A 3D reflection seismic survey over a CO_2 injection site: Rock Springs Uplift, Wyoming

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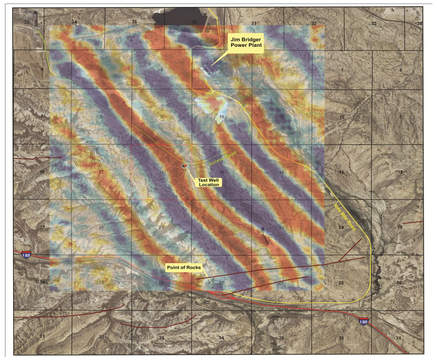
Abstract

Seismic reflection data and processing techniques can improve evaluation of deep geologic reservoirs for CO_2 storage. Model-based noise attenuation, pre-stack Kirchhoff time migration, velocity investigations, and post-stack attribute analyses were applied toward detailed seismic interpretation, geological model construction, and flow simulation of a potential commercial-scale CO_2 storage site on the Rock Springs Uplift (RSU) in southwestern Wyoming. Velocity, frequency, reflection continuity, and directional seismic attributes quantify reservoir petrophysical characteristics, and new spectral decomposition techniques resolve changes in reservoir thickness and compartment boundaries. Results of seismic attribute and petrophysical analysis combined with reservoir simulation of CO_2 injection into deep, saline aquifers will allow accurate estimates of the CO_2 storage capacity of the Paleozoic Weber Sandstone and Madison Limestone.

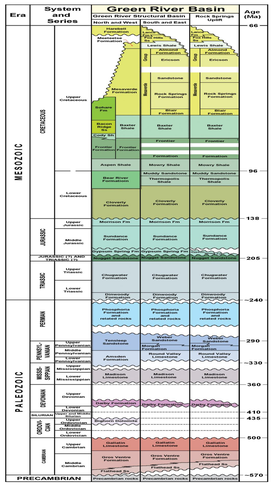
The study site lies on the east flank of the Rock Springs Uplift. The 3D survey area covers approximately 5 miles by 5 miles, and includes a stratigraphic test/monitoring well at the center. Field recording parameters were a sweep band of 6–110 Hz, nominal fold coverage of 100x, and maximum source-receiver offset of 20,000 feet. The correlated record length is 6 seconds, and the resultant (after pre-stack migration) bin size is 110 feet in both in-line and cross-line directions. The 3D field geometry minimized acquisition cost while maintaining high fold over the stratigraphic well location. The target region is approximately 13,000 feet below the surface and consists of Paleozoic sandstone and carbonate strata. Three dimensional reflection seismic data were processed to determine both pre-stack and post-stack seismic attributes. Data conditioned for attribute analysis (after pre-stack time migration) are relatively good. Seismic reflections originated on target, reservoir horizons (within the time range of 1.5–2.4 seconds or depth interval 12,000 to 14,000 ft) have sufficient intensity and continuity for confident horizon-picking within the whole data volume.

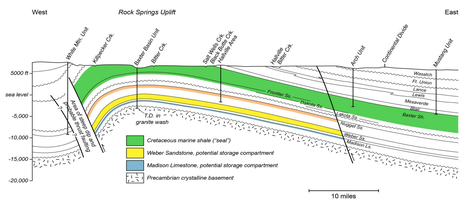
Seismic reflections define the study area as a monocline with an average dip of 4º NE. A northwest-trending fault zone divides the rock strata into two zones of differing dip. The proposed stratigraphic well is up-dip, approximately 2/3 miles southwest of the fault. Seismic reflections at the potential injection sites are characterized by steeper dips of 5°–6°.

Jim Bridger 3D Seismic Survey



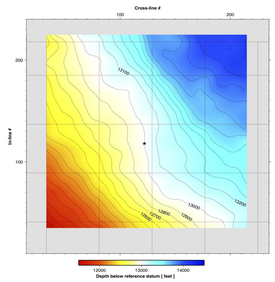
Aerial photograph of the study area overlain with seismic amplitudes selected from the Jim Bridger 3D seismic volume, Rock Springs Uplift, Wyoming.



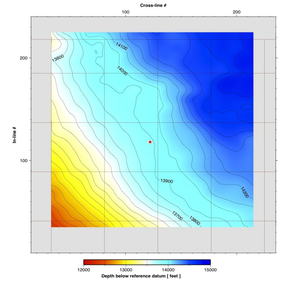


Stratigraphic column (above) and an east-west cross section (below) of the RSU. The CO_2 storage target formations, the Weber Sandstone and the Madison Limestone, are overlain by more than 5,000 ft of Cretaceous shales and more than 1,000 ft of Triassic Chugwater shales.

Structural Contour Maps of the Target Horizons

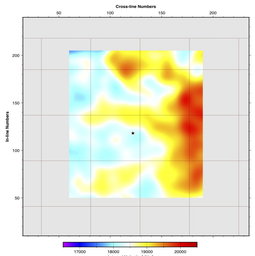


Weber Sandstone

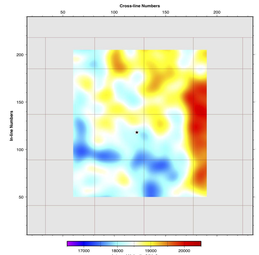


Madison Limestone

Interval Velocity Variation along the Target Horizons

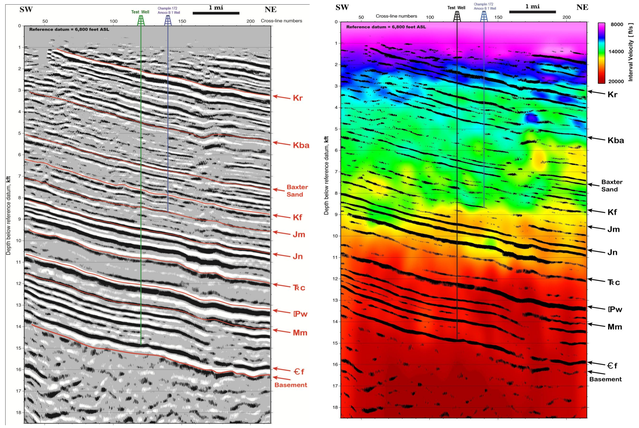


Weber Sandstone



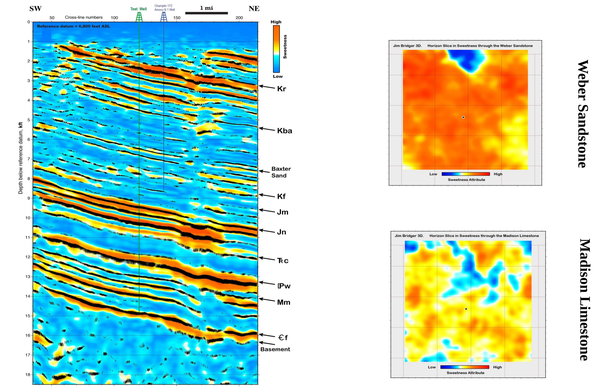
Madison Limestone

Amplitude and Velocity Profiles Through the Test Well



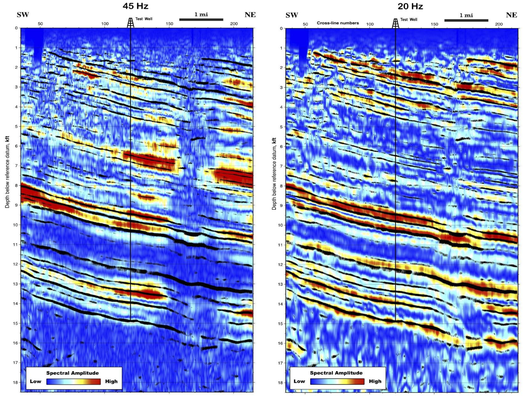
Amplitude profile (left 3D seismic volume. Time-to-depth conversion was done using interval velocity volume calculated from detailed velocity analysis of reflection common-depth-point data. Stratigraphic interpretation was done based on seismic data calibration with the well logs from the neighboring wells. Positive seismic deflections (left panel) are shown in black, negative in white. Velocity profile (right panel) selected from the interval velocity volume. This velocity volume was used for the time-to-depth conversion.

Lithology delineation (Sweetness Attribute)



Vertical profile (left) through the test well site and horizon slices selected from the sweetness attribute volume. Parts of a seismic volume characterized by both high amplitudes and low frequency will have high sweetness (Hart, B. AAPG Bulletin, June 2008). Note that shale-dominated intervals (non-reflective sequences) tend to be characterized by low sweetness, whereas isolated sandy intervals and coalbeds in Kr are marked with relatively high sweetness.

Spectral-Decomposition, Fault delineation



Isofrequency profiles through the test well selected from the spectrally decomposed 3D seismic volume. Note fault-zone attenuation of high-frequency seismic waves (45 Hz, left panel).

Acknowledgements

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