Lott Ranch 3D Project

Garza County, Texas
A Yates Energy Corporation Project

FINAL REPORT

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ABSTRACT

The Lott Ranch 3D seismic prospect located in Garza County, Texas is a project initiated in September of 1991 by the J.M. Huber Corp., a petroleum exploration and production company. By today's standards the 126 square mile project does not seem monumental, however at the time it was conceived it was the most intensive land 3D project ever attempted.

Acquisition began in September of 1991 utilizing GEO-SEISMIC, INC., a seismic data contractor. The field parameters were selected by J.M. Huber, and were of a radical design. The recording instruments used were GeoCor IV amplifiers designed by Geosystems Inc., which record the data in **signed bit** format.

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In 1997, Yates Energy Corp. located in Roswell, New Mexico, formed a partnership to further develop the project. Through discussions and meetings with Pinnacle Seismic, it was determined that the original Lott Ranch 3D volume could be vastly improved upon reprocessing. Pinnacle Seismic had shown the viability of improving field-summed signed bit data on smaller 2D and 3D projects. Yates contracted Pinnacle Seismic Ltd. to perform the reprocessing.

This project was initiated with high resolution being a priority. Much of the potential resolution was lost through the initial summing of the field data. Modern computers that are now being utilized have tremendous speed and storage capacities that were cost prohibitive when this data was initially processed. Software updates and capabilities offer a variety of quality control and statics resolution, which are pertinent to the Lott Ranch project.

The reprocessing effort was very successful. The resulting processed data-set was then interpreted using modern PC-based interpretation and mapping software. Production data, log data, and scout ticket data were integrated with the 3D interpretations to evaluate drilling opportunities resulting in an initial three well drilling program..

Thousands of miles of signed bit data exist. Much of this data was processed during a time when software and hardware capabilities were either incapable or cost prohibitive to glean the full potential of the data. In fact in some circles signed bit gained an undeserved reputation for being less than optimum. As a consequence much of the older signed bit data sits on the shelf long forgotten or overlooked. With the high cost of new acquisition and permitting it might behoove other exploration companies to reconsider resurrecting perfectly viable existing volumes and have them reprocessed at a fraction of the cost of new acquisition.

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EXPERIMENTAL

PHASE ONE: DATA REPROCESSING

The Lott Ranch 3D seismic prospect located in Garza County, Texas is a project initiated in September of 1991 by the J.M. Huber Corp., a petroleum exploration and production company. By today's standards the 126 square mile project does not seem monumental, however at the time it was conceived it was the most intensive land 3D project ever attempted. Utilizing two different seismic acquisition companies, J.M. Huber spent two years and a vast sum of money in acquiring the data. Several initial problems had to be solved and overcome to achieve success. Permitting for seismic acquisition was difficult and many negotiations were necessary to eventually obtain approval for property access. The data acquisition was interrupted on several occasions because of weather, crop considerations, equipment problems and failures, cash flow problems with the initial seismic contractor, and other reasons.

Acquisition began in September of 1991 utilizing GEO-SEISMIC, INC., a seismic data contractor. The field parameters were selected by J.M. Huber, and were of a radical design. The recording instruments used were GeoCor IV amplifiers designed by Geosystems Inc., which record the data in signed bit format. Two individual recording systems were brought in for this highly intensive effort. Initially, 2048 channels per source point were recorded. The GeoCor IV recording systems provided the highest channel capabilities of any seismic systems at that time, and the client had experienced previous success in utilizing the signed bit data. Shortly after acquisition began, the number of receiver lines was reduced due to the equipment and personnel limitations of Geo-Seismic Inc. J.M. Huber was determined to maintain extremely high sampling and acquisition was much slower than anticipated. Weather delays caused further problems and as equipment became stuck and cables were left standing in puddles, the project became too much for Geo-Seismic to handle. At this time Geo-Systems Inc., the developer of the GeoCor IV recorder, and a competitor of Geo-Seismic, was contracted to finish the project. Since Geo-Systems and Geo-Seismic both utilized the GeoCor IV recorder, it was felt that a minimum of problems and differences in the acquisition would occur. However, after arriving in the processing center many problems associated with the acquisition became apparent. Although the two acquisition contractors had similar equipment, the phase of the seismic data being recorded was very different. The acquisition of the project evolved and was changed many times to simply expedite flow. The group intervals, number of channels recorded, and source point spacing changed through the project.

The seismic processing contract was awarded to a processing contractor located in Midland, Texas. Debbie Lawrence was designated Project Manager upon request by J.M. Huber because of their prior experiences with her work. Debbie is currently a partner with Pinnacle Seismic Ltd. The unique nature of the acquisition variables created problems heretofore never seen. A tremendous amount of set-up work was necessary to even prepare the project for processing. Due to equipment constraints, receiver number locations were not unique and presented considerable problems initially. Special procedures in processing needed to be incorporated due to the phase differences of the two field crews. Although both contractors used the same amplifier, differences in phones, cables and vibrators still had effects. Great effort was made to minimize all variables, but factors such as ground saturation by rain could not be avoided. This data volume was processed in an age where mainframe computer systems had vastly inferior capabilities than today's machines. Practically all seismic work at that time utilized 9-track magnetic tape. The Lott Ranch project constitutes over 26 million field traces and nominal fold is upwards of 280 percent. Reading in 9 track tapes on a 24 hour basis would have taken over three weeks for any one processing step. The cost of processing the project without reducing the volume was prohibitive, not only in terms of time, but also dollars. For this reason the data was recorded on tape with the full volume, and additionally the raw data was summed spatially 6 to 1 in the field by the field crew. In other words, 6 receiver locations with 50 ft. spacing were summed and output essentially resulting in a 300 ft. group interval. Naturally this reduced the volume to 1/6th of the original recorded data, but in doing so the resolution and detail suffered considerably.

It would not have been practical, if not impossible, to have processed the entire raw volume with the tools available at that time. Several specific acquisition questions arose during the span of the project. Data was being processed as tapes were delivered as acquisition was ongoing. Fortunately Debbie was able to meet and speak with the party chiefs, observers, surveyors, and field computing personnel and make corrections and adjustments while the information was still fresh and available. Several reasons dictated that the processing of the project be conducted in manageable size pieces. Digestible sized pieces were processed and eventually merged to create the final volume. Working closely with the interpreting geophysicist, it was decided that the most expeditious method of handling weathering static's would be to simply flatten a shallow reflection known as the Yates formation, prior to stack. The original processed version of the Lott Ranch 3D, therefore, contains no regional dip. The project was considered by all to be very successful and J.M Huber continued to specifically require Debbie Lawrence to work on all their Garza County seismic projects.

In 1997, Yates Energy Corp. located in Roswell, New Mexico, formed a partnership to further develop the project. Through discussions and meetings with Pinnacle Seismic, it was determined that the original Lott Ranch 3D volume could be vastly improved upon reprocessing. Pinnacle Seismic had shown the viability of improving field-summed signed bit data on smaller 2D and 3D projects. Yates agreed to fund the reprocessing effort and contracted Pinnacle Seismic Ltd. to perform the reprocessing.

Several reasons and circumstances existed to justify the reprocessing of the original field data. One of the most significant improvements can be realized by processing all 26 million field traces. This project was initiated with high resolution being a priority. Much of the potential resolution was lost through the initial summing of the field data. Modern computers that are being utilized have tremendous speed and storage capacities that were cost prohibitive when this data was initially processed. Software updates and capabilities offer a variety of quality control and statics resolution, which are pertinent to the Lott Ranch project. Although 26 million field traces constitutes a sizeable project, we now have the capability of processing the entire volume on disk. Simply bypassing the time consuming task of hanging tapes saves months. Further refinements in wavelet processing have greatly enhanced the ability to minimize the problems with phase and recording differences.

During the late 1970's, Sam Allen of Pasadena California, developed and began the manufacture of a radically new design of seismic recording instruments. The GeoCor IV seismic recording amplifier enabled a tremendous increase in the number of channels being recorded per source location. This had obvious advantages concerning multiplicity or "fold" of the sampling. Up to 1024 channels were available during an era where typical competitors were recording 24 or 48 channels. Instead of recording each sample of each channel in a 16 bit format, the signed bit method recorded only a zero, negative one, or positive one. This was the key to high channel recording because of constraints of speed and capacities of other 16 and 32 bit recorders. Once the data was recorded and correlated, the resulting seismic trace was "fleshed out" to conventional 16 bit data. The key element is high multiplicity to achieve a significance of amplitude. The theory and details of these specifics are a matter of another presentation. The GeoCor IV recording system was such a quantum leap in channel capacity that its real application was seriously hampered by data processing software limitations. Also, processing this volume of data was hindered by computing hardware limitations during its infancy. Some experimentation had been done concerning 3D seismic acquisition in the 60's and 70's, but channel constraints hampered results. With 1024 channels available, swath shooting and other methods that took advantage of maximum utilization of source points became feasible. GeoSystems was hindered initially because of the failure of an associated seismic contractor to perform the necessary software upgrades that the GeoCor IV required. In the early 80's other seismic processing companies with vision started updating software and acquiring more powerful hardware to handle the volume of data. These were "boom times" and a flurry of seismic acquisition ensued. Many contractors were using signed bit recording systems and thousands of miles of data were recorded. Turn-around time was a critical factor at that time because of the scramble, and 1024 channel data was still hampered by capacities. For that reason, much of the signed bit data being recorded was being summed. A typical signed bit project might be shot with 30 ft. group intervals, and 30 ft. source intervals. The data would then be summed spacially to reduce the volume. A 3 to 1 group summing would result in a 90 ft. interval, and a 3 to

1 field record sum would also achieve a 90 ft. source interval. This 9 to 1 reduction in volume obviously greatly decreased processing time. There was however inherent problems associated with this procedure.

The 1024 channel data was usually recorded in its entirety onto 9 track tape. Then, either in the field, or in a data processing facility the summing was performed. Usually a “ballpark” velocity function, based on the first breaks, was applied before summing to account for the moveout between the 30 ft. group spacing. This did not take into account the near surface weathering situation, or the topography. Unfortunately, the high resolution and high sampling capabilities of the instruments was in large part negated by this summing. Some geoscientists began to complain that the definition of faults and other geologic character suffered as a result. The Lott Ranch survey was summed 6 to 1 in the field as previously stated. Although the initial processing of the Lott Ranch survey achieved splendid results, it was deemed necessary to increase the resolution of the volume to further develop the project. Initially Pinnacle Seismic merged all of the 9 track field tapes with the recorded geometry coordinate tapes. The GeoCor IV was the first system that provided the geometry information in digital form. A simple but effective geometry quality control routine was utilized to ensure the integrity of the surveying and the observers’ reports. Many errors and discrepancies in the surveying and observers notes were discovered and rectified during this process. Each and every field record’s geometry was checked, and if no viable solution could be found, the field record was discarded. More than 8 percent of the records were corrected, and 2 or 3 percent were discarded. The importance of perfect geometry cannot be discounted due to the distortion that geometry problems can create. It was known that the two seismic contractors that acquired the data were out of phase by generally 180 degrees. A synthetic seismogram from a key well was used as a model to adjust the phase of the data that it tied into. Then the 2nd volume was rotated 180 degrees, and common subsurface points between the two sets of acquisition were cross-correlated and an inverse filter was designed and applied. At this point the two individual volumes matched one another and the synthetic. The data was finally ready for the refraction statics to be calculated. A considerable effort was executed on the volumes prior to refraction static calculation for a simple reason. When merging volumes of differing genre, often phase and character differences exist. If statics are calculated prior to addressing this, phase difference will be construed as time discrepancies-hence static. If two volumes are 180 degrees out of phase, and the first breaks are in the 20 Hz. bandwidth range, the resulting error in static solution between the volumes will be in the range of 25 ms. This is an extreme, but very possible case. When stratigraphic detail is paramount, these problems must be minimized.

Reprocessing at this point did not differ substantially from the initial effort. Of great importance was the tremendous speed of the state of the art hardware. Coupled with major advancements in interactive processing software, this allowed much more testing and diagnostics to be performed. Quality control was greater, and the use of paper was practically eliminated. Velocity analysis detail and frequency was increased, as were successive static iterations. Minimum phase conversion in association with surface consistent spiking deconvolution further enhanced resolution. Relative amplitude retention was increased because of processing all 1024 channels of raw data. Bin spacing was flexible throughout the processing flow to optimize parameter selection and final bin spacing was half of the original volume. The geologic structure was maintained and the shallow markers reflect true time. Dip Moveout, or DMO, was performed and even though the structural aspect of the volume is not great, the overall effect was justifiable. The initial processing consisted of a 2 by 2 migration of the volume, whereas upon reprocessing, a true 3D migration routine was applied. Minimal noise reduction and frequency enhancement routines were necessary to present an excellent product.

PHASE TWO: INTERPRETATION

Prior to receipt of the data set, several preliminary studies were completed in order to facilitate the process of prospect generation. Forty-nine wells with bulk density, compensated neutron density, and/or sonic logs were identified and digitized within the 3D area. Several synthetic seismogram tests were completed, utilizing a range of wavelets, frequencies, trace amplitudes, and polarities. After rigorous analysis across the entire 3D area, a unique combination of synthetic seismogram variables was determined to best fit the reprocessed data set. Digirule Inc. software packages were utilized in the log digitization and synthetic seismogram generation processes.

A major integrated well correlation project was completed throughout the data area and including an extended study area consisting of a swath extending approximately five miles outside of the 3D data area. Twelve significant and correlatable horizons were interpreted in an extensive data set consisting of over 900 wells. These twelve horizons were then digitally transferred to the synthetic seismograms and master project data spreadsheets.

Scout tickets and production data were pulled over the study area. Show, test and production summary maps were generated to determine prospective plays in the area and provide data necessary to prioritize 3D interpretation efforts to evaluate prospective horizons.

Upon completion of the reprocessing effort, some minor processing adjustments were made and a final migrated interpretation version was made available in April of 2000. The data set was loaded on a dual head, PC based geophysical workstation utilizing the Seismic Microsystems Inc. Kingdom 3D PAK interpretation module. Synthetic seismograms were rigorously tied to the seismic lines such that a "framework" of synthetically tied reference lines was established prior to interpretation of the data set. All key horizons were then interpreted throughout the data set.

Based on the seisimic interpretations and integrated well data and production analysis, seven major exploration targets were identified for prospect level mapping. Three "shallow" (less than 7000') targets are characterized by combination structural and stratigraphic trapping mechanisms with mixed clastic and carbonate reservoir development. It was determined that structure mapping combined with 3D attribute analysis and facies mapping from well control provided the best exploration methods to identify prospects for these targets. The enhanced quality of the dataset allowed these prospecting techniques to be implemented. The pre-reprocessing dataset did not posses adequate resolution for the application of these mapping techniques.

Four "deep" (greater than 7000') target zones are characterized by carbonate reservoirs with primarily structural trapping mechanisms. Accurate structure mapping was determined to be the best exploration method for these targets.

Structure mapping for the "shallow" targets was achieved by mapping a regional shallow structural datum, constructing datum-to- target isochron maps, constructing datum-to-target velocity models, constructing datum to target interval isopach maps, and constructing final structural depth maps. Attribute analysis mapping of the mixed carbonate and sandstone facies and porosity distribution was achieved by interpreting significant tops, bottoms, peaks , and troughs in great detail based on synthetic seismic modeling of known producing reservoirs to guide seismic interpretation. Synthetic seismic modeling was done with the Digirule Inc. "Interpalog" program. Multiple seismic attributes were mapped and tested against well data for predictive usefulness. A unique set of seismic attributes was determined to be predictive when tested against well data. These maps, in conjunction with the structure maps and integrated show, test, and production data were utilized for prospect generation.

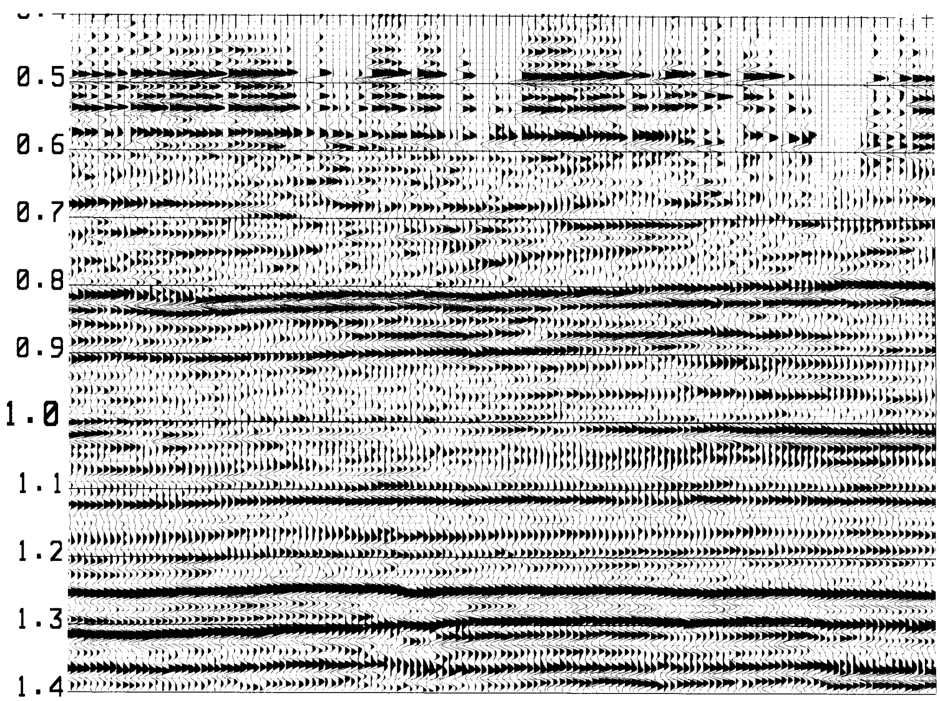
Structure mapping for the "deep" targets was achieved by mapping a regional deep structural datum located above the deep targets but significantly below the shallow targets., constructing datum-to- target isochron maps, constructing datum-to-target velocity models, constructing datum to target interval isopach maps, and constructing final structural depth maps. These maps, in conjunction with integrated show, test, and production data were utilized for prospect generation. The interpretation phase of the project was completed in December of 2000. The project implementation phase began in 2001 and is ongoing. All gridding, depth conversion, grid math, contouring, and fault analysis was computer aided with the Digirule "Geomap" software and Golden Software Inc. "Surfer" software.

RESULTS AND DISCUSSION

A comparison of the original processing effort with the reprocessing completed in this study follows. The final product was of excellent quality and resulted in a true 3D migration with an increase in fold from 4000% to 24,000%.

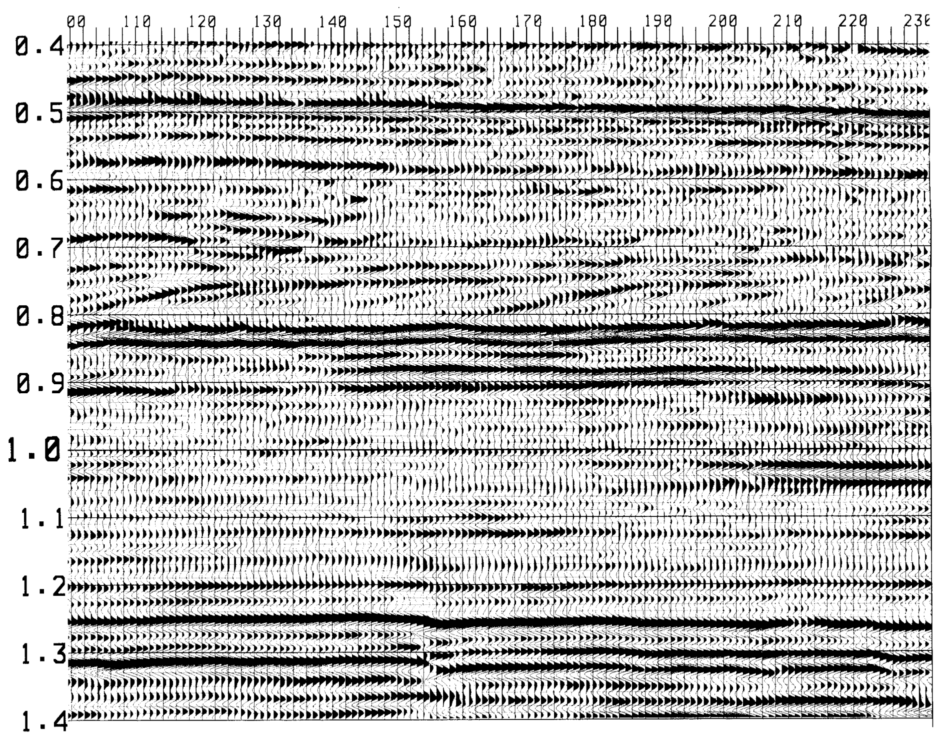
ORIGINAL PROCESSING

- 6 to 1 receiver sum in field
- Phase shift 2nd crew data 180 degrees
- Renumber source & receiver locations
- Apply survey information to field data
- Deconvolution testing and application
- Datum and elevation corrections
- Normal moveout application
- Surface consistent statics
- Hand statics (flattening shallow event)
- CDP residual statics
- CDP bin sorting(165' X 165')
- CDP stack (4000% effective stack fold)
- F-K noise attenuation filter
- 2 by 2 Migration



REPROCESSING

- Renumber source & receiver locations
- QC and correct survey data and apply
- Generate brute stack on 2 data volumes
- Phase match volume “A” with well log
- Phase match volume “A” with volume”B”
- Calculate and apply refraction statics
- Datum and elevation corrections
- Surface consistent Deconvolution
- Normal moveout application
- Surface consistent statics
- Normal moveout application
- Surface consistent statics
- CDP residual statics
- CDP bin sorting(82.5’ X 82.5’)
- CDP stack(24,000% effective stack fold)
- Full 3D Migration



The end result of the reprocessing and interpretation efforts was the identification, leasing, drilling, and completion of economically viable oil and gas prospects. Prospect summary maps were constructed for each of the seven targets identified. Multiple prospects and leads were identified for each of the seven prospective zones. Drilling results to date are summarized below:

WELL #1

- Two "deep" primary targets
- One target structurally as mapped
- One target structurally high to map
- Successful Oil completion with multiple zones behind pipe.

WELL #2

- One "shallow" primary target
- Target structurally as mapped
- Target facies as mapped
- Target porosity development as predicted
- Zone wet, no trap.

WELL #3

- Two "deep" primary targets
- Both targets structurally as mapped
- Successful Oil completion with aditional zones behind pipe

CONCLUSION

In conclusion, the reprocessing and interpretation efforts made possible by a grant from the U.S. Department of Energy has resulted in the implementation of economically viable drilling projects, that would not have been possible to generate with the pre-existing data set.

The grant money was utilized towards the reprocessing of the original seismic volume. Feasibility of the potential results had been previously exhibited on other similar volumes. The grant was awarded under the auspices of Reservoir Enhancement Potential based on new technology or methodology, and the general application to the industry as a whole. As previously stated, thousands of miles of signed bit data exist. Much of this data was processed during a time when software and hardware capabilities were either incapable or cost prohibitive to glean the full potential of the data. In fact in some circles signed bit gained an undeserved reputation for being less than optimum. Over time new amplifiers such as the IO2 systems achieved high channel capabilities that recorded 32 bit-full word samples. As a consequence much of the older signed bit data sits on the shelf long forgotten or overlooked. With the high cost of new acquisition and permitting it might behoove other exploration companies to reconsider resurrecting perfectly viable existing volumes and have them reprocessed at a fraction of the cost of new acquisition. GeoSystems Inc. has evolved into a present company called Subsurface Exploration Company, or SECO, and continues to develop and acquire signed bit seismic data.

REFERENCES

- NONE CITED