Magnetotelluric Well Stimulation Monitoring in the Cooper Basin, South Australia

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ABSTRACT

Hydraulic stimulation tactics allow for the economical extraction of tight-gas plays by increasing the hydraulic conductivity of impermeable formations. The rise of shale-gas exploration and production has seen the implementation of horizontal drilling to pump pressurised fluids into a formation, reactivating paleo-fracture networks from induced pressure instability. The fracture networks stimulate: reduction in pore pressure, increasing pore connectivity and provides new paths for hydrocarbon migration. Deep geophysical monitoring is required to analyse the geological impacts from hydraulic fracturing (fracking), they also aid to increase well success rates. Microseismic surveying is currently the only technique employed to monitor these induced effects, however passive seismic monitoring is not directly sensitive to the physical properties of formation fluids.

In Australia's Cooper Basin a hydraulic fracturing procedure has been monitored using the electromagnetic technique magnetotellurics. Electromagnetism is highly sensitive to subsurface fluid properties and those impacting flow rates, magnetotellurics aims to map the temporal and spatial fluid dynamics of the injection. The proposed outcomes are to monitor temporal changes the injected fracture fluids cause to regional electromagnetic distortions. Distortion analysis is used to describe the geoelectric strike, to infer fluid-flow. Magnetotelluric inverse modelling aims to constrain spatial regions of induced resistivity changes. Temporal fluid percolation properties can then be related to the migration of bulk-fluid movement and also regions of accumulations, highlighting potential stratigraphic traps.

This report describes early-stage feasibility evaluation monitoring the hydrogeological changes induced from hydraulic fracturing at 3000 m depths. This study presents the findings from phase tensor dimensionality and inverse modelling in two dimensions

of a 12 hour recording prior to injection and another recording posterior to fracking. Current data quality is below conclusive standards, particularly in the dead-band (5 - 20 seconds). The regional low resistivity estimates from the Cooper Basin correlate to injection distortion depths within the dead-band, reducing the likelihood of small error margins for depths of interest. Inverse models show sensitivity to the spatial changes at 3000 m depth, showing a 300 m vertical dispersion of fluids at one station. If station and daily resistivity error estimates are enhanced, particularly in the dead-band, and if they follow the same trend as the highest-quality station's modelled temporal changes the changes could be monitored. At this stage, this report provides the background for the on going study attempting to resolve these changes.

KEYWORDS

Magnetotelluric, Resistivity, Monitoring, Dimensionality, Phase-Tensor, Distortion

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