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The Value of Interpreting a Suite of Time-Lapse DAS VSP at Quest

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Abstract

The Quest CCS Facility located near Fort Saskatchewan, Alberta, Canada, has been in operation since August 2015. The Facility is operated by Shell Canada on behalf of the AOSP Joint Venture which includes Canadian Natural Upgrading Limited, Chevron Canada Oil Sands Partnership and 1745844 Limited. Since first injection, over eight million tonnes of CO_2 have been safely stored into a deep saline aquifer, the Basal Cambrian Sandstone (BCS), at a depth of about two kilometers below ground.

As part of the licensed injection scheme, the Quest Facility is required to demonstrate the containment of CO_2 within the storage complex and demonstrate conformance of the pressure and plume models against acquired data. The types of acquired surveys and the frequency of acquisition are detailed within an approved Measurement, Monitoring and Verification (MMV) plan. The MMV plan is designed to be adaptive, and is periodically updated to provide new data, which are subsequently used for model updating. The survey data footprint and the frequency of acquisition are estimated based on initial modelling, but updated if the acquired data provides insights to solicit a change.

In the first 6 years of injection at Quest, time-lapse seismic data was acquired for the purpose of demonstrating containment and conformance of the modelled CO_2 plume [1]. The aim of this presentation is to continue the story from acquisition, signal processing and imaging, to showcasing the interpretation of the acquired data, and the evaluation of DAS VSP (Distributed Acoustic Sensing Vertical Seismic Profile) as a key acquisition technology at Quest. Novel interpretation methodologies have been established for the Quest data, to address the unique nature of the DAS VSP data type and the novel star shaped acquisition footprint. The results of the established interpretation methodology conclude that even with sparse data, when combined with enhanced signal processing and imaging, as well as a multi-vintage data suite and inter-discipline integration, you can extract valuable information about plume growth. The insights on the pros and cons of the acquisition footprint, frequency of acquisition and the technology used to acquire data will be presented.

The suite of DAS VSP time-lapse data acquired at the central injection well includes one baseline survey and three

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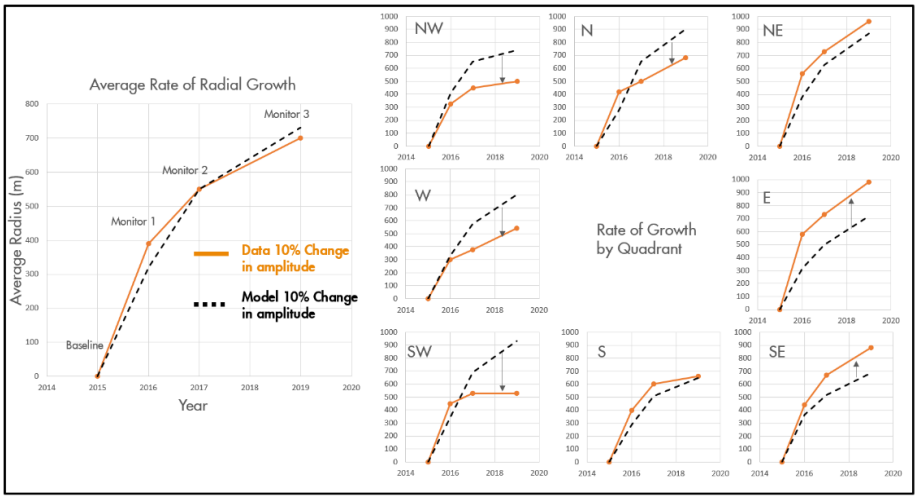
monitor surveys, providing insights to the plume movement details. With three unique time-lapse difference observations, a reservoir model that fits the data may be established using different insightful relationships.

The following are a few of the most impactful relationships that will be discussed:

- The relationship between normalized time-lapse attributes and the distribution of CO_2 saturations,
- The relationship between the spatial crispness of the difference anomaly and the relative permeability,
- The relationship between plume shape and permeability distribution
- The relationship between the character of the time-lapse difference in depth and the vertical segregation of the CO_2 plume (connected to vertical and horizontal permeability ratio).

Different reservoir properties impact the plume at different stages of injection and post injection. The observation that one reservoir property is most impactful at the initial stages, does not mean that this same property will continue to dominate later. Insights during the early stages of injection can help to understand the interplay between reservoir properties as the CO_2 plume evolves.

Constraining the reservoir model using 4D seismic, benefits a lot from validation. When it comes to single monitor DAS VSP datasets, the results can be quite different depending on the processing, imaging, and interpretation methodology. The non-unique nature of a single monitor DAS VSP dataset can be constrained by undertaking parallel studies or by evaluating a suite of datasets. Both targeted approaches can be quite cost effective and insightful to the overall initiative of maturing interpretation and understanding of the reservoir model. Evaluating a suite of monitor datasets acquired in the first years of injection, provides enough supporting information to build an interpretation, which a single monitor dataset is not capable of supporting. With the right amount of data and a



calibrated methodology, site-specific findings from a suite of datasets may be translated to new wells in the injection scheme, potentially resulting in less data acquisition required for the additional wells.

Figure 1: This figure compares the directional growth of the interpreted seismic anomaly vs the forward modeled response from modeled saturations. Arrows are drawn to show where the model extent needs to increase or decrease to represent the data. The average radius and rate of growth are very comparable. The quadrant comparison shows that the data interpretation indicates Eastern growth that is not fully represented by the model.

References

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