Training toward Advanced 3D Seismic Methods for CO2 Monitoring, Verification, and Accounting

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Executive Summary

This report presents major advances in progress made through the report period from January 1 to March 31 of 2010 for the CO_2 sequestration training project in the Dickman field, Ness County, Kansas.

The Dickman training project is based on the numerical simulation of improved seismic technology that addresses key challenges to monitoring movement and containment of CO_2 in the reservoir, specifically, better quantification and sensitivity mapping of caprock integrity and potential leakage pathways. This will be accomplished by elastic wavefield simulation based on a previous DOE-funded CO_2 sequestration study site in Ness county, Kansas (Figure 1).

Elastic wave simulation typically employs compressional (P), and shear (S) wave velocities as well as density for the simulation of a full seismic wavefield. To build the elastic model, existing well logs in the will be used. With this model, multi-component common shot gather could be obtained from elastic forward modeling and then could aid in identification of wave types and P-S converter beds. Information from this work may lead to changes in the survey design. The study will then focus on the simulation of a new 3-D seismic survey. The 3-D common shot gathers will be populated with traces for later processing. Finally, interpretation of the data set will be completed, including generation and mapping of horizon slices in the simulation migrated data volumes. From this study, a comprehensive workflow will be built for simulation of simultaneous source seismic data for CO2 sequestration.

Geology and Geophysics

<u>Geology</u>

The Kansas Geological Survey has recently updated the regional stratigraphic chart (Figure 2) for Kansas (Sawin, 2008, 2009). Researchers have synchronized the local stratigraphy at the Dickman field to the new regional chart (Figure 2), including the project target interval of Ft. Scott to top Viola ('This Study' blue box in Figure 2). The purpose of this synchronization is to reconstruct a regional structural deformation history that may have controlled the faulting and fracturing events in the target strata.

In the studied area, a part of the younger strata including the Upper Cretaceous and Tertiary is exposed on the steep slopes of the river valleys. The surface exposures include the Upper Cretaceous sandy and chalky shale, and overlying Tertiary unconsolidated or consolidated sand, shale and gravel.

Over 4,900 ft of the older strata were penetrated in the studied area and have been correlated, some with uncertainties, to the regional stratigraphic column established mainly on outcrop studies. The subsurface strata overlaying the Pre-Cambrian basement, from the oldest to the youngest are as follows: Undifferentiated Ordovician/Cambrian and Ordovician dominated by carbonates, Mississippian carbonates, Pennsylvanian cyclic carbonates and clastic rocks, Permian red-bed secessions, and Lower Cretaceous shale and sandstones with chalky beds.

The reconstruction of major structure deformation events is based mainly on published studies (Blakely, 2004; Merriam, 1963). Well tops in the KGS database on the southwest side of the Central Kansas Uplift (CKU) are also used to used to trace deposition, deformation, and preservation of strata as evidence of structural activities. The movement of the CKU controlled the local faulting and fracturing.

After the major post-Miss. and Pre-Penn. structural movement related to the continental collision along the Ouchita mountain belt, there were at least two structural events that may have left significant footprints in the studied area. The first event was during the late Pennsylvanian time, as indicated by significant thinning of the Upper Penn. Lansing group on top of the CKU and the abrupt thickness changes (up to 200 ft) of Lansing and Kansas City groups along a NE-trending lineation. This lineation is parallel to the south boundary of the CKU. Since Lansing group conformably underlays the younger Penn. strata (Zeller et. all, 1968), these thickness changes suggest syn-depositional uplift of the CKU and local subsidence along the NW side. This event might influence the faulting and fracturing in the Dickman area, such as the NE-trending boundary fault and a couple of NW-trending faults to the north end of the survey area. The second structural event is during late Cretaceous or later, probably associated with the Laramide Orogeny. It results in secondary structures, such as the Northeast trending Aldrich Anticline seen in the Eldritch Northeast field of the studied area. They are perpendicular to the axis of the CKU, and are probably the result of uplift and adjustment caused by stresses along pre-existing zones of weakness (Ramaker, 2006). These anticlines are likely associated with strike-slip movements. As a result, the northeast trending boundary fault in the studied area may have been closed to become a sealing fault to the pay zones in Dickman, Humphrey and Sargent field areas.

Geophysics

Work was started this quarter to build a 1D elastic model representative of the project area that will be used as input to reflectivity modeling. The elastic model requires P-wave, S-wave, and density values at all subsurface levels on well log resolution (approx 1 ft). Normally this would involve a standard density log and running a full wave sonic in one well to get P- and S-wave velocities. No full wave sonic data exists at Dickman, but we do have some sonic and density logs, along with other standard non-geophysical logs. Our challenge is to use existing log data and geological knowledge to estimate a vp, vs, density model from surface through Viola (our deepest horizon of interest).

An alternative approach is full waveform inversion of prestack seismic data at Dickman. The resulting elastic model is not on log scale (blocked layers), but it has the advantage of being fully 3D. Project data has been shared with Prof. Mrinal Sen of UT Austin and early results are encouraging (Phan and Sen, 2010).

Target site selection

Our Kingdom SMT project contains 143 wells in and around the project area. A total of six wells have sonic logs; Humphrey 4-18, Elmore 3, Dickman 1, Dickman 6, Noll 'C' 3 and Sidebottom 6. Figure 3 shows logged sonic intervals in the six wells (black and green curves). Note that only the Sidebottom 6 sonic gives complete penetration of the Mississippian interval.

Three wells in the project area have density logs, the Humphrey 4-18, Schaben 4 and Sidebottom 6. Figure 4 shows the logged density intervals in these wells In these wells (red curves). Only the Humphrey 4-18 and Sidebottom 6 have both sonic and density logs.

The Sidebottom 6 was selected as the target site for elastic model building since it is the deepest well (4957 ft) with both sonic and density log. We note, however, the density log interval is only 3500-TD (total depth), meaning that we will have to splice or estimate density in the upper missing section.

Elastic model building

Table 1 shows the logged intervals in the Sidebottom 6 well for gamma ray (GR), sonic (DT), and density (RHOB). The sonic log is in units of microseconds per foot and directly supplies P-wave velocity (Vp) at each depth level through the relationship

$$Vp = 1{,}000{,}000 \,/\, DT$$

as shown in Figure 5 for the Sidebottom 6. In this well Vp ranges from 7174 ft/s to 25024 ft/s.

For the 1D shear wave velocity Vs model building, the lithology in depth will be interpreted first based on Gamma Ray (GR) log and geology, to distinguish up to six lithologies: shale, sandstone, limestone, dolomite and anhydrite.

Table 2a shows lithology interpretation for the Sidebottom 6 well based on all available geological information, along with interval average Gamma Ray (GR), Photoelectric log (PE), Density, and sonic (DT) values. The table is sorted on increasing GR value and color coding corresponds to gross lithology. Thus, if a GR log were available from near surface to viola, we could use it to directly estimate lithology. No such GR log exists at Dickman. However, we do have a sonic log over this interval in the Sidebottom 6 well. Table 2b is the same information and color coding as Table 2a, but now sorted on sonic. A lithology classifcation based on sonic alone is only approximate, but we can generally see the following rough relationship between sonic (DT) and lithology for the Dickman area:

$$0 < DT < 60 \text{ (limestone)}$$

60 < DT < 72 (sandstone)

72 < DT < 105 (shale)

If a well had both GR and sonic logs, and we have an assumed GR-lithology relationship, it would be possible to generate a shear wave sonic from characteristic Vs/Vp ratios. An example is given in Table 3.

For the 1D density model, the available density log (RHOB) for Sidebottom 6 has information in the deeper layers only (3500 ft to 4957.5 ft). Therefore, to make up density information for shallower layers, we propose to find out the relationship between density and compressional wave velocity for each lithology first, and then apply this relationship to the compressional wave velocity depend on lithology, to obtain the density information for shallow layer between 255.5 ft to 4979.5 ft.

See figure 8, 9, 10 and 11 for the cross plot of compressional wave velocity and density for shale, sandstone, limestone and dolomite. For each lithology, a power function was employed to fit the relationship, see the power fitting function and R-squared value in the plot.

Figure 12 is the workflow summary for our approach to building an elastic layered model at well log resolution from existing data at in the Sidebottom 6 well. Primary well logs are shown in blue (gamma=GR, sonic=DT, density=RHOB).

1. Sonic log values over the entire well are used to calc Vp
2. Vs is calculated via the following steps:
    a. Where GR exists (deep section)
        i. GR is used to determine lithology
        ii. Vs/Vp is used to calc Vs from DT within each lithology
        iii. For use uphole, DT is mapped to lithology
    b. Where no GR exists (shallow section)
        i. The DT-lithology mapping is applied
        ii. Vs/Vp is used to calc Vs from DT within each lithology
3. Density is estimated via the following steps:
    a. Where RHOB exists (deep section)
        i. Density is known
    b. Where no RHOB exists (shallow section)

i. Within lithologies, make DT-RHOB crossplot
ii. Apply crossplot equation on DT to calc density

Early results from the prestack waveform inversion work of Phan and Sen (2010) are shown in Figure 13.

Seismic reflectivity modeling

The reason we build an elastic layered model is for use in simulating prestack seismic data to populate a 3D seismic survey design. Of the many methods of seismic wave simulation, we focus on reflectivity modeling. This method can model complete wave fields propagating in elastic or anelastic media with high numerical stability and accuracy at low cost.

Reflectivity modeling is always carried out in a cylindrical coordinate system, through which one can conveniently reduce wave equations into 1D. The modeling theory describes wave behavior in stratified earth models in a convenient way, where all wave types can be decomposed into upgoing and downgoing waves; and waves can be decoupled into P-SV and SH wave types (Kennett, 1983). Reflections, transmissions, conversions of all wave modes, and the corresponding multiples inside thin layers inserted between two half spaces or a free surface and a half space can be fully modeled.

The plan is to generate a elastic common midpoint gather (CMP) at very fine offset interval from the designed near offset to the designed far offset. In this way, every trace in the 3D survey design will have a corresponding trace in the CMP gather. More on this in later reports.

Educational Plan Implemented

Ms. Qiong Wu joined the Dickman Training project as a research assistant in January 2010. She is responsible for elastic synthetic data processing under guidance of Dr. Liner. With the help of the CO2 sequestration team, she had begun work with the 1D elastic model based on well logs from the Dickman field and plans an improved 1D model and elastic reflectivity modeling in summer 2010. At the same time, as part of the Dickman Training educational plan, she had taken two courses taught by Dr. Liner; *3D seismic data interpretation* and *Geophysical data processing*, which equipped her with knowledge and skill in seismic data processing and interpretation. She would like to thank NETL and Dr. Liner for the financial support and

opportunity to undertake this research, and also thank the CO2 sequestration team for helpful discussions.

Mr. Johnny Seales joined the team in late December 2009. He is an undergraduate geology/geophysics double major at UH.

Student biographical information is located in Appendix A.

Summary of significant Events

Prof. Mrinal Sen of University of Texas at Austin submitted a paper to the 2010 SEG, and presented results from seismic inversion study of a 3D pre-stack seismic data volume collected over the carbonate brine reservoir in the Dickman Field, Kansas. The purpose of this study is to use seismic data to quantitatively estimate some reservoir parameters (porosity, permeability) of this formation. Their analyses include extensive pre-stack velocity analysis, pre-stack inversion (figure 13) and mapping of inversion results to porosity. Seismic inversion results together with several other attributes derived from seismic data were used in a multi-attribute linear regression to estimate an effective porosity volume. The porosity is one of the most crucial parameters in assessing different possible scenarios for injecting CO2 within this reservoir. Their results will be incorporated in a reservoir simulator to investigate different 'what if' time-lapse scenarios.

Work Plan for the Next Quarter

As the principal investigator, Dr. Christopher Liner will administrate work in next quarter on generating elastic seismic simulations by reflectivity forward modeling. With the 1D elastic model built in the first quarter, simulation of an elastic common midpoint gather (a collection of seismic traces) will be completed to aid in identification of wave types and P-S converter beds. Information from this work may lead to improvements in the survey design. The study will then focus on simulation of a new 3-D seismic survey. The 3D survey design will be populated with traces from the simulated gather for later processing. Estimates will be made about relative efficiency of single versus simultaneous sources.

Cost and Milestone Status

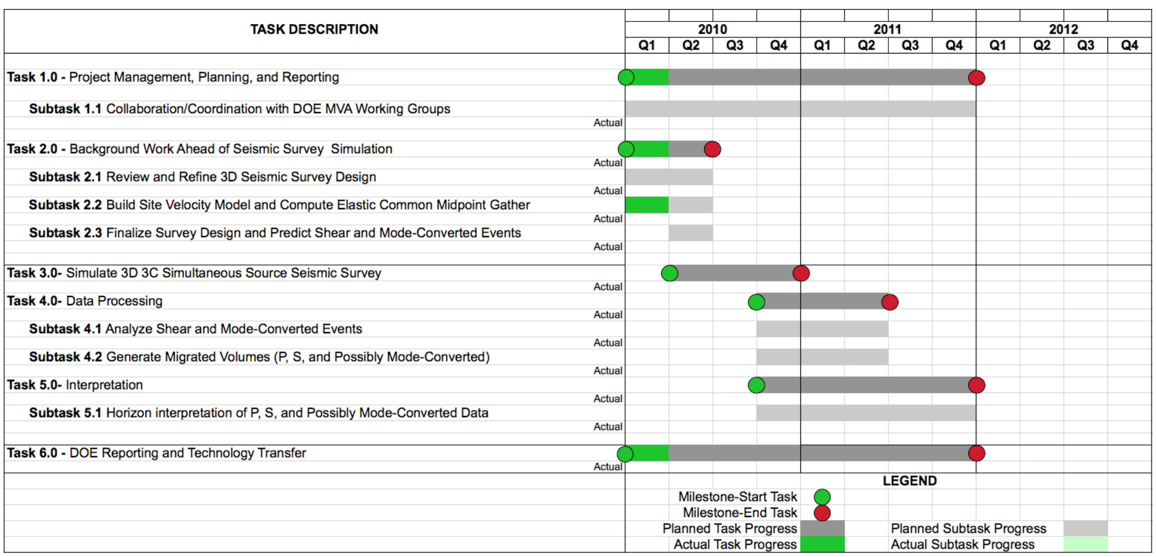
Baseline Costs Compared to Actual Incurred Costs

1/1/10 – 3/31/10	Plan	Costs	Difference
Federal	$36,668	$25,188	$11,480
Non-Federal	$4,063	$0	$4,063
Total	$40,730	$25,188	$15,542

Forecasted cash needs vs. actual incurred costs

Notes:
(1) Federal plan amount based on award of $293,342 averaged over 8 reporting quarters.
(2) Non-Federal plan amount based on cost share of $32,500 averaged as above.
(3) Cost this period reflects 3 months salary for J. Zeng, Q. Wu, and J. Seales.

Actual Progress Compared to Milestones



Continuing Personnel

Prof. Christopher Liner is Principle Investigator and lead geophysicist. He is a member of the SEG CO_2 Committee, Associate Director of the Allied Geophysical Lab, and has been selected to deliver the 2012 SEG Distinguished Instructor Short Course.

Dr. Jianjun (June) Zeng has been working exclusively on this project since Dec 2007 and is lead geologist.

Ms. Qiong Wu is a graduate PHD student in geophysics who joined the project in January 2010 as a research assistant. She will be funded year-round out of the project.

Mr. Johnny Seales is an undergraduate student majoring in Geology and Geophysics. He is also a U.S. Army veteran, having served in Iraq. He will be funded year-round from the project. He anticipates earning his undergraduate degree in Dec. 2011.

Technology Transfer Activities

Phan and Sen (2010) will be presented at the SEG 2010 annual meeting in Denver (acceptance pending).

Contributors

Christopher Liner (P.I, Geophysics)
Jianjun (June) Zeng (Geology and Petrel Modeling)
Qiong Wu (Geophysics PHD candidate)
Johnny Seales (Geology and Geophysics Undergraduate)

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Tables

Gamma (GR)	3500.0 - 4943.0 ft
Density (RHOB)	3500.0 - 4957.5 ft
Sonic (DT)	255.5 - 4980.0 ft

Table 1. Logged depth range for key logs in the Sidebottom 6 well.

Depth	GR	PE	Lithology interpretation	Density	DT	Sample	In Formation
4637.5-4651	20	3.34	Dolomite (with limes?)	2.63	55	23	Viola Limestone
1693-1702	22	N/A	Anhydrite (Schaben 4)	N/A	50	41	Stone Corral (Permian)
4460-4517	22	2.51	Cherty Dolomite, Porous	2.3	72	114	Osage (Mid.-L. Miss)
4517-4624	22	3.86	Limestone, Tight	2.63	54	214	Gilmore City (L. Miss.)
4760.5-4771	23	3.27	Dolo (w/Lime?) Tight	2.69	51	22	Arbuckle (L. Ord –Cam)
4355-4375	24	2.3	Cherty Dolo. Congl?	2.27	72	41	Lower Cherokee Sandstone
4375.5-4460	25	2.74	Cherty Dolomite, Porous	2.38	69	170	Warsaw Limstone (Mid. Miss.)
4657-4744	25	3	Dolomite	2.5	62	175	Voila Limestone
4002-4005	26		Limestone	2.62	55	7	Lansing Group
4780	26	2.85	Dolomite	2.48	59	8	Arbuckle
3740-3746	28		Limestone	2.64	55	13	Heebner Shale
3930-3941	31		Limestone	2.62	57	23	Lansing Group
4257.5-4260	32	3.5	Limes	2.43	63	6	Fort Scott Limes (M. Penn)
3616.5-3618.5	33		Limes	2.5	64	5	Shawnee Group
4094.5-4100.5	35	N/A	Limestone	2.63	57	13	Marmaton Group (M. Penn)
4176-4188.5	38	3.45	Limes	2.56	64	26	Pawnee Limestone (M. Penn)
4275.5-4279.5	38	4.19	Limestone	2.59	56	9	Fort Scott Limes
4294.5-4297.5	40	4.35	Limestone	2.69	52	7	Cherokee Group
4205-4238	48	3.7	Sandstone	2.58	67	67	Pawnee Limestone
3746-3753	51		Sandstone	2.6	59	14	Heebner Shale
3961-3971	54		Sandstone	2.63	53	21	Lansing Group
4262-4268.5	54	3.9	Sandstone	2.62	62	14	Fort Scott Limes
3625-3632	57		Sandstone	2.56	66	15	Shawnee Group
4311-4322	62	4.01	Sandstone (Limey?)	2.54	71	23	Cherokee Group
4101-4109	66	3.75	Sandstone	2.6	70	17	Marmaton Group
3733-3740	69		Sandstone	2.24	77	14	Heebner Shale
4633.5-4637	83	3.14	Shale, at erosional contact	2.51	68	8	Top Viola Limestone (Mid. Ord)
3503-3505	106		Shale	2.44	79	5	Shawnee Group (U. Penn)
4747-4750.5	110	2.72	Shale	2.38	75	8	Base Voila Limes
4328-4347.5	113	3.58	Shale (Limey?)	2.24	103	40	Cherokee Sandstone
4173-4174.5	118	3.38	Shale (Fracture?)	2.33	74	4	Base Marmaton Group
4626.5-4628	119	3.1	Shale, at erosional contact	2.49	78	4	Base of Gilmore City
3836-3837.5	123		Shale	2.36	84	4	Lansing Group (U. Penn)
4301-4310	123	3.35	Shale	2.23	84	9	Cherokee Group
4110-4115	153	3.53	Shale (Limey)	2.34	97	11	Marmaton Group
3632.5-3636.5	177		Shale	2.4	72	9	Shawnee Group
4027.5-4030.5	178		Shale	2.37	82	7	Lansing Group
4250-4255	209	3.03	Shale	2.2	101	12	Base Pawnee Limestone
4281.5-4285	220	3.05	Shale	2.16	87	8	Top Cherokee Group (M. Penn)
3716.5-3721	224		Shale	2.3	90	10	Heebner Shale (U. Penn)

Table 2a. Sidebottom 6 log analysis in multiple log intervals. The table is sorted on gamma ray (GR) and color coded for lithology.

Depth	GR	PE	Lithology interpretation	Density	DT	Sample	In Formation
1693-1702	22	N/A	Anhydrite (Schaben 4)	N/A	50	41	Stone Corral (Permian)
4760.5-4771	23	3.27	Dolo (w/Lime?) Tight	2.69	51	22	Arbuckle (L. Ord –Cam)
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4328-4347.5	113	3.58	Shale (Limey?)	2.24	103	40	Cherokee Sandstone

Table 2b. Same data as Table 2a, now sorted on sonic reading (DT). This shows that lithology can be approximately discriminated based on sonic alone, a key result since our only log reading through the entire Dickman stratigraphic section is the sonic log in the Sidebottom 6 well.

Lithology	GR	Vp/Vs
Shale	80~140	1.6~1.8
Sandstone	1~30	1.6
Limestone	0~5	1.9
Anhydrite	0~30	1.72~1.85
Dolomite	5~20	1.8

Table 3. Example range of GR and VP/Vs ratio for various lithologies.

Figures

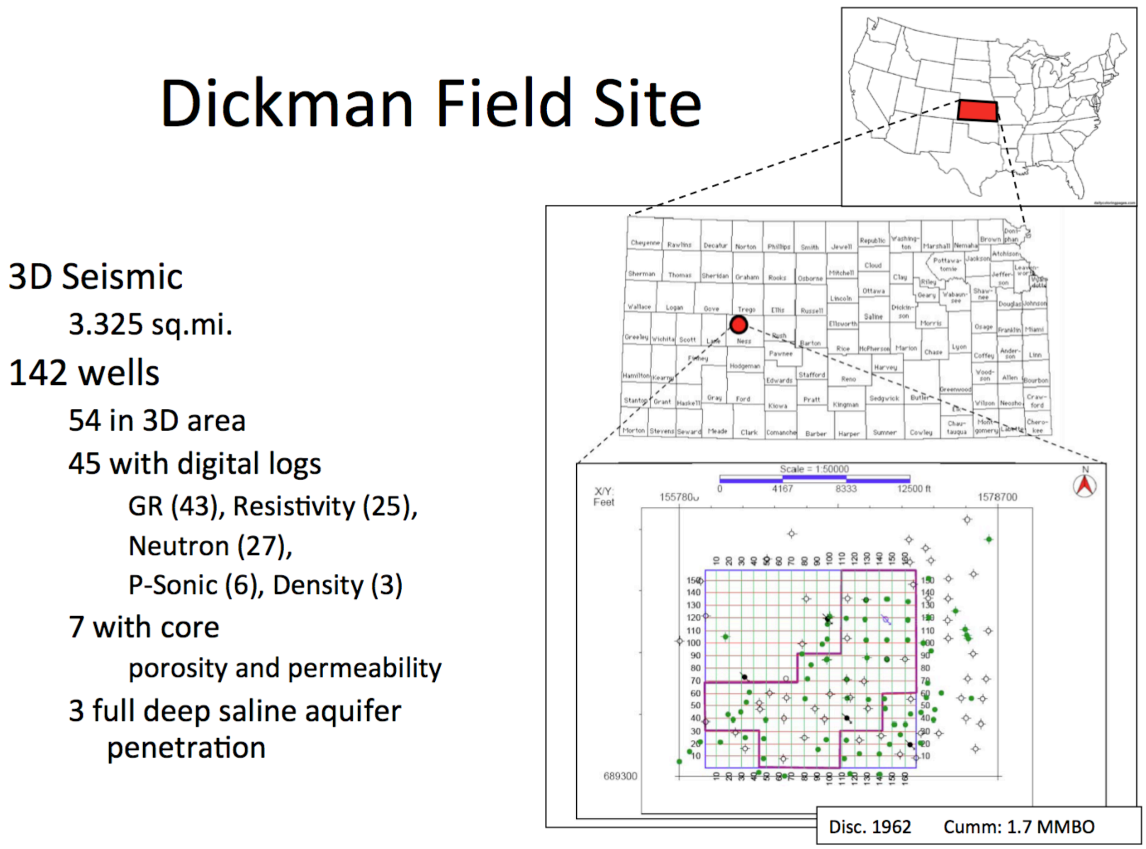

Figure 1. Area map depicting the location of the project area, Dickman field, Ness County, Kansas. On detail map, seismic inline and crossline numbers are shown, as well as the live 3D seismc area (purple polygon).

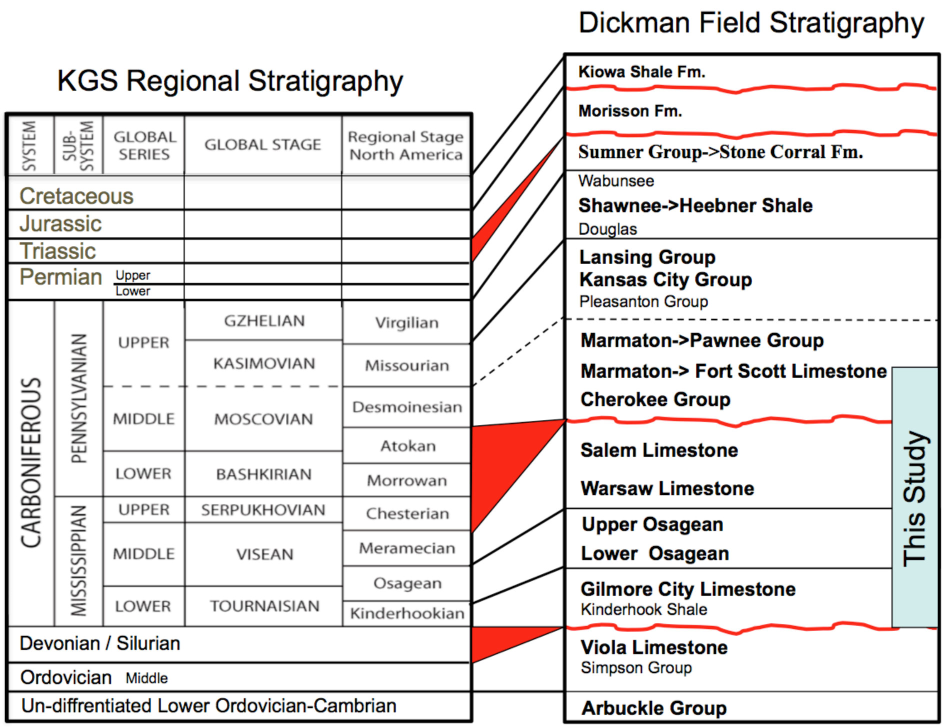

Figure 2. Top Mississippian time structure maps. (A) Tracking result using zero crossing in the amplitude volume. (B) Tracking result using peak in spice volume. Note improved continuity on this irregular, karsted surface in the spice-generated map.

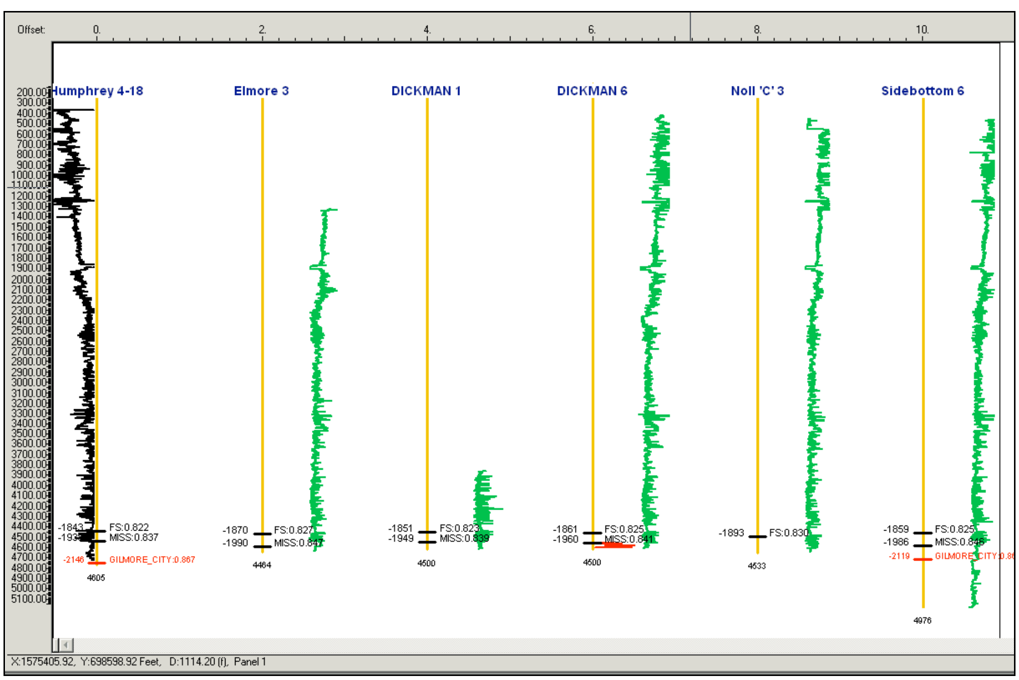

Figure 3. 6 Selected sonic logs (black and green) in the project area.

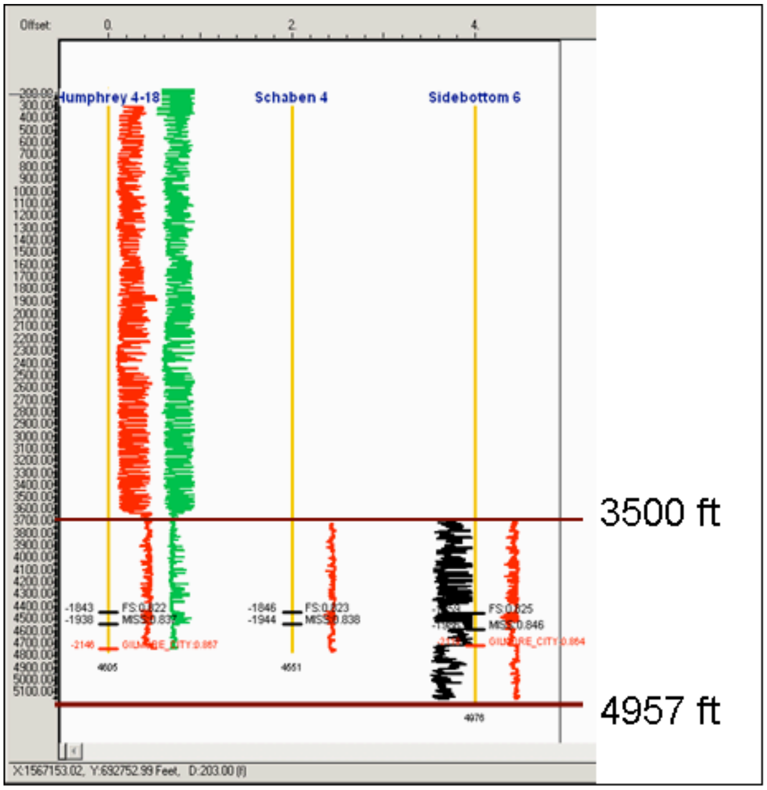

Figure 4. Selected density logs (red) in the project area.

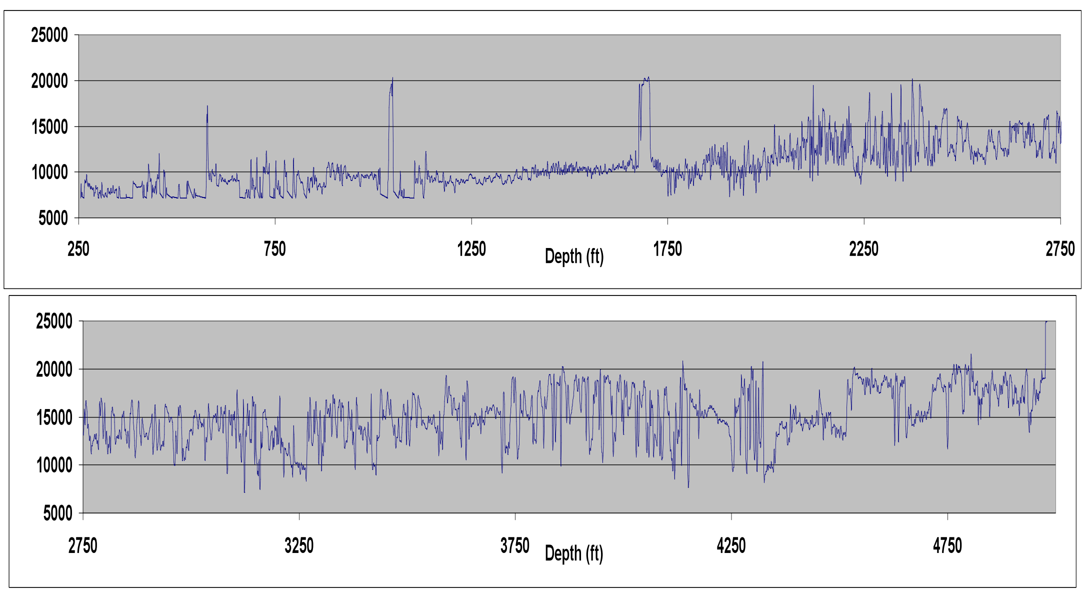

Figure 5. P-wave velocity (ft/s) for Sidebottom 6 well computed from sonic.

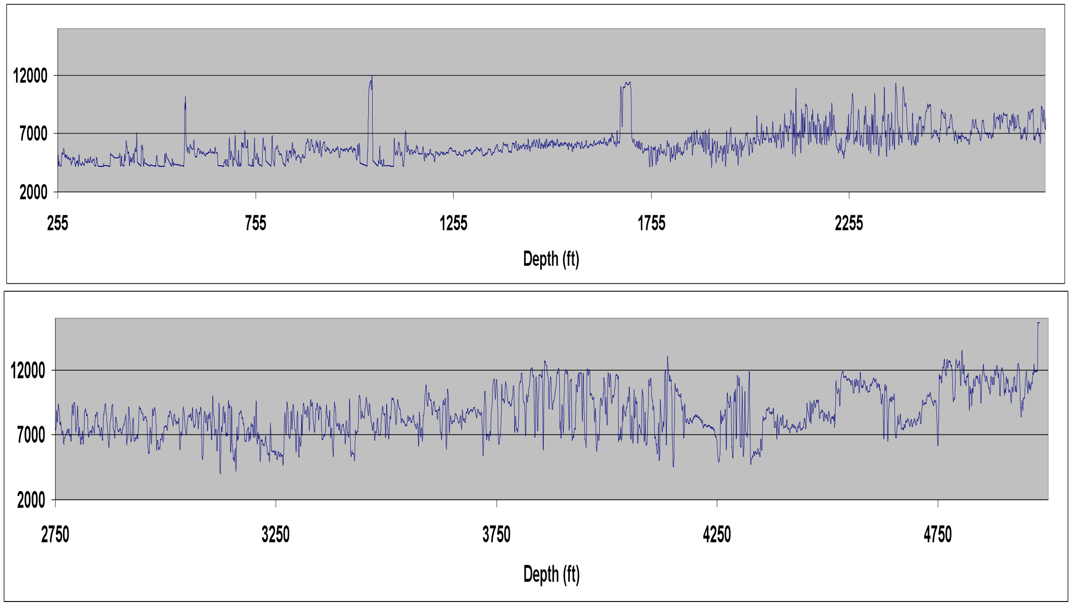

Figure 6. Estimated S-wave velocity (ft/s) for Sidebottom 6 well.

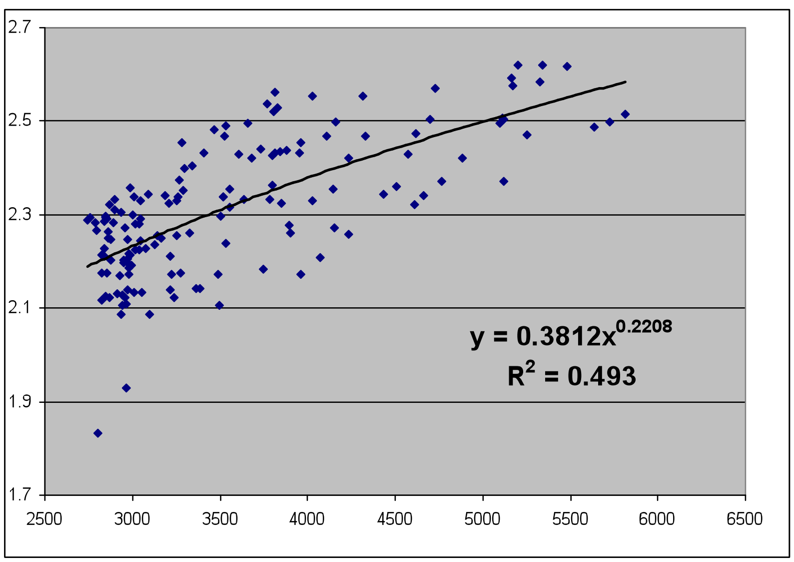

Figure 7. Crossplot of V_P and density for shale (N=187).

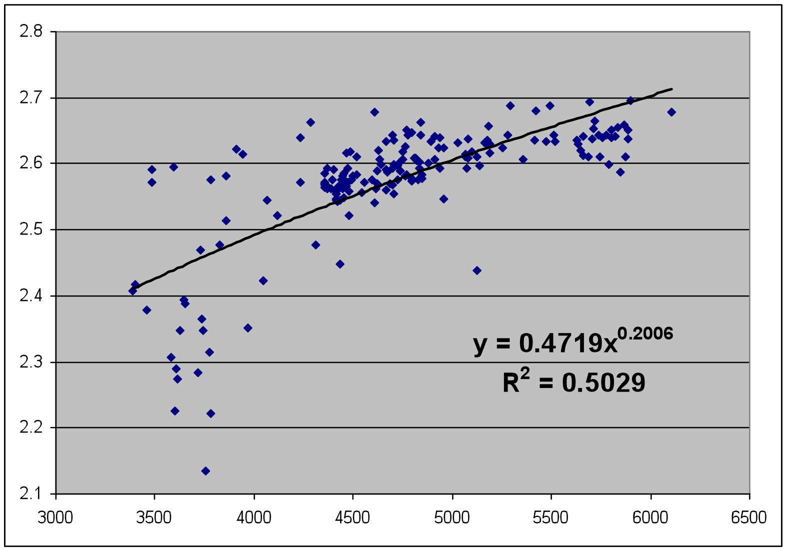

Figure 8. Crossplot of V_P and density for sandstone (N=151).

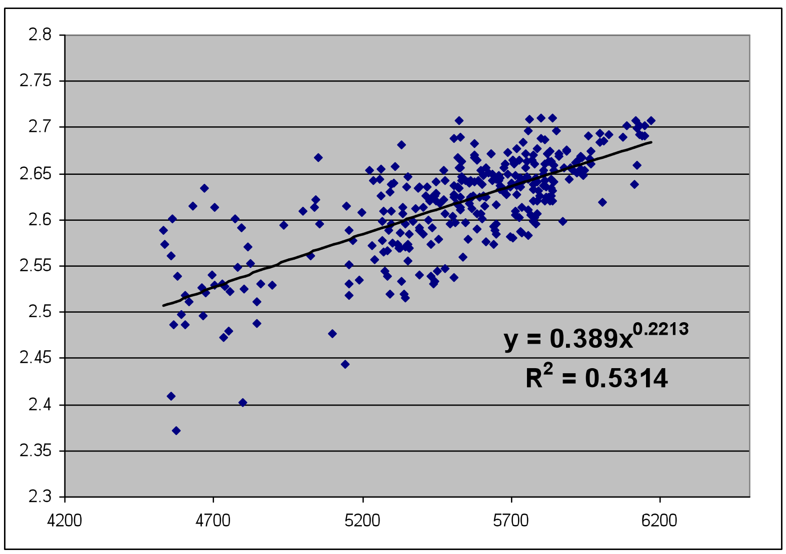

Figure 9. Crossplot of V_P and density for limestone (N=324).

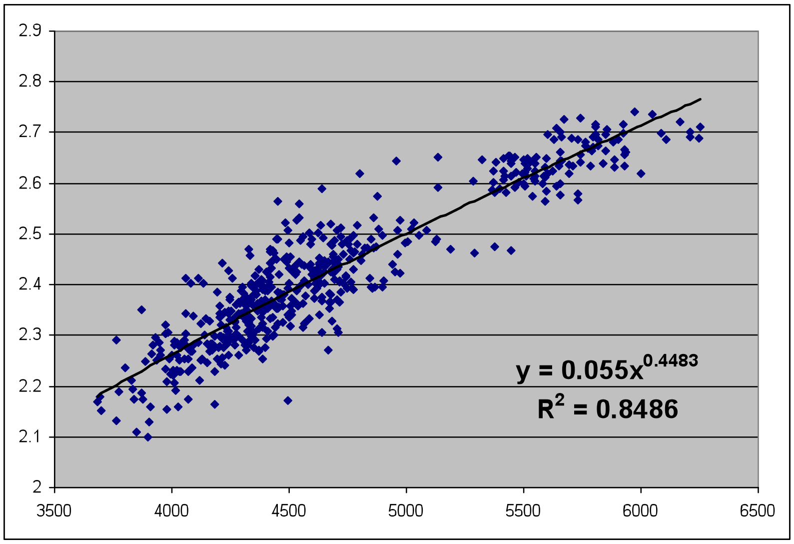

Figure 10. Crossplot of V_P and density for dolomite (N=551).

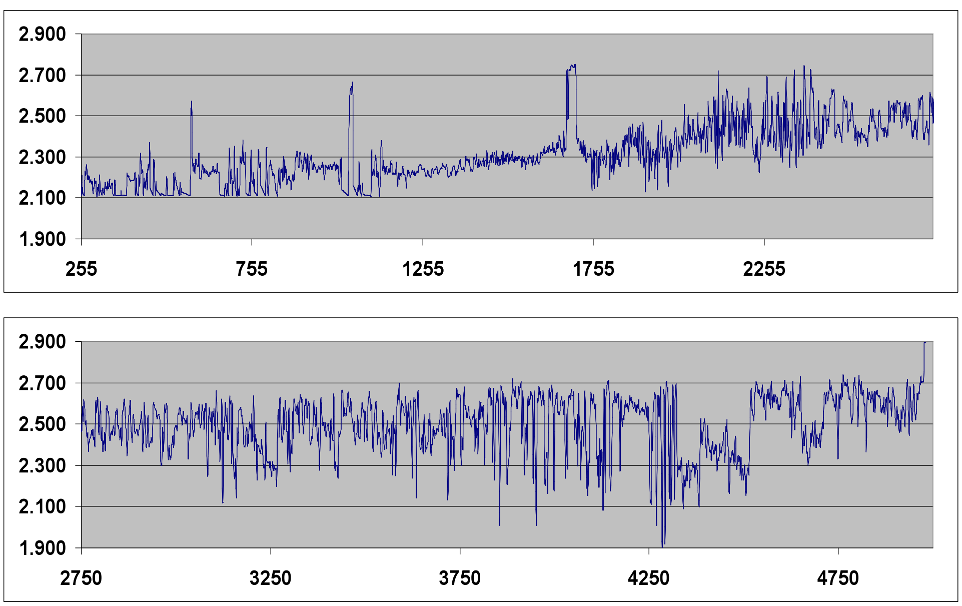

Figure 11. Density log for Sidebottom 6, spliced to estimated density between 255.5 ft to 3500 ft.

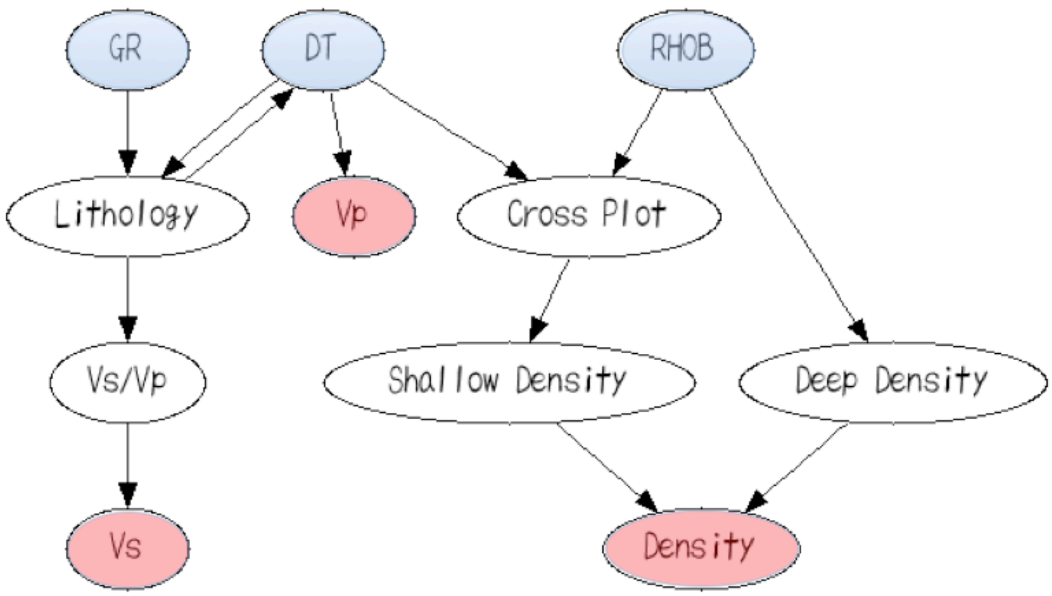

Figure 12. Workflow for Sidebottom 6 well to generate elastic model (at well log resolution). Input well logs colored blue, and output elastic parameter logs in red.

Note: Plot created at this web site: http://ashitani.jp/gv/#
Using the following code (color done in PPT):

```
"DT"->"Vp"
"GR"->"Lithology"
"DT"->"Lithology"
"Lithology"->"DT"
"Lithology"->"Vs/Vp"
"Vs/Vp"->"Vs"
"RHOB"->"Deep Density"
"DT"->"Cross Plot" [red]
"RHOB"->"Cross Plot"
"Cross Plot"->"Shallow Density"
"Shallow Density"->"Density"
"Deep Density"->"Density"
```

To recreate figure, paste code in the supplied window and hit Return

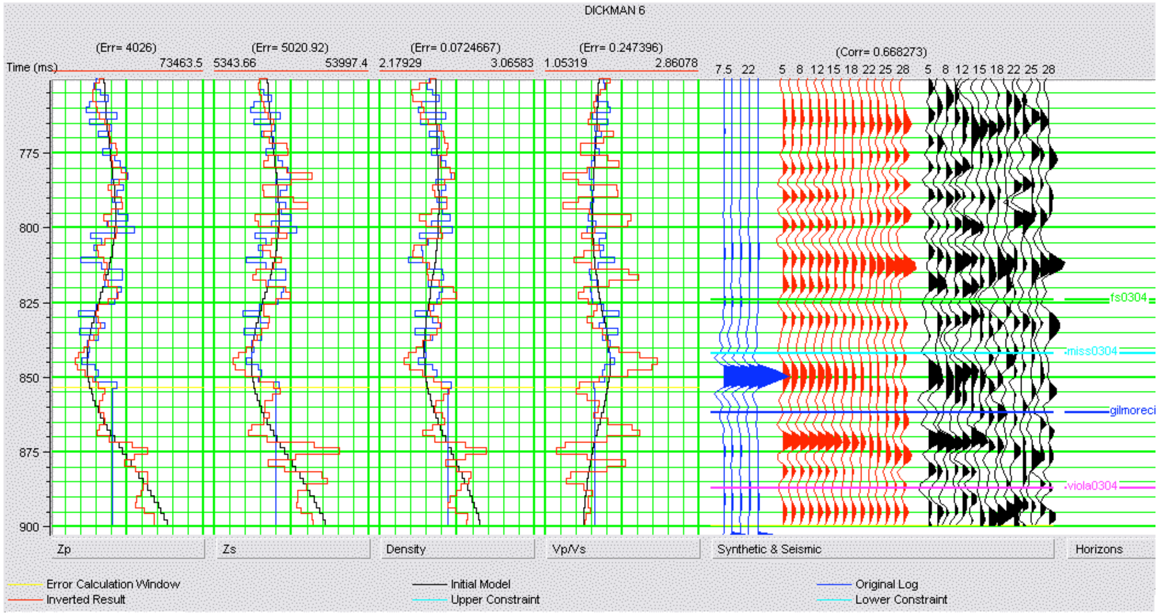

Figure 13: Inversion results at Dickman 6: the starting model (smooth black line), true log (blue) and inverted model (red) of Zp, Zs, density and Vp/Vs ratio are shown in the left 4 panels. The right two panels show synthetic and true angle gathers. (From Phan and Sen, 2010)

Appendix A: Student Biographies

Ms. Qiong Wu

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Houston, TX 77204-5007 qiongwu2010@gmail.com

Geophysicist on Seismic Exploration

Education

PHD student, Geophysics, University of Houston. January 2010 - now
M.S., Geophysics, University of Utah, December 2009. GPA 3.2
M.S., Geophysics, Chinese Academy of Sciences, Beijing, June 2007. GPA 3.6
B.S., Geophysics, China University of Geosciences, Beijing, June 2004. GPA 3.0

Summary of Qualifications

- Industry experience with 2D and 3D seismic data processing. Familiar with many industry processing packages.
- Research experience on novel seismic imaging and processing technology.
- Enjoy teamwork and the challenge of new project. Open and positive personality.

Related Skills and Experience

Seismic Data Processing

+Prestack time migration of a 3D land dataset from Shengli Petroleum Administrative Bureau of China.
+Data preprocess, sorting and NMO velocity analysis using ***Omega*** on a 2D marine dataset process project in cooperation with Korea Institute of Geosciences and Mineral Resources.
+Geometry database generation and migration velocity analysis using ***Omega*** in a 3D land dataset project from Shengli Petroleum Administrative Bureau of China.
+Workshop on seismic data processing using ***ProMax*** on geometry generation, data sort, amplitude recovery, F-K analysis, velocity analysis, NMO, stacking, and migration.

Seismic Data Interpretation

+Workshop on seismic data interpretation using ***SeisWorks*** and ***GeoProbe***.
+Course on 3D interpretation using ***KINGDOM***.

Research Experience

+Currently work on DOE project on studying 3C 3D data to detect fracture and subtle fault for CO2 sequestration.
+Conversion of seismic-while-drilling VSP dataset acquired in Wyoming into surface seismic profile using seismic interferometry, a recently developed technique.
+Application of an inexpensive iterative migration deconvolution to improve reverse time migration image of 2D PEMEX OBS dataset from the Gulf of Mexico.
+Matching for seismic dataset acquired on land and adjacent shallow marine area in different times.

Work History

- Research Assistant, Dept. of Earth and Atmospheric Sciences, University of Houston. Jan. 2010 - now
- Research Assistant, Utah Tomography and Modeling/Migration Consortium (UTAM) in University of Utah, Aug. 2008- Dec. 2009
- Seismic Processor, Beijing Co-Sail Oil Technology Corporation, Apr. 2007- Mar. 2008
- Research Assistant, Complicated Structure Seismic Imaging Lab of Institute of Geology and geophysics, Chinese Academy of Science, Sept. 2004 - Jun. 2008

Courses Taken

Geophysics Data processing (by Chris Liner)
Advanced Seismic Imaging (by Gerard Schuster)
Inversion Theory and Application (by Michel Zhdanov)
Global Geophysics
Well Logging
Seismology (by Gerard Schuster)
Petroleum System
Seismic Interpretation
Structural Geology
Digital signal processing

Computer Skills

+Skilled in ***Omega*** processing package, familiar with ***ProMax***, ***CGG***, ***Views***, ***SeisWorks***, ***GeoProbe***, ***SU*** and ***KINGDOM***.
+Skilled in ***MATLAB***, familiar with ***Shell scripts*** and ***FORTRAN 90***.

Field Trips

3D land seismic data acquisition for Washington fault survey, Arizona. Oct. 2008
Geology field trip at Choukoutien, Beijing, China. Jun. 2002

Qualification and Professional Memberships

Completion of the Petroleum Industry Career Path courses in University of Utah.
Student member of the Society of Exploration Geophysicists (SEG).
Student member of the American Association of Petroleum Geologists (AAPG).

Honors and Awards

Excellent Graduate Scholarship of Chinese Academy of Sciences. Jun. 2007
Excellent Academic Achievement Scholarship of China Univ. of Geosciences. 2000-2004
Scholarship for outstanding leadership in Student Union of China Univ. of Geosciences. Jun. 2003

Publications

+ Qiong Wu, Changchun Yang, Wenzhong Zhang, Research on processing technology on matching seismic data acquired on land and adjacent marine prospect. Progress in Geophysics, Vol. 23 No.3 P761~767.
+ Gaojie Xiao, Changchun Yang, Qiong Wu, Application of spectral decomposition method to channel identifying at W area. Progress in Geophysics, Vol. 23 No.2 P568~572.

Mr. Johnny Seales

Biography

My name is Johnny Seales. I was born in Humble, Texas where I have spent the majority of my life. While growing up, I played many sports such as baseball, football, track and martial arts. While attending Humble High School I started out running cross-country and playing baseball, and then shifted my main focus to playing baseball after my sophomore year. I made above average grades and managed to stay a year ahead in my math and science courses all through school.

During my senior year, I was blessed with a baby girl whose name is Hailee. After her birth, many things changed for me. The biggest change I made in my life came when I enlisted into the army. With this decision, it became apparent I should stop chasing my dream of playing college baseball, and focus on what would be best for my new family. In August of 2004, I left for basic training in Fort Jackson, South Carolina. Following graduation, I was shipped to Arizona where I attended my Advanced Individual Training as an Intelligence Analyst in the Military Intelligence Corps. Once meeting all standards for academic and physical tests, I was shipped to Fort Hood, Texas where I joined my new unit.

The unit was just beginning a training build up course, so I received new instruction on different analysis systems and techniques that would be relevant for deployment situations. After many months and exercises, the unit was placed under the 1st Cav Division. Final preparations were made in training before beginning pre-deployment operations. During this time, my second child, Landen, was born. The unit was then deployed to Baghdad, Iraq where we spent 15 months in support of Operation Iraqi Freedom. I held the position of night shift intelligence analyst for my unit giving over 1000 combat briefings. While in Iraq, after becoming soldier of the quarter, I earned the rank of sergeant shortly after two and half years of my commitment was complete. Following a successful deployment, the unit was redeployed to Fort Hood, Texas where I would resume day-to-day operations in maintaining security clearances and operational security tasks for the unit.

After returning in January of 2008, I had a few short months before my separation date. I had already been accepted to the University of Houston with only an idea of what degree I wanted to pursue. After considering all options and knowing my love for math, the sciences and the outdoors, I determined the best choice of academic program was geology or geophysics. Initially I had decided to just attempt the geophysics program, but after much deliberation and guidance, I determined a double major in geology and geophysics would best suit my future goals.

The first of these goals include hopefully graduating in December 2011. Following that, I would like to attend further schooling to advance my education to at least a masters degree and hopefully a PhD at some point. I am greatly pleased Dr. Liner presented this opportunity to grow and expand my knowledge of new technology ahead of my peers. It will facilitate me with the skills needed to help achieve my long-term plans.

Since attending the University of Houston, I have been overjoyed with my college experience. Following my freshman year, I was awarded two scholarships, the Allan Wong scholarship as well as the John C. Butler Presidential Endowment. Recently, I have also been selected to join the ranks of the College of Natural Sciences and Mathematics Ambassador program. The purpose of this group is to help attract undecided incoming students to our college and answer any questions about what the college life is like in our respective degree programs.

Class and Analysis

In the beginning of January, I was encouraged to take the 3D Seismic Interpretation class. This was a short course that lasted approximately three weeks. The SMT Kingdom software was used to analyze different aspects of seismic. The course was structured to provide approximately twelve hours a week to familiarize with this software. The help tutorials coupled with example data were useful to learn the different features and applications.

There were three tasks given throughout the course. The first was to work through the SynPAK tutorial in order to generate a synthetic seismogram, fit it to the seismic and display it at the well location. The second of these tasks was to learn how to track horizons. This was done using the 2d/3d Pak tutorial where also time maps were created, gridding and fault interpretation were also explored while using this area. Lastly, a data set of the Gulf of Mexico was given to be analyzed. It was around this time a deep find had been made in the area, so it was encouraged to explore and see what could be discovered at depth since we had the available data and resources. Amplitude anomalies were examined in the data set. The horizon this was located in was then thoroughly tracked and faults were interpreted. An estimate was then made to determine how much oil and gas was present at the location. The course concluded with a presentation of results that had been located within the data set.

After receiving a solid foundation of analytical skills to work with, it was possible to begin interpreting given data for the Dickman field. The first task was to break a specified area of the Sidebottom 6 well into its respective lithologies. The depth that would be analyzed lay between 4256 ft and 4516 ft in depth. Once this would become accomplished, determined sonic values would then be translated from the analyzed depth to surface.

The first process attempted was the use of cross plots in Kingdom. In the tutorial section of Kingdom, there is an exercise located in EarthPAK named Facies Modeling that lists a workflow for determining lithology. The same example data used in previously mentioned class would be used to gain an understanding of this workflow. The basic outline of this is as follows. First the well to be analyzed is selected. Following this, determination of which logs should be used is accomplished. The cross plot consisted of an x-, y- and z-axes containing RHOB, LLD and GR respectively. Once groupings of points were located on the cross plot, polygons were digitized and labeled accordingly allowing three lithologies to be determined in the given example. Once this was completed, the analyzed logs showed the location of determined lithologies color-coded by the points grouped in each polygon. This technique allowed the breakdown of any well log used in the cross plot and could be transferred up the well.

The limit to this workflow is the analysis was limited to which logs were present in each well. The attempt to apply this concept to the Dickman data set and allow five lithologies, sandstone, shale, limestone, dolomite and anhydrite, showed immediate problems. The types of logs used in the tutorial were not all present in the Sidebottom 6 well. In fact, all three logs were not present simultaneously in any wells throughout the entire field of study. An attempt to overcome this problem was made by making further cross plots of different well logs to no avail. At this point Helander (1983) was consulted to see what type other cross plots maybe of use in lithology determination. Majority of the cross plots discussed could have been useful, but would only help determine percentages of lithology. An example would be that an area that plotted between lines of sandstone and limestone would be 55% limestone and 45% sandstone. In the case of attempting to break an area into five lithologies, this was not much help.

The next option was to analyze the GR log in Sidebottom 6 to determine if lithologies could be broken out based on this. The analysis initially conducted resulted in overlapping ranges for a majority of the lithology types. This in itself was a problem. Another problem then presented itself. The GR log did not run completely up the well. With further goals in mind, the only useful log that reached from surface to analyzed depth was the Sonic log. Somehow correlation would have to be made between the GR and Sonic logs in an attempt to analyze the entire well.

The information that was available consisted of the GR ranges. This could somehow be further analyzed and broken down into different lithologies. After previous persons had analyzed the well, a spreadsheet was made with determined lithologies and bed depth as well as values for GR, DT and RHOB. With this information given, an apparent value of the GR could then be determined. After sorting the information in ascending order, it was easier to break out what values might be used for GR to break out the five lithologies. The previous information was then reanalyzed and the following values were given to different lithology boundaries based on the breakdown of GR values: Shale 80-above, Sandstone 40-79, Limestone 28-39, Dolomite 23-27 and Anhydrite 0-22.

Now that values had been determined for the GR, it was possible to attempt a correlation between these and listed values of DT. The problem with this is initially, the assumed lithologies did not match up next to each other once sorted. Only 25 of 40 samples were correlated correctly by both GR and DT sorted in an ascending manor. This produced an estimated 62.5% correct prediction rate. Further analysis would then be conducted. The next theory applied would be to take into account that there could be some mixture in the lithology types. This could be taken into account by reanalyzing the GR values and taking a small variation at the boundaries and including this in the DT values as a mixture in rock type. Once this was accomplished and lithology type was readjusted with the mixed boundaries, a total of 30 of 40 samples would match correctly. This results in an increase of 12.5% correctness to a total of 75%. The goal is to have an accuracy of approximately 85-90%. This means further analysis must me completed.

References

Helander, D.P., 1983, Fundamentals of Formation Evaluation: Oil and Gas Consultants International, Inc.