormal reflection of low-frequency (1-5 Hz) longitudinal waves.

Within the framework of the geological exploration of hydrocarbon reservoirs, LFS Technology may be applied for the following purposes:
- Forecasting of hydrocarbon-bearing prospects of an exploration area.
- Delineation of reservoirs.
- Detecting of hydrocarbon accumulations in non-structural traps.
- Identification of bypassed pay in watered out pools.

FIRST LFS ACQUISITION CASE STUDY UN AUSTRALIA – CANNING BASIN

During September and October 2021 passive seismic data was acquired in the Paradise area in EP 428 in the Canning Basin for Buru Energy Ltd and its joint venture partner Origin Energy West Pty Ltd. The multi component nodes used were provided by the ANSIR research group for Buru's use based on a joint application by Buru Energy Ltd as Operator of EP 428, joint venture participant Origin Energy West Pty Ltd and the Australian National University ANU. As part of this a full copy of the acquired data from these 3C geophones will be made available for open file use.

The LFS data acquisition occurred concurrently with an active seismic campaign. The placement of the 3C geophones utilised the existing surveyed positions for the 1C phones, but at a much larger spacing (Figure 1).

The 2D acquisition over the Paradise area was heavily restricted in terms of access, with permission to acquire active seismic being limited to the existing tracks. It is likely that permission to shoot 3D active seismic in this area will be complicated Therefore, Buru were pro-active in using this survey to test other innovative methods for improving the understanding of the sub-surface without any additional impact, of which LFS is only one.

3C geophones were placed approximately every 300m along each survey line (every 10m for 1C geophones). The locations of these are seen on the final results map in figure 2. All 3C geophones were planted in 30cm deep pits, levelled, oriented to north and fully covered with ground to reduce wind impact.

The grid of 87 nodes were deployed in a single day on 23rd September 2021. While the LFS method only requires 24-36 hours of passive listening (2 days if in a quiet area, or at least 3 nights during an active campaign), for operational logistical reasons the nodes remained in place until 14th October 2021, when they were collected, and the data harvested.

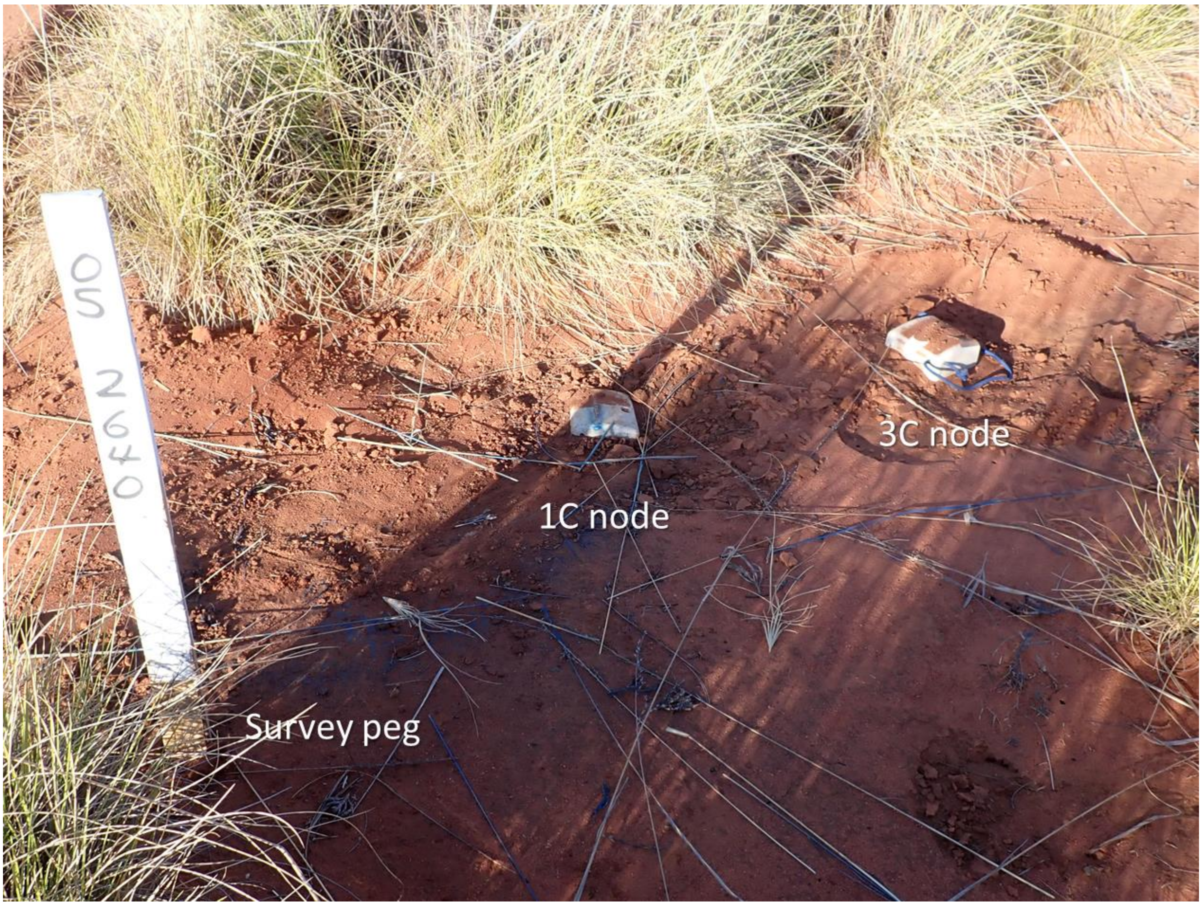

Figure 1. 3C geophones were deployed adjacent to 1C phone at surveyed positions. The nodes were dug in to be flush with the surfaces to minimise wind noise.

PROCESSING AND INTERPRETATION

After acquisition, the acquired data was processed and interpreted.
Below is the outline of the eight stages in that process:

1. Existing well data analysis (oil depths, oil-filled thickness (net pay)).
2. Model preparation using vertical seismic profiling (VSP) and other conventional seismic results (structural and isochronous map).
3. Numerical simulation of the vertical component of media responses.
4. Filtering of strong rolling wave noise from non-moving surface sources using a linear prediction algorithm.
5. Filtering of an ambient background surface noise.
6. QC of the filtering and simulation stages by matching filtered spectra of nearby wells with simulated spectra.
7. Construction of spectra correlation maps.
8. Hydrocarbon presence probability map construction.

The resulting hydrocarbon probability map is shown in Figure 2.

As part of the processing work, significant sensitivity analysis was performed to determine how sensitive the result was to alterations in the earth model used for the forward modelling. This included the addition of an oil layer into the model in an underlying formation, and also variations of the modelled velocities of the Lower Laurel Carbonates, which differ between offset wells. Neither of these model variations materially impacted the resulting map.

Processing was varied out with the financial assistance of a grant under Exploration Incentive Scheme (EIS), Energy Analysis Program (EAP), from the Department of Mines, Industry Regulation and Safety (DMIRS). As part of this grant, a full copy of the processed results and the accompanying report will be made available for open file use in March 2023.

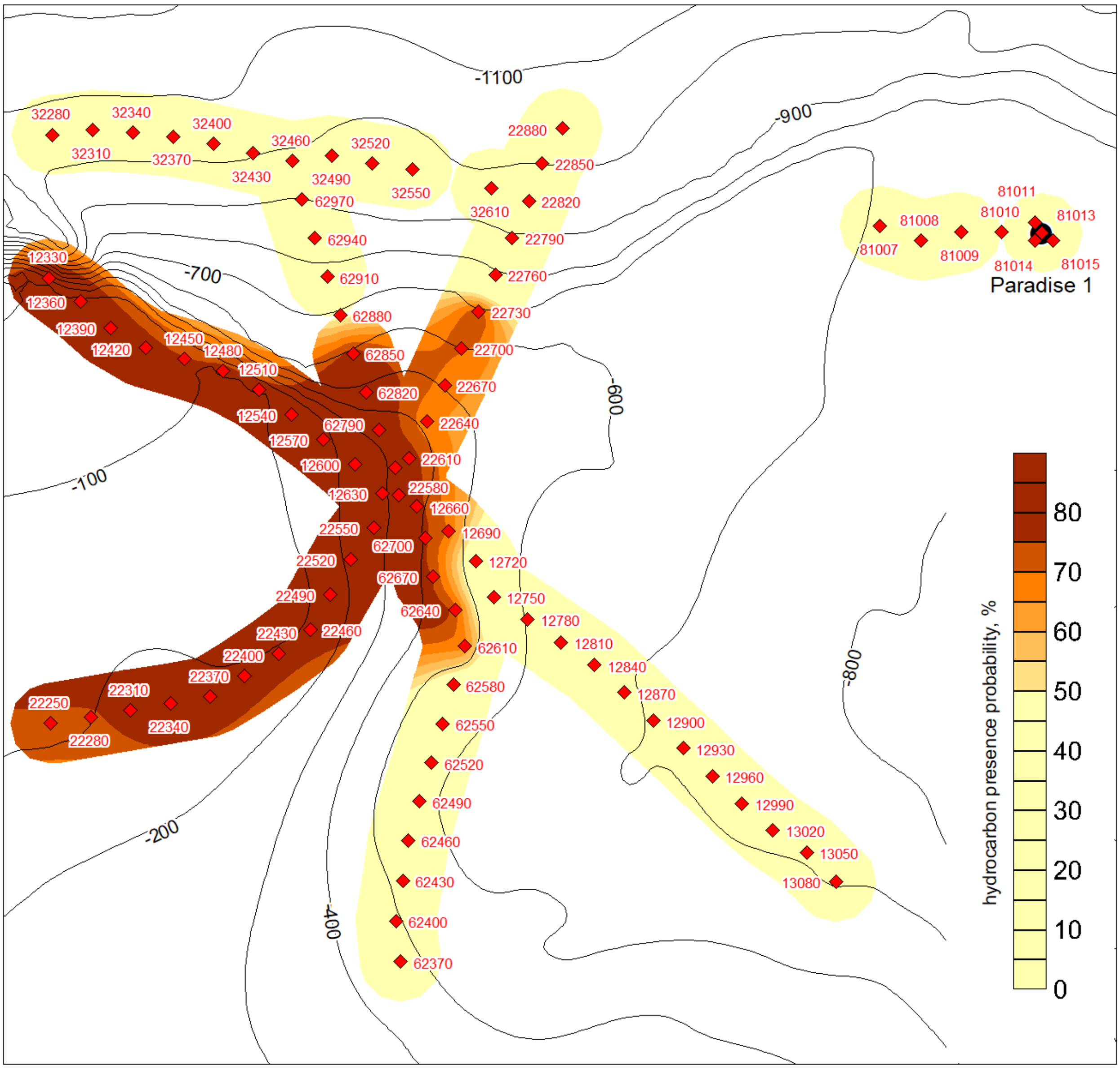

Figure 2. Hydrocarbon presence probability map at the Winifred Shale, Grant Group

CONCLUSIONS

The acquired data was suitable for processing with only 2 of the 87 stations being rejected for processing. The forward modelling was proven to be robust by sensitivity analysis, and the resulting Hydrocarbon probability map shows a good correlation with the results of the 2D active seismic survey interpretation.

The LFS method can directly detect hydrocarbons based on the effect they have on low frequency passive seismic data. This allows for exploration, de-risking near-field step-outs and siting infill wells in hydrocarbon accumulations. The technology is complementary to vintage seismic and reduces the need for multiple acquisition campaigns.

Deployment of 3C nodes and recording of passive seismic in both offshore and onshore areas has significantly reduced environmental impact compared to conventional acquisition. The cost of and time taken to complete a passive survey is materially lower than conventional acquisition through a combination of shorter acquisition and processing periods, and lower environmental impact.

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