Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report (Period ending 12/31/2013)

Structural and Stratigraphic Controls on Methane Hydrate occurance and distribution: Gulf of Mexico, Walker Ridge 313 and Green Canyon 955

Project Period: 10/01/2012 – 09/30/2015

Submitted by:

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Signature

Office of Fossil Energy

Executive Summary

This quarterly progress summarizes the progress made towards Phase 1, Subtask 3.1 – Processing of MCS and OBS data that we have obtained from the USGS. These data are 2D and have been acquired along the same transect.

Background

The overall objective is to identify and understand structural and stratigraphic controls on hydrate accumulation and distribution in leased blocks WR313 (WR: Walker Ridge) and GC955 (GC: Green Canyon) in the Gulf of Mexico using seismic and well data. The effort shall be completed in three phases. In the first phase, the objective is to create a large-sale (resolution in the order of Fresnel zone) P-wave velocity model using traveltime inversion and a corresponding depth image using pre-stack depth migration (PSDM). In the second phase, the objective is to refine the resolution of the P-wave velocity model created in the first phase to the order of seismic wavelength using full-waveform inversion and simultaneously create P-wave attenuation model. The third phase has two objectives. The first objective is to create a hydrate distribution map with the help of P-wave velocity and attenuation model created in the second phase and standard rock physics modeling method. The second objective is to jointly interpret the saturation map, Full-Waveform Inversion (FWI) velocity and attenuation, and the PSDM image to determine the structural and stratigraphic controls on hydrate occurrence and distribution.

Approach

Work outlined in this report falls within the scope of subtask 3.1, which is initiated by meticulously studying the details of headers values in the seismic gathers provided by Seth Heins, USGS. A major part of the work was to setup the navigation correctly. After setting up the navigation, the data were imported into ProMAX© processing software and visually verified for their correctness. Following this, bad traces were selectively removed and the remaining dataset was processed using conventional methods (see below) to enhance the signal-to-noise ratio. The data will be assembled from shot to CMP domain where velocity analysis was conducted. Finally, a stack was created. The stacked data were then depth migrated and verified with the well depths.

Results and Discussion

A considerable time and attention was spent on navigation setup. The navigation coordinates in the header of the field data were in arcsec, which was changed to UTM coordinates in the following manner:

```
[srcy_u,srcx_u,zone,lcm] = ell2utm(deg2rad(srcy/3600),deg2rad(srcx/3600));
```

```
[recy_u,recx_u,zone,lcm] = ell2utm(deg2rad(recy/3600),deg2rad(recx/3600));
```

The corresponding locations with _u are the utm coordinates in meters, utm zone 15N.
Programs ell2utm and deg2rad are part of the freely available geodetic toolbox: http://www.mathworks.com/matlabcentral/fileexchange/15285-geodetic-toolbox.

First, the data headers were scanned for corroborating byte locations with key navigation parameters such as FFID, and CHAN. Next based on the notes provided to by the USGS, the acquisition geometry was set up. The receiver spacing was set to 6.1 m in both GC955 and WR313 datasets. The CDP spacing is therefore 3.05m in both cases. The near-offset (distance between the source and closest hydrophone) was 40m but we changed it to 42.7m to make it a multiple of the receiver interval. A change in 2.7m results in net aperture increase of ~0.1^0 in reflection which is negligible in velocity analysis. The shot interval in GC955 dataset was 24m (4 times the receiver interval) and in WR313 dataset was 36m (4 times the receiver interval). The most critical step was to correctly bin the datasets so that enough CPDs are available in each bin. Our CDP bins were 12m apart, implying that the higher spatial resolution in the data is ~12m.

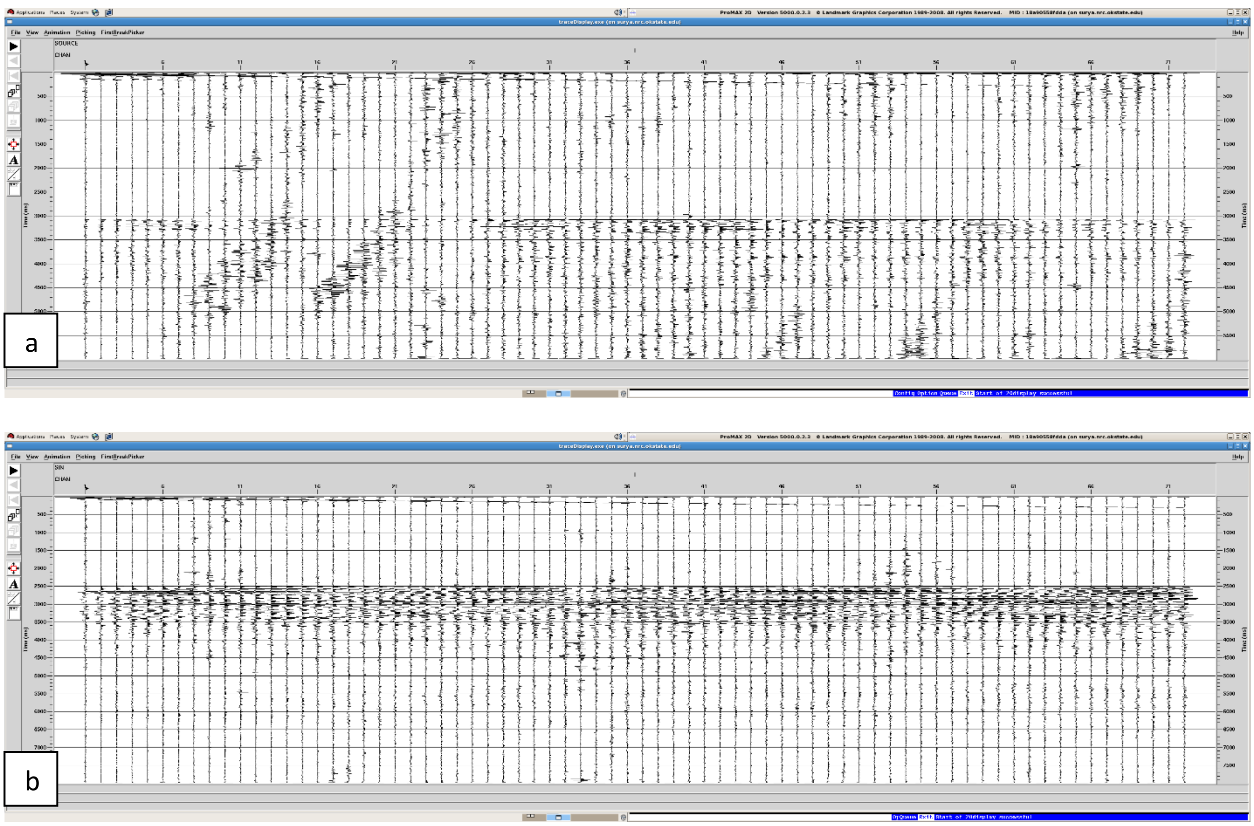


Figure 1. General data quality from a) GCC955 and b) WR313. In (a) note the linear noise trains between channels 11 and 26. There could be due to shooting elsewhere in the region.

After successfully loading the datasets, the gathers were visually checked for quality. The WR313 data (Figure 1a) were much “cleaner” than its GC955 counterpart (Figure 1b). Approximately ~20% of the GCC955 data were muted. Only ~5% of the WR313 data were muted. After navigation assignment and general QC, a standard processing flow aimed at increasing the signal-to-noise ratio was followed:

1. Data Input
2. Muting of energy above the seafloor reflection.
3. Spectral analysis for filtering (10 – 20 – 100 – 200 Butterworth bandpass was ultimately used).

4. F-K analysis for filtering (for attenuating linear noise, e.g. Figure 1a).

5. Dip move-out (DMO) binning for DMO correction using 1D velocity model.

6. Normal move-out (NMO) velocity analysis followed by NMO correction

7. Stacking.

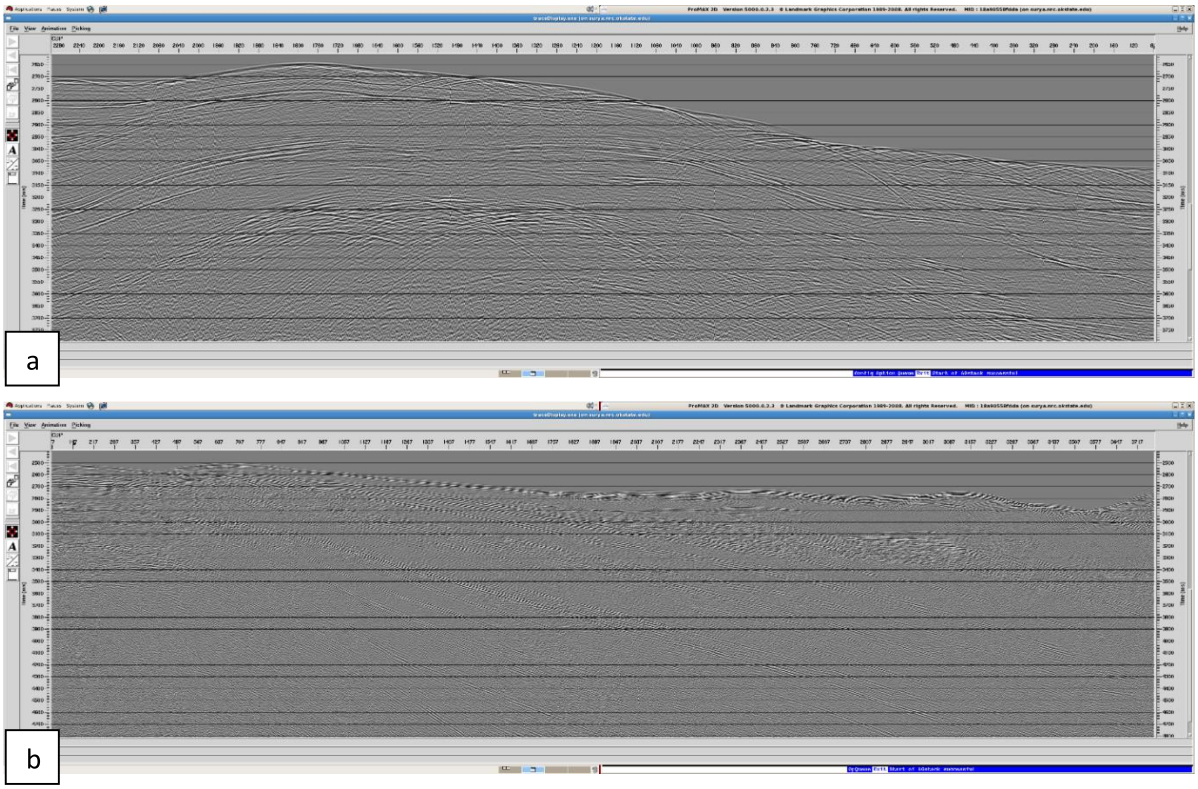


Figure 2. Stacked data from a) GCC 955 and b) WR313. WR313 stack seems to be relatively cleaner

Figure 2a and b are stacks from the GCC and WR313 MCS datasets. The 2D MCS data are very short offsets. As a results, velocity picking cannot be done reliably. However for stacking purposes a generic velocity description is needed. The depth of the coincident wells in WR and GC blocks have been used to constrain the depth migration at this stge. The depth migrated image with well overlay are shown in Figures 3a and b.

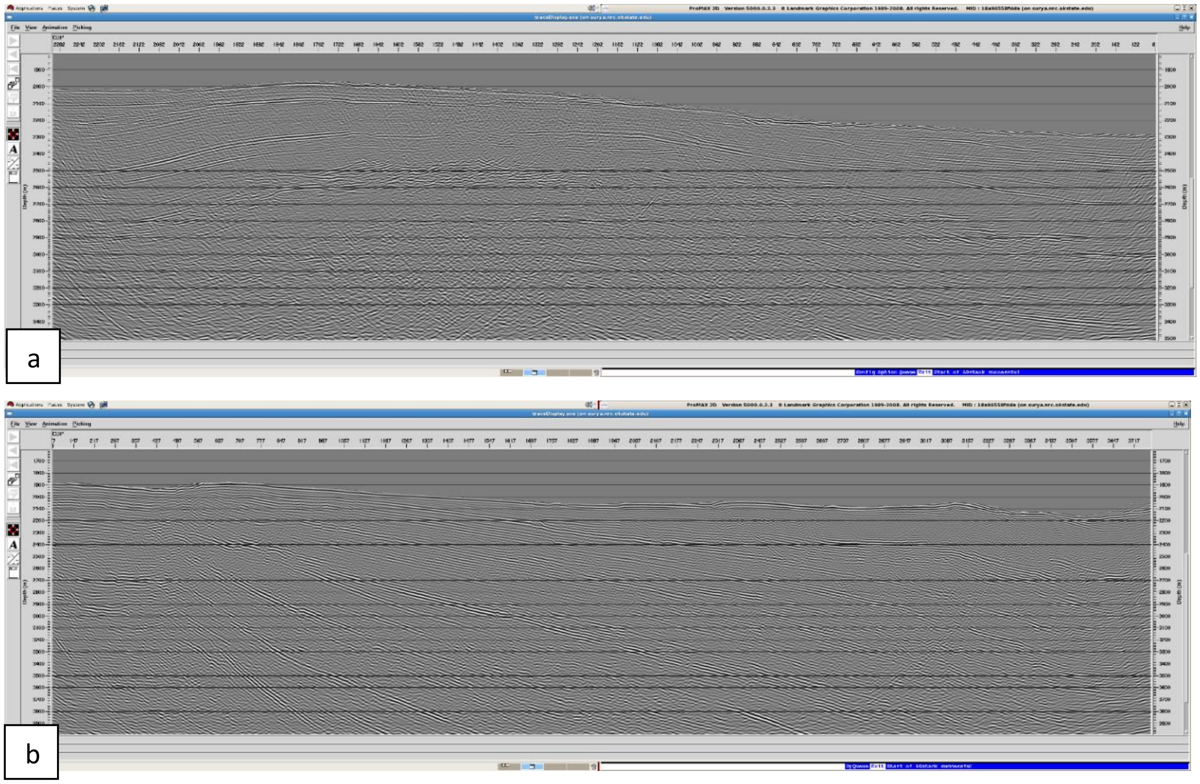


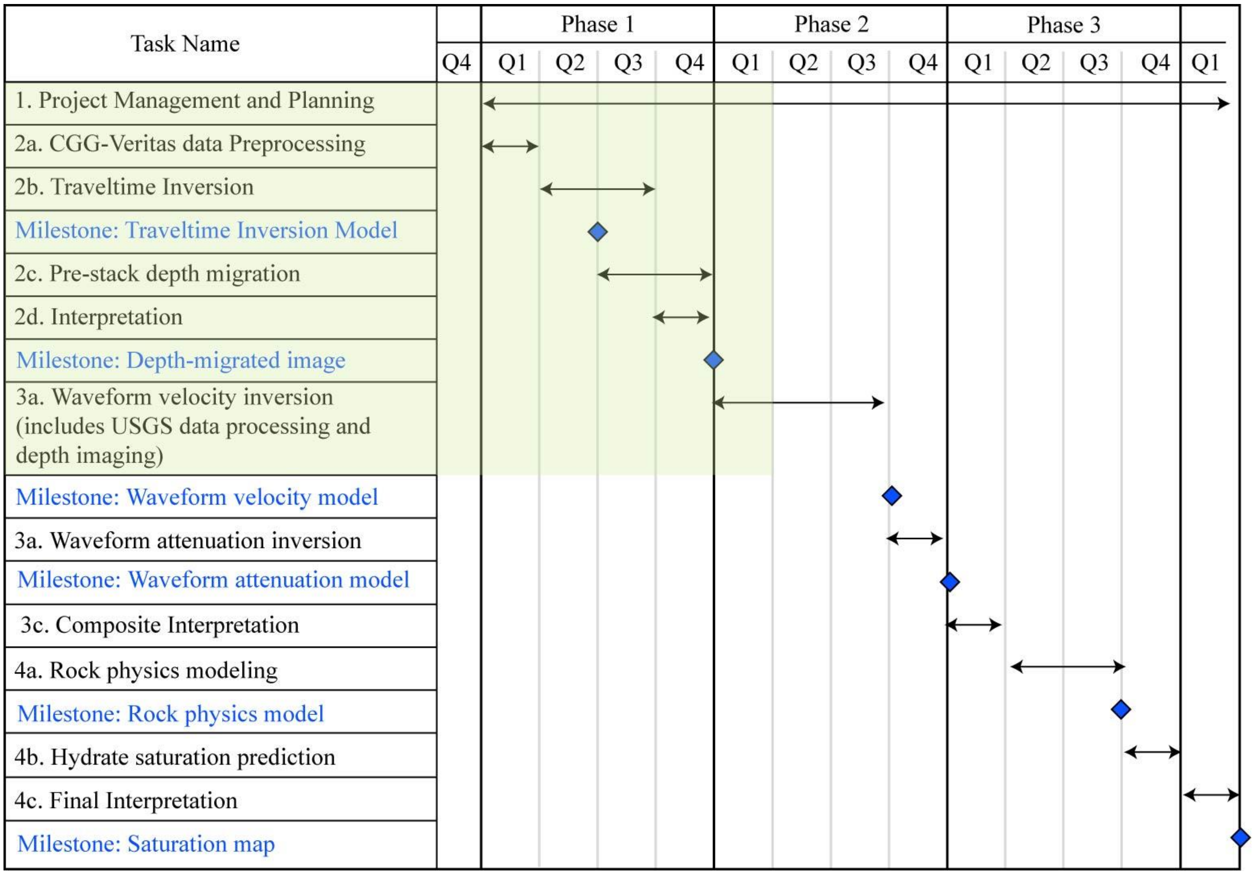
Figure 3. Post Stack Depth Imaged for a) GC955 and b) WR313. The velocity model chosen to migrate the stacked data in Figure 2 are based on well depths along the coincident seismic lines.

The intent of this DOE proposal was to understand the structural and stratigraphic controls on hydrate distribution in GC955 and WR313. Depth images and stacked data are key to addressing the objectives as they form the basic framework on which the velocity model can be built. At this stage the OBS and the MCS data are being merged. Preliminary interpretation of the MCS stacks are to follow along with traveltime picking in the OBS data followed by traveltime inversion.

Conclusions:

The 2-D data acquired by the USGS has adequate temporal and spatial resolution for serving the purposes of this proposal. The WR313 data are less noisy than GC955 data. Similarly processing flow could be applied to both datasets to obtain stacks that are in line with published geology from both sites. The depth images from both sites are in line with the corresponding well depths, indicating that the velocity models are good approximation of the geology and should be fit for serving as starting model for inversion.

Project milestone chart



The project is on target till date. Tasks already completed in the milestone chart are shaded in green.

Milestone Status:

Milestone	Description	Status	Schedule
Traveltime Inversion Model	The recipient shall compare the real and predicted reflection traveltimes from the final velocity model to be used for PSDM.	Done for CGGVeritas Datase Ongoing for USGS dataset	Completed on target Delayed: will be completed by Year2 Q2
Depth Migrated Image	The recipient shall compare structure and stratigraphy between the final depth image and images in literature and SSRs.	Done	On target
Waveform velocity model	The recipient shall compare waveform inversion velocity and sonic logs at well locations.	Ongoing	On target
Waveform attenuation model	The recipient shall compare real and synthetic simulated data.	Ongoing	On target
Rock physics model	The recipient shall compare predicted hydrate saturation at well locations with that available in the literature and methods of other DOE funded PIs, if available.	Ongoing	On target
Saturation map	The recipient shall compare consistency between hydrate distribution and structural/stratigraphic features interpreted in the study area.	Ongoing	On target

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