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OPTIMIZING RESOURCES

Initial 3C-2D surface seismic and walkaway VSP results from the 2015 Brooks SuperCable experiment

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Summary

A 3C walkaway VSP and surface seismic experiment was conducted at the Containment and Monitoring Institute (CaMI) Field Research Station (FRS) in May of 2015. Multiple objectives for the program included student training, surface source and receiver comparisons, walkaway multi-component VSP acquisition and velocity tomography.

Introduction

A 3C walkaway VSP and surface seismic experiment was conducted at the Containment and Monitoring Institute (CaMI) Field Research Station (FRS) in May of 2015. Two parallel NE-SW receiver lines were laid out with one line (Line 108) centered on well CMCRI COUNTESS 10-22-17-16, and the other (Line 106) offset 100 m to the northwest. Receiver lines 106 and 108 had single-component SM-24 geophones at a 10 m receiver spacing, connected to an Inova Aries SPML recorder. In addition, receiver line 108 had three-component SM-7 geophones in nail-type casings at a 30 m receiver spacing recorded by Inova Hawk nodal systems. A three-component ESG SuperCable was deployed in the well at three different levels, giving receiver positions in the well from 106 to 496 meters depth at a 15 m spacing. These data were recorded using ESG Paladin recorders. A Geode recorder was present in the cab of the EnviroVibe source in order to record the ground force. Two source lines were acquired three times, once for each tool position in the well. The source was an IVI EnviroVibe sweeping from 10-200 Hz linearly over 16 s with an additional 4 s listening time. Source line 208 (NE-SW) had a Vibe Point (VP) every 10 m, offset to the NW of the surface receiver locations, for a walkaway VSP. A semi-circular source line (204) with a radius of 400 m and a VP every five degrees was acquired for a velocity tomography study. Finally, source line 208 was re-acquired using a variety of filtered and unfiltered m-sequence sweeps while the SuperCable was removed from the well. The m-sequence data can be combined and used to test multiple simultaneous source scenarios.

Initial Results

P-P and P-S synthetic offset gathers calculated from well log data show good reflectivity in the zone of interest. Travel-time variations for source line 204 and a receiver at 383.5 m depth show a several millisecond travel time variation. The fast wave propagation direction (with minimal travel time) coincides with the direction of the NE-SW line and generally follows the orientation of regional maximum horizontal compressional stress. This indicates the existence of weak HTI anisotropy likely due to fractures caused by the regional stress field.

Twenty second VSP source gathers were created from the ESG continuous data, and were then vertically stacked and correlated with TREF. A maximum power two-component rotation was applied to rotate the horizontal components to radial and transverse components. (Figure 1). The P-wave velocity measured for depths 166-496 m (excluding the first four traces) is 2740 m/s. We observe strong down- and up-going events that do not have the same slope as the first breaks. Picking a slope from this up-going wavefield gives a velocity of 1370 m/s which in turn gives a Vp/Vs ratio of 2.0. Average Vp/Vs from the VPVS well log is 2.09. Therefore, we are seeing up-going S-waves for a Vibe point 20 m from the well. Figure 2 and Figure 3 show Figure 1 after attenuation of down-going P-waves and flattening up-going P- and up-going S-wavefields based on first break pick times.

Surface seismic processing included refraction statics, air blast attenuation, spike and noise burst edit, surface wave noise attenuation, and Gabor deconvolution. In order to compare Aries to Hawk data, we post-stack migrated receiver stacks using a finite difference migration and applied a bandpass filter of 10-15-80-90 Hz. The migrated data are shown in Figure 4, which also shows for comparison an arbitrary line extracted from a 2014 3D volume coinciding with the 2015 2D line. The strong event at about 0.25 s corresponds to the Basal Belly River sandstone, which is the primary CO_2 injection target at this site.

Discussion

A variety of seismic work was successfully completed at the Containment and Monitoring Institute (CaMI) Field Research Station (FRS) in May of 2015. Over the course of two days data were acquired for a variety of experiments, including a walk-away 3C VSP, data for a velocity tomography study, 1C-2D and 3C-2D surface seismic, and m-sequence sweep tests. This report has shown examples of field data as well as some preliminary processing results.

Future work

There are a number of projects that will result from these data. We plan to finalize processing of the radial component of the 3C-2D surface data, as well as process the zero-offset VSP to P-P and P-S corridor stacks and process the multicomponent walk-away VSP data. We can simulate multiple Vibes simultaneously running different m-sequence sweeps, and see how successfully the source gathers can be separated and processed to migrated sections. We can study how best to attenuate (or use) source-generated m-sequence multiples. Finally, everything needs to be interpreted/inverted.

Acknowledgements

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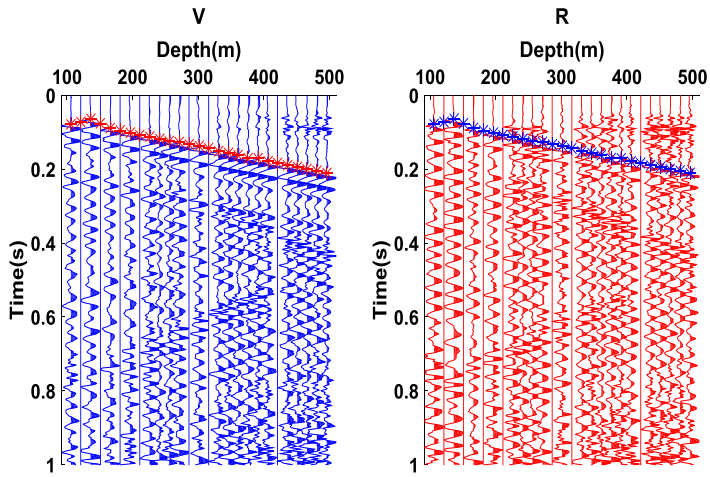

Figure 1. Vertical and radial component unprocessed P-P and P-S correlated source gathers for VP 208149.

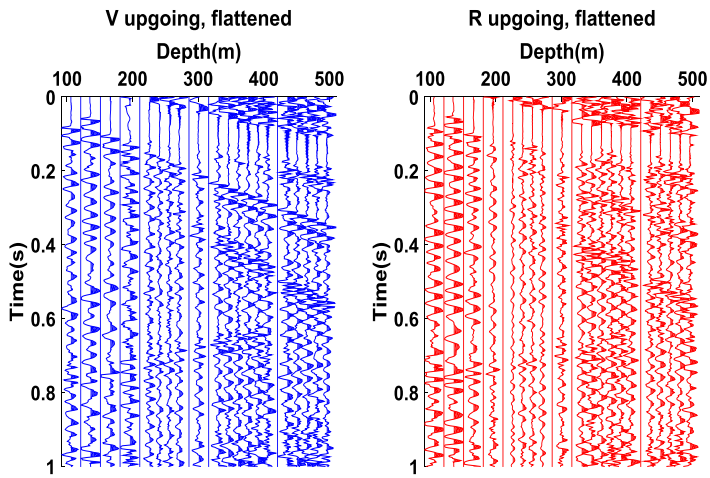

Figure 2. VP 208149 flattened for up-going P-waves after attenuation of down-going P-waves.

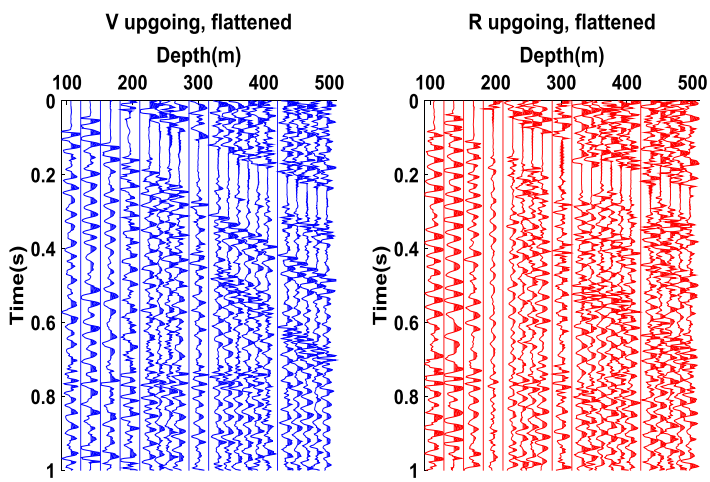

Figure 3. VP 208149 flattened for up-going S-waves after attenuation of down-going P-waves.

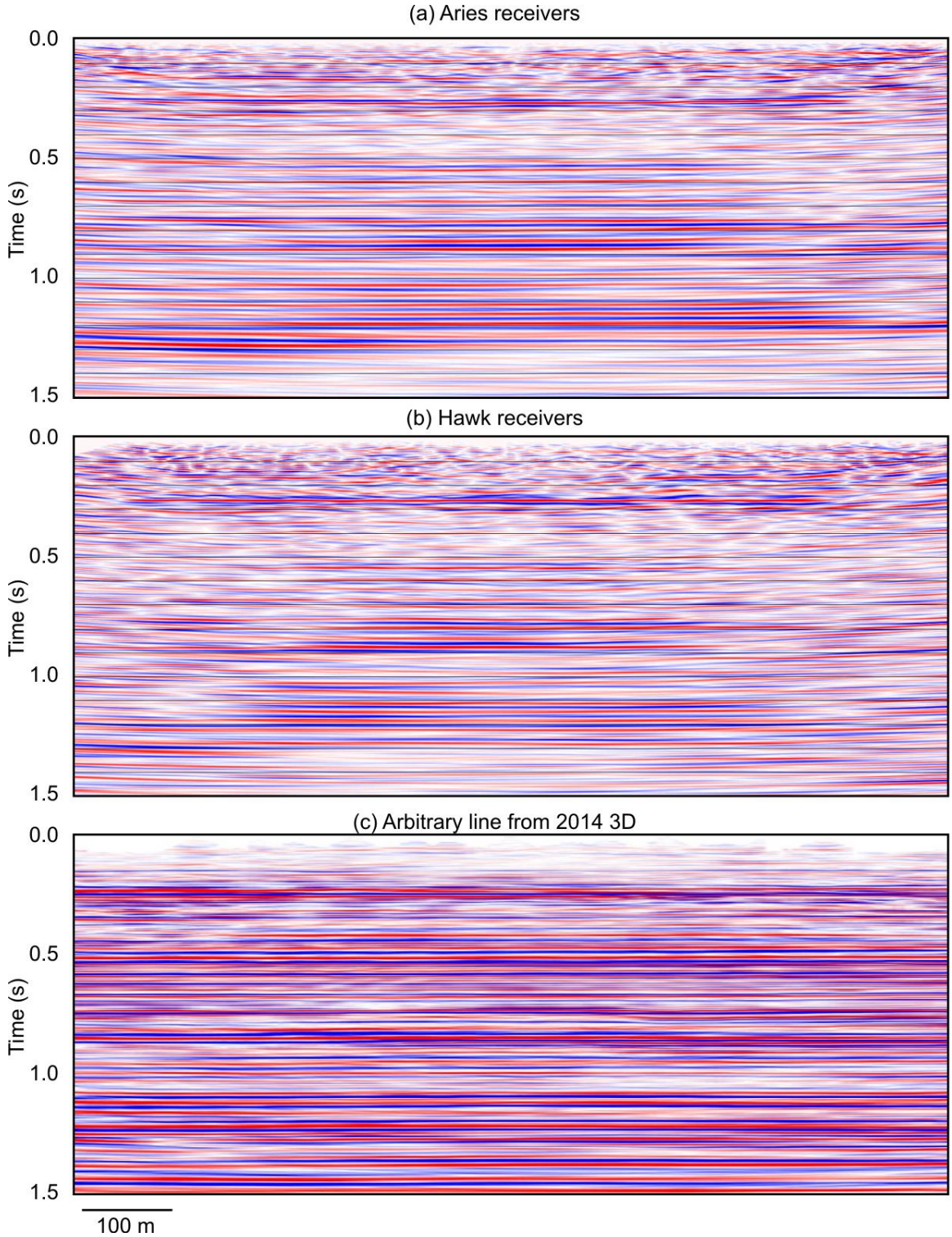

Figure 4. Post-stack migrated lines. (a) and (b) are the Aries and Hawk data, respectively, and (c) is an arbitrary line extracted from a 2014 3D volume corresponding to the location of the 2015 2D line. Data have an AGC applied for display.