Cotton Valley Production Stimulation Hydrofracture

Microseismic Monitoring & Imaging

Union Pacific Resources Sponsored Industry Consortium

Data Collection & Analysis Report
Prepared by ARCO Exploration & Production Technology

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1. Introduction

This report is a summary of the data acquisition and field analysis for the microseismic monitoring of production stimulation fracturing in the Cotton Valley formation of a gas well located in the Union Pacific Resources Company (UPRC) Carthage gas field in east Texas. This effort was consortium of industry and academic representatives led by Union Pacific Resources Company. ARCO Exploration & Production Technology (AEPT) provided expertise in the monitoring process along with data acquisition hardware and software as well as event detection, location, and visualization software.

The basic field setup consisted of the production well being stimulated and two monitoring arrays located in wells situated along the anticipated fracture growth path. Each monitor array consisted of 48 levels of 3-component geophone pods attached to production tubing and cemented into the wells. These wells were to be completed as production units after the completion of the experiment.

The following is a detailed discussion of the setup and configuration of each of the components of this process, a description of the data being provided to the consortium members, and a discussion of the location and display of a subset of the detected events.

2.0 Field Recording

2.1 Data Acquisition Systems

The OYO DAS-1 seismic data acquisition system was the basic building block of the complete monitoring system. The DAS systems were modified somewhat for this application. This modification was developed jointly by AEPT and OYO Instruments in 1993 to meet the specific needs of this process. The modification consists of installation of a FDDI network adapter card, modification of the DAS operating software, and installation of circuitry to provide synchronization of the sample clocks between the three DAS systems.

There were two monitoring arrays each consisting of 48 levels of 3-component geophone pods. This yielded an initial total of 288 sensors which needed to be recorded. Although the DAS-1 is capable of being configured with 2 expansion modules to provide 144 channels, there were some potential limitations in the transfer of data from the PC memory of the DAS to the FDDI adapter which prompted the decision to limit a DAS configuration to 96 channels. This was a configuration which was known to work in this application. AEPT owns one such system and the other two systems were leased from OYO for the project. Each DAS was operated with 1000 samples per second, with a gain of 48 dB. No filtering other than the instrument provided anti-alias and the approximately 3 Hz DC filter were used during recording.

Appendix 1 shows the configuration of the cables which were constructed to distribute the signals to the three recording systems. The intent of this arrangement was to minimize the loss of coverage in the event that one of the DAS systems or an expansion module went down during the fracturing process. With such an arrangement the missing sensors would be distributed throughout both arrays rather than creating a large gap in one or the other.

Clock synchronization circuitry was developed and implemented by OYO to insure that all three DAS systems were sampling data simultaneously. In the original configuration of this modification the AEPT DAS was chosen as the master unit and was named DAS-A on the network. It provided synchronization clocks to DAS-B which then provided the synchronization clocks to DAS-C. This implementation employed a minimal amount of additional circuitry but had limitations which made it susceptible to noise. The electrical noise intermittently caused one of the slave systems to miss synchronization and hang. During the calibration and other recording efforts in the field leading up to the actual fracture process this problem became evident and worsened. Consequently, the systems were taken back to the OYO facilities just prior to the beginning of the fracture process to have these circuits upgraded. The upgrade consisted of the implementation of a differential driver and optical isolator. The differential driver provided noise immunity and the optical isolator relieved potential ground loop problems.

Modification of the DAS standard operating software consisted of two parts. The OYO software engineers developed a continuous data acquisition mode under guidance from ARCO. This consisted of the creation of a double buffer in memory which allowed the digitization process to write data to one buffer while the other buffer is being transferred to the FDDI adapter for transmission to the workstation. The transfer of data from the memory buffer to the FDDI adapter is accomplished through a library of functions which was developed by AEPT and linked into the DAS operating software. Data is collected at an operator specified sample interval in blocks which are sized according to the operator specified record length. The resulting process creates a seamless and gapless flow of data to the workstation.

2.2 Geophone Arrays

Two geophone arrays each consisting of 48 levels of 3-component geophone pods with a vertical spacing of 50 feet were used for monitoring of the hydrofracture. These were installed by attaching each pod to the 2 7/8" production tubing and cemented into the wells. A complete discussion of the deployment aspect of the project may be found in the paper published by UPRC (SPE38577). Figure 1 shows a plan view of the geometry of the deployed arrays. The first array was deployed in the CGU-21-09 well, approximately 1000 ft to the east of the CGU-21-10 injection well. The second array was deployed in the CGU-22-10 well, 1200 ft to the north-east of the injection well. Geophones were installed between 6666-9016 ft and 7322-9674 ft in the respective wells. A cross-section of the active sections of the deployed arrays is shown on Figure 2. It is clear from Figure 2 that coverage in the lower section of the first array was sparse. It should also be noted that additional sensors failed in both arrays before and during recording.

The geophone arrays for this project were specially designed as none were commercially available which would meet the specific needs. Design criteria called for the downhole geophone arrays to operate at depths greater than 10,000 feet. Downhole pressures were expected to be as high as 7600 psi as the cement slurry displaced the drilling muds. The design also had to take into consideration an ambient downhole temperature of 260 degrees F which was expected to rise slightly during the curing of the cement. This combined to set an operating temperature design criteria of 350 degree F.

Both cables contained 179 twisted pairs of 26 gauge copper wire. Below 5000 feet the cable used 392 degree F rated Tefzel insulation while the shallow section used 275 degree F rated EPC insulation. The twisted pairs are wrapped in a double layer of aluminum shielding and an outer jacket of 392 degree F rated Nitrile was applied. The completed cable had an outside diameter of 1.5" and weighed approximately one pound per foot.

Experience from various members of the consortium indicated the dominant frequency of the seismic events that would be recorded with this well geometry would be around 200 Hz. The consortium designed a downhole amplified tri-axial geophone sonde for the project. These were constructed of stainless steel cylinders designed to withstand 10,000 psi with electrical connection through high pressure Sea-Con connectors. Each sonde contains three orthogonally mounted Geospace Model SMC-1850 geophone elements. This particular model is an omni-directional unit with a natural frequency of 30 hertz and a spurious resonance above 500 hertz. They also meet the design criteria for operating temperature of 392 degree F. A 60 dB amplifier circuit provided downhole amplification of the geophone signals before transmission along the cable. The amplifier circuits exhibited low distortion and high common mode rejection. A test circuit was also incorporated to allow the geophone element coils to be levitated and released in unison to provide a pulse test. This capability proved very useful during the deployment stages.

2.3 Recording Configuration

The sample interval for the Cotton Valley Fracture Imaging was 1 millisecond or 1000 samples per second. The block length of the data transferred from the DAS systems to the workstation was 8 seconds. Due to problems in the design of the amplifier circuitry for the geophone pods as well as some mechanical difficulties in getting monitor array 1 in the well there were a significant number of channels in this array which were either dead or unusable (SPE 38577). In order to reduce the load on the FDDI network and the DAS systems and improve the reliability of the overall data acquisition process these channels were turned off on the DAS output control. The table in Appendix 2 shows this final channel configuration. In this configuration DAS-A had 67 live channels, DAS-B had 76 live channels, and DAS-C had 58 live channels. In addition, each DAS was recording and transmitting 2 auxiliary channels. This yielded a total number of recorded channels of 207.

The primary purpose of the auxiliary channels was for verification of sample synchronization between the three systems. During the primacord calibration records described below the output of a geophone in the head of the perforation gun was input to the auxiliary channels and used as a trigger signal and time zero indicator for the shot. During the fracture recording a periodic pulse from a signal generator was input for timing verification.

2.4 UNIX Workstation Configuration

The UNIX workstation employed was a Silicon Graphics (SGI) Indigo-2 with a FDDI network board. At the inception of this technology SGI was chosen because of its extremely fast graphics which are essential in monitoring the quality of the data acquisition process. The large input/output buffering capabilities were also important for throughput efficiency. The SGI along with the 3 DAS recording systems were connected to a 4 port FDDI concentrator to create the data transmission network.

Attached to the SCSI ports on the SGI were a Metrum tape drive for archival recording of the raw data stream and a 4mm DAT for transferring the detected events from the hard disk to a second SGI system for location and display. The Metrum tape system employs a standard VHS format tape cartridge which has a capacity of approximately 14.7 gigabytes. It can sustain data transfer rates of 1.2 megabytes per second which is essential to this application.

2.5 Data Collection, Display, & Recording

There are multiple processes running on the SGI to orchestrate the data collection, display, and event detection. The first process, DA_SERVER, is the data acquisition server which creates shared memory buffers for the incoming data, opens ports on the FDDI network for each specified data acquisition system, and is responsible for placing the incoming data in the shared memory buffers so that it can be accessed by the other processes. There are up to 10 shared memory buffers created in this process which allows other processes attaching to the memory sufficient time to work on the data.

The second process, WRITETAPE, monitors the shared memory control buffer and transfers a data block from the shared memory to the Metrum tape drive each time a new one becomes available. Each data block is written to the tape as a file with a small attached header describing the recording system parameters and channel configuration. These files can subsequently be read back into the system in a simulated data acquisition mode for later reprocessing if necessary.

To display the incoming data for the system operator an interactive data viewer called SCOPE is started. SCOPE also monitors the shared memory control buffer and displays each block of data as it becomes available in a wiggle trace format with time on the horizontal axis and channels on the vertical axis. As each new block of data is received from the recording systems and placed in the shared memory SCOPE updates its display with the new data. There are controls within SCOPE which allow the operator to increase and decrease the display gain, zoom in both axis, scroll in both axis while zoomed in, freeze the screen update for more detailed study of the data, and save a snapshot of the current data displayed on the screen. An example of a SCOPE display is provided in Figure 3 with a typical event present.

2.6 Event Detection

The incoming data is scanned for events by the background process “DETECT”. This process runs a traditional earthquake detection algorithm over the data scanning for events. The algorithm calculates short term and long term sliding window averages over the derivative of the incoming data. When the ratio of these averages exceeds a specified threshold on a specified number of channels within the scanned channel list and within a specified time gate length an event is declared and a file containing the event is written to the hard disk. All of the above parameters are controlled by the operator through a configuration file. The configuration file also specifies a pre-trigger time to insure that the beginning of the event is not missed as well as a record length. An example of the configuration file used for this project is provided in Figure 4. On occasions, the high detection sensitivity triggers on shear arrivals since the compressional arrival was very weak. These events were useable since the pretrigger recording time captured the weak compressional data which is often below the noise threshold.

DETECT is capable of spanning across data block boundaries to produce the appropriate output file. Thus, if the onset of an event occurs very near the end of a data block DETECT will wait until the next data block has been received before writing the necessary file to the disk. Likewise, if an event occurs very near the beginning of a data block such that the specified pre-trigger time requires data from the previous data block DETECT will make that adjustment as well.

2.7 Primacord Calibration Recording

Primacord shots were detonated in the treatment well and recorded on the monitor arrays for purposes of testing the arrays and determining the velocity field. This was done in three different phases leading up to the actual fracture monitor. The first set of shots were recorded after deployment of the first array. These were recorded the week of March 10 by Roy Wilmer of Branagan & Associates with a 144 channel DAS system owned and provided by Gas Research Institute (GRI.) The second set of shots were recorded the week of April 7 on both arrays with the complete recording configuration as described above.

The final set of shots were recorded again on both arrays with the complete recording configuration during the week of May 6. The purpose of this set of shots was to provide a tomographic velocity model prior to the fracturing. Standard perforating guns were used for this effort. A typical gun configuration provided four potential shots per run. In some cases all four levels were successfully detonated while in other cases less than four shots were acquired due to various failure modes. A more complete description of the operational aspects of this effort may be found in the UPRC paper.

2.8 PGS Downhole Vibrator Record

Paulsson Geophysical Services was on location with their downhole vibrator energy source prior to the fracture operations. It was intended that a cross-well tomographic survey be recorded into the monitor arrays with this source. Due to difficulties with the vibrator system along with problems with the triggering interface to the AEPT recording system and record length limitations of the DETECT program, only one sweep record was obtained from the monitor arrays with this source. These crosswell arrival times were not used since there was some uncertainty in the position of the source during this recording.

3.0 Event location analysis

3.1 Event Location Software

The ARCO event location package employs proprietary software to rapidly and interactively locate the events in the field during the injection process. From past experience, locating events using picked first arrivals, picked either by automatic algorithms or manually, has been found to be too slow. During a hydrofracture the approximate locations of a large number of is required. Accuracy to within 10's of feet is sufficient to detect formation breakout and determine the fracture length.

The method adopted has been found to be very robust, being able to identify very weak events with signal-to-noise ratios of less than one using the discriminating power of the array geometry. The analysis is performed quickly with minimal requirement to identify weak phase arrivals. Weak events recorded on both arrays could be located within a few minutes by operators with minimal seismic experience after a limited training period.

The process was developed using an interactive matching of calculated and observed P and S phase arrivals on a graphical display of the seismic event. A trial solution is moved interactively within a map window, and the predicted travel time calculated from a provided velocity model. When an acceptable match is achieved, the event location and origin time is stored in a database. The database can then be plotted on three dimensional displays showing other event solutions, the receiver locations, and engineering data.

The match between the calculated ray path times and observed data usually agreed to within a few milliseconds at a wide range of offsets and incident angles. The quality of the match is a function of the accuracy of the velocity model. The important step of determining the appropriate velocity model is described in detail below. Event location accuracy was high at the Carthage site due to the large number of recording geophone locations distributed along the two long aperture arrays. The vertical control on the depth determination is estimated to be within ± 25', which is one half the geophone pod spacing. The horizontal location accuracy is estimated at ± 50' when the event is detected on multiple geophones from both arrays. This estimate is, of course, dependent on the size and position of the detected event.

Polarization analysis of the compressional first arrivals is also possible with the ARCO software. This sometimes assists in locating the event position The current version of this software is manually intensive and cannot be applied quickly to large numbers of seismic events. Consequently, this capability was not used for the field location of the Carthage fracture.

An attempt was made to locate the events as soon as possible after fracturing. The location procedure followed a routine of displaying all detected events and selecting a quality indicator. One star indicated events detected on only a single array, and which consequently could only be located along an arcuate path at a constant radius from the well. Two star events were detected on at least one sensor on both arrays thus making a unique x,y,z location determination possible. Three and four stars indicate higher quality events requiring detailed investigation. False events due to instrumentation or other reasons were flagged during this review process.

All events from the Monday fracture were evaluated and located by the end of the day on Tuesday. It was impossible to locate in real time the larger number of events occurring as frequently as one every second during the Wednesday and Friday fractures. It was decided to locate only every 10th event to obtain a representative analysis of the growth of the later two fractures. A total of 350 of the over 2000 recorded seismic events were located and presented to UPRC on Wednesday of the week following the fracture process. This provided a detailed description of the fracture length, height and development and the results are discussed below. UPR have decided to locate the remainder of the events using the ARCO-AEPT software.

3.2 Velocity Calibration by Check Shots

The event location is based on matching a calculated travel-time with the observed travel-time. Various analytical functions have been used at other sites, however, it was expected that the high velocities and layered structure encountered in this area would require a complex velocity model. Attempts to collect a tomographic image between the injection and monitor wells were thwarted after hardware difficulties were encountered with the P/GSI borehole vibrator. As a backup, 50 explosive shots were collected between depths of 6754 ft and 9766 ft to provide this information.

A subset of the perforations shots were used to derive a velocity model suitable for event location. P and S arrivals were manually picked for shots at 6806, 7654, 8254, 8752, 8962, 9554, and 9766 ft. This interval represented the range of expected fracture induced event depths. The time break for each shot was provided by a geophone placed in the casing collar locator of the perforating gun used to carry the primacord charge.

It was immediately obvious that a simple constant velocity model or one with a velocity gradient increasing with depth was inadequate to describe the travel-times. Strong vertical anisotropy was present. This was evidenced by a fast horizontal velocity with a decreased velocity for rays with a component of vertical raypath. In addition, the fast horizontal velocity was found to increase with the depth of the shot. This was attributed to vertical lithologic variations.

For fast, interactive event location, an analytical function was required to match these observed P and S first arrivals. Various velocity functions were plotted; however, a function of the form below was adopted.

$$V(Z_i) = V_o (Z_1) [\cos^2 (\phi) + \varepsilon \sin^2 (\phi)]$$

$$\tan(\phi_i) =(z_i - z_1) / (\mathrm{sqrt} ((x_i - x_1)^2+(y_i - y_1)^2)$$

where x_1, y_1, z_1 is the shot position, and x,, y,, z; is the location of the i^{th} receiver location. Both $V_o(Z_1)$ is the horizontal velocity at depth Z_1 and ε were found to vary with depth.

A matrix of the values determined for the shots is as follows:

Shot Depth (ft)	**Vp(0) (kft/s)**	**$Grad_p$(e)**	**Vs(0) (kft/s)**	**$Grad_s$(e).**
6806	16	-0.4	10.0	-0.2
7654	17.	-0.4	10.5	0.0
8254	16.	-0.4		
8752	16.	-0.2	10.0	-0.1
8962			10.0	0.0
9554	17.	-0.1		
9766			9.5	0.0

During the field location of fracture events the appropriate velocity function was selected from the table corresponding to the perforation interval. The events generally stayed within the perforation interval and thus the perforation shot calibration seems a reasonable approximation to the velocity model. Some events were located with multiple velocity functions which lead to slightly improved matches between the observed and calculated raytimes.

4.0 Fracture interpretation

The solutions produced for the 300 events are presented in Appendix 3. The data were analyzed as 3 separate injections and cross referenced with the injection bottom hole pressures and rates.

4.1 5/12/97 Fracture Results

The events located for the 5/12/97 fracture are summarized on Figures 5 and 6. All the events detected for this fracture were determined in the field. The perforated interval was between 9620 ft and 9640 ft, and the fracture followed the normal pattern of injecting treated water in two stages, and two gel stages. The injection rate was approximately 20 bpm with the main stage consisting of 55,000 gals of gel and sand. The treatment schedule is described in more detail in the UPRC SPE paper.

Figure 5 shows a cross section for all the events located during this first fracture. All events fall in a tight vertical range within the perforated interval. This demonstrates the fracture growth is confined within the injection interval.

The fracture length is described on Figure 6. The fracture rapidly grew to a length of 1200 ft along a direction of N70E, but 400 ft along the second wing in the direction of N110W. The fracture direction was expected from previous information, but the asymmetric growth was surprising.

The data quality was lower than that recorded in later fractures and the events were small. Many of the stage 2 events were only detected on the CGU-22-09 array and could not be observed on the CGU-21-09 array. Consequently, it was necessary to locate the events by placing a trial solution along an arc at a distance from the CGU-22-09 well determined from the p-s time. The single well locations were further constrained by requiring them to fall along a N70E azimuth plane consistent with the better solutions from larger event locations. This constrained location methodology explains some of the horizontal scatter in the width of the fracture and was applied to approximately half the events recorded from this fracture.

4.2 <u>5/14/97 Fracture Results</u>

This fracture was produced using a perforation interval between 9044-9310 ft. The injection rate was increased to 40 bpm with the main stage consisting of 140,000 gals of gel and sand.

There were many large events recorded at frequencies of over one event per second at times. Fortunately, the automatic detector parameters were well established at this time, and no significant events were missed. This large event count created difficulties for the analysis since it was no longer possible to locate all the events in the field. A decision was made to locate only every tenth event. Since most of the events were larger and recorded on both arrays, the quality of the locations was higher and the horizontal positions well defined.

Figure 7 shows the fracture was located with a flat top within the upper portion of the perforated interval. The fracture top was above the upper perforation, suggesting breakout to a thick shale layer observed on the log. The fracture growth seen in Figure 8 followed the same pattern of the earlier fracture although the location quality is higher and the fracture width much tighter. Considerable asymmetry is again interpreted from the detected events, growing to 1100 ft along a direction of N70E, and only 500 ft along the second south-west wing.

4.3 <u>5/16/97 Fracture Results</u>

The 5/16/97 fracture was produced from a perforation interval between 8580-8844 ft by injection of 160,000 gals of gel and sand at a rate of 45 bpm. A large number of events were recorded but at a slower rate than during the previous fracture. Again it was decided to locate every 10th event in the field.

The vertical distribution of these events is more widely scattered than the 5/14/97 fracture, however, the events still fall within a wider perforation interval. The fracture is again interpreted to grow asymmetrically, to a long wing growth to 1200 ft. The second wing was longer for this fracture, growing to a distance of 700 ft. The distribution of events located for the 5/16/97 are summarized on figures 9 and 10.

5.0 <u>Organization of Distribution Data</u>

The format of the disk files written by both DETECT and SCOPE is non SEG standard and unique to this application. The file extension for these files is “.short” which was adopted because the files are a shortened subset, in time, of the data blocks received from the DAS. An example filename from the Cotton Valley project is 970512083036.05596.short. The first part of the name is composed of the date and time. So the date that this event was recorded was 5/12/97 which was the first day of fracturing. The time stamp of the file in this case is 8:30:36. This time is extracted from the header which the DAS operating software attaches to each data block before transmission to the workstation. When a data block becomes available the system clock is read and inserted into the header.

The second part of the name denotes the offset of the file from the beginning of the data block from which it was extracted. In this case the offset was 5.596 seconds. DETECT incorporates a leading zero in this section of the name which allows the use of a minus sign when it has to back up to the previous data block to begin a file. In the case of files written by SCOPE there is no leading zero. An example file written by SCOPE is 970514074418.61030.short which was offset 6.103 seconds from the beginning of the data block. There is a mix of both SCOPE and DETECT files in the event dataset due to the fact that in the early stages of the process many of the events were not passing the criteria set in DETECT’s configuration file as it was still being adjusted for optimal performance. In these cases, the events were windowed and manually saved by the operator through SCOPE.

In order to facilitate analysis of this data through means other than those tools developed for this application a conversion utility was written which produces a standard SEGY format file from a SHORT file. These files may then be read by seismic processing and analysis systems such as Promax. The members of this consortium are each provided with a copy of this report along with a standard

UNIX “tar” format tape containing all of the SHORT file data converted to SEGY. Figure 11 presents the directory structure for the data on this tape. Also included on this tape are various files with information pertaining to this project. A summary of these files and their contents is provided in Figure 12. Users of this data set should note that approximately 672 megabytes of disk space will be required to extract all of the data from the distribution tape.

The Fracdata directory contains a subdirectory for each of the three days of fracturing. Within these subdirectories are subdirectories which further break each day’s process down to its various injection stages. The longer stages were broken up into multiple subdirectories to avoid UNIX labeling limitations. An example of this would be May 14 where stage3 has been broken up into stage3a and stage3b.

The Primacord directory contains three subdirectories which represent the three different phases of primacord recording. the 0310data directory contains the records for the primacord shots into array 1 which were recorded on the GRI system. A typical filename within this directory is shot01_6798.segy. The first number signifies the shot number within this series and the second number corresponds to the depth at which the shot was taken. The 0407data and 0506data directories contain the data recorded on both arrays with the full AEPT recording system. A typical filename within these directories is upr01_1_9290.segy. The first number in the name signifies the run number within the series of primacord records within the directory and the second number represents the shot number within the run. The final number corresponds to the depth at which the shot was taken.

The Paulsson directory contains the one record recorded by the AEPT system with the Paulsson downhole seismic vibrator.

The Pulse_tests directory contains four pulse test files which were recorded at the conclusion of the final day of fracturing. Two records for each array were recorded. The pulse test was initiated through the circuitry built into the amplifiers in the geophone pods. A more complete description of this circuit may be found in the UPRC report.

6.0 Summary

The data recorded at the Cotton Valley hydrofracture were of high quality and provided definitive results in gaining an understanding of the fracture generations at this site. The instrumentation worked admirably with only minor problems resulting from loss of some of the downhole sensors. This did not compromise the interpretations.

The fractures grew along the expected direction. The recorded data suggests an asymmetry in the fracture with the long fracture wing to the north-east. Further studies will be made of the amplitudes recorded, the signal attenuation in the more detailed analysis. This should show if the asymmetry is a function of placing the monitoring well along the one side of the fracture. ARCO is undertaking this study.

All the events from the first day of fracturing were located in the field. The large number of quality events detected on the later days, only permitted every 10th event to be located in the field. These results are presented here and provide a good understanding of the fracture process. UPR have added additional staff to work on the unprocessed data and should finally produce locations for over 2000 seismic events.

References

Walker, R. N. Jr., 1997; Cotton Valley Hydraulic Fracture Imaging Project, SPE 38577.

Appendices

Appendix 1 Acquisition system input cable configuration

Appendix 2 Input channel map

Appendix 3 Distribution data tape miscellaneous files

Figures

Figure 1 Plan view of the site, showing the CGU-21-10 injection well and the CGU-21-09 monitor well (array 1) and the CGU-21-10 monitor well (array 2).

Figure 2 Cross-section view of the deployed geophone from a north facing projection. The arrays in the CGU-21-09 has several of the lower pods fail during installation. The symbols in the CGU-21-10 injection well indicate the upper and lower tops of the three injection zones.

Figure 3 An example of the SCOPE display with a typical event present. The events fall within a tight vertical interval within the perforated interval.

Figure 4 An example of the event detection configuration file used for this project. All the parameters may be changed through a data file.

Figure 5 Cross section of 5/12/97 fracture events showing the fracture height.

Figure 6 Plan view of events located for the 5/12/97 fracture. The asymmetry was unexpected, but the fracture orientation is consistent with other observations. The fracture width is explained by weak events from this fracture.

Figure 7 Cross section of 5/14/97 fracture showing the fracture height. The fracture has a well defined top of fracture above the upper perforation. The vertical fracture growth corresponded to the bottom of a thick shale which confined vertical growth.

Figure 8 The event location for the 5/14/97 fracture are again asymmetric with a long wing growing to 1200 ft along a N70E azimuth.

Figure 9 Cross section of 5/16/97 fracture showing the fracture height. The fracture stayed within the wide perforation zone.

Figure 10 Events located for the 5/16/97 fracture The fracture asymmetry is less evident with wing length of 1200 ft and 700 ft along a direction of N70E.

Figure 11 Distribution data tape data directory structure.

Figure 12 Distribution tape data, miscellaneous file description

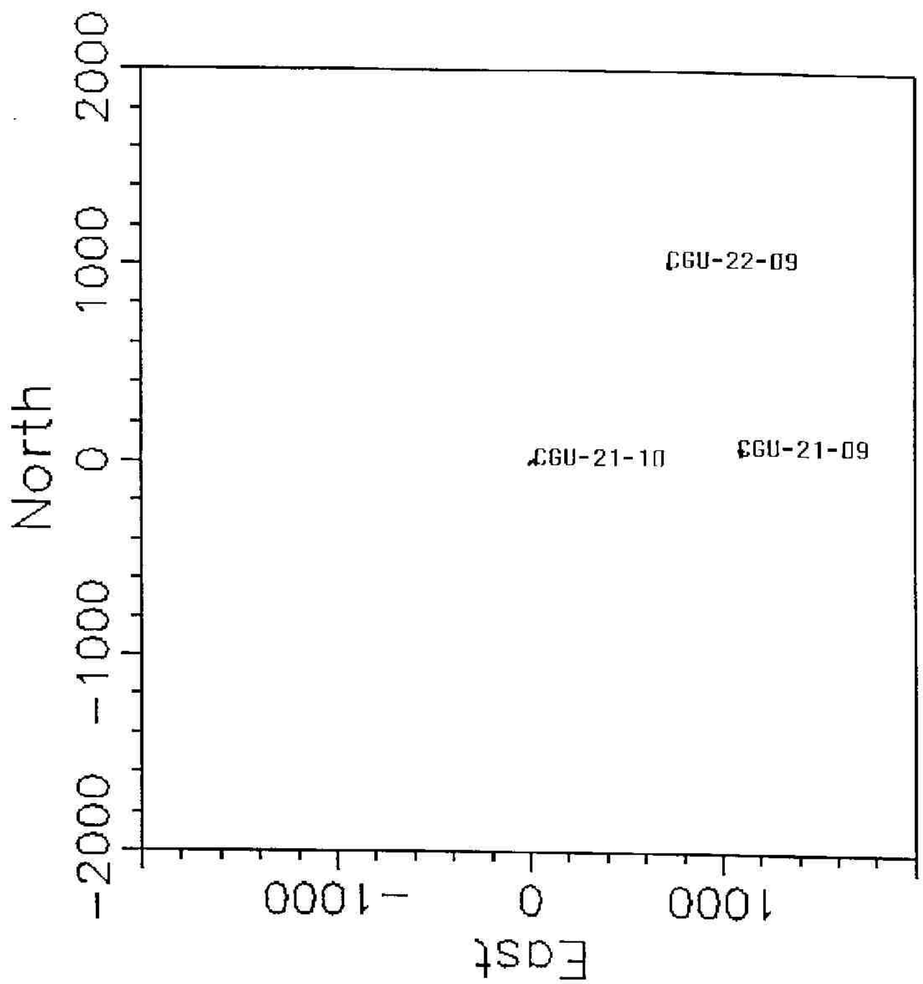


Figure 1

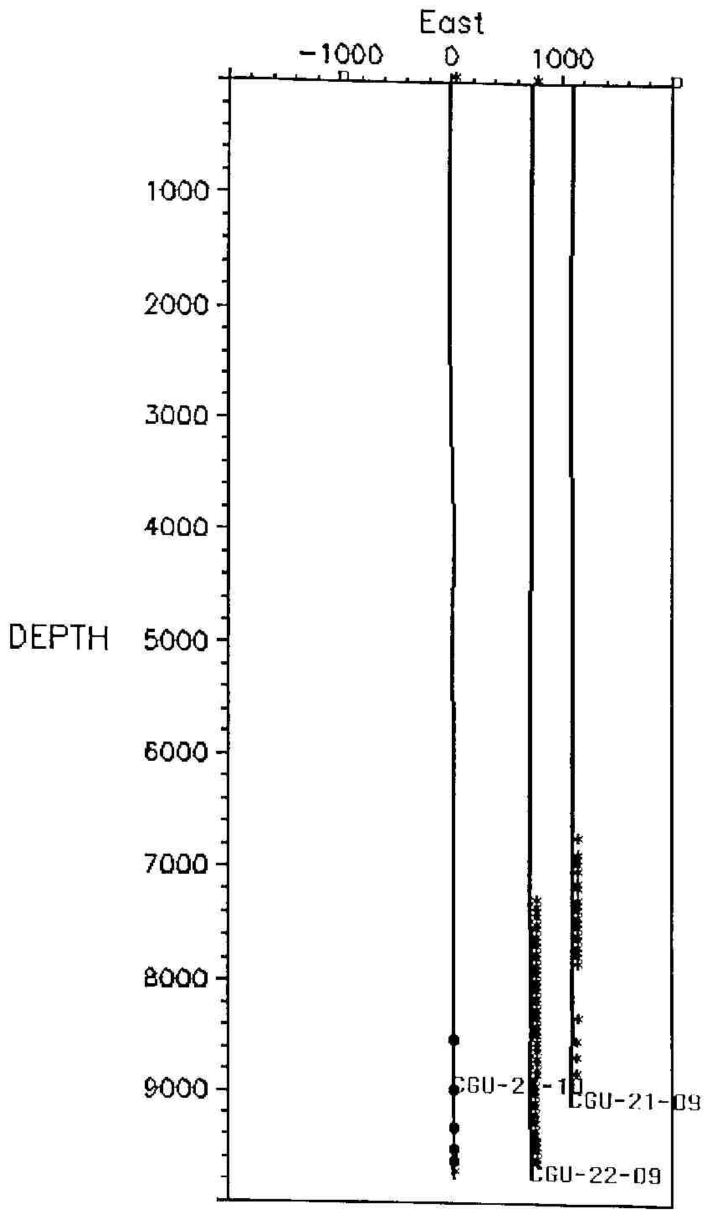

East
-1000
0
1000
DEPTH
1000
2000
3000
4000
5000
6000
7000
8000
9000
CGU-21-09
CGU-22-09

Figure 2

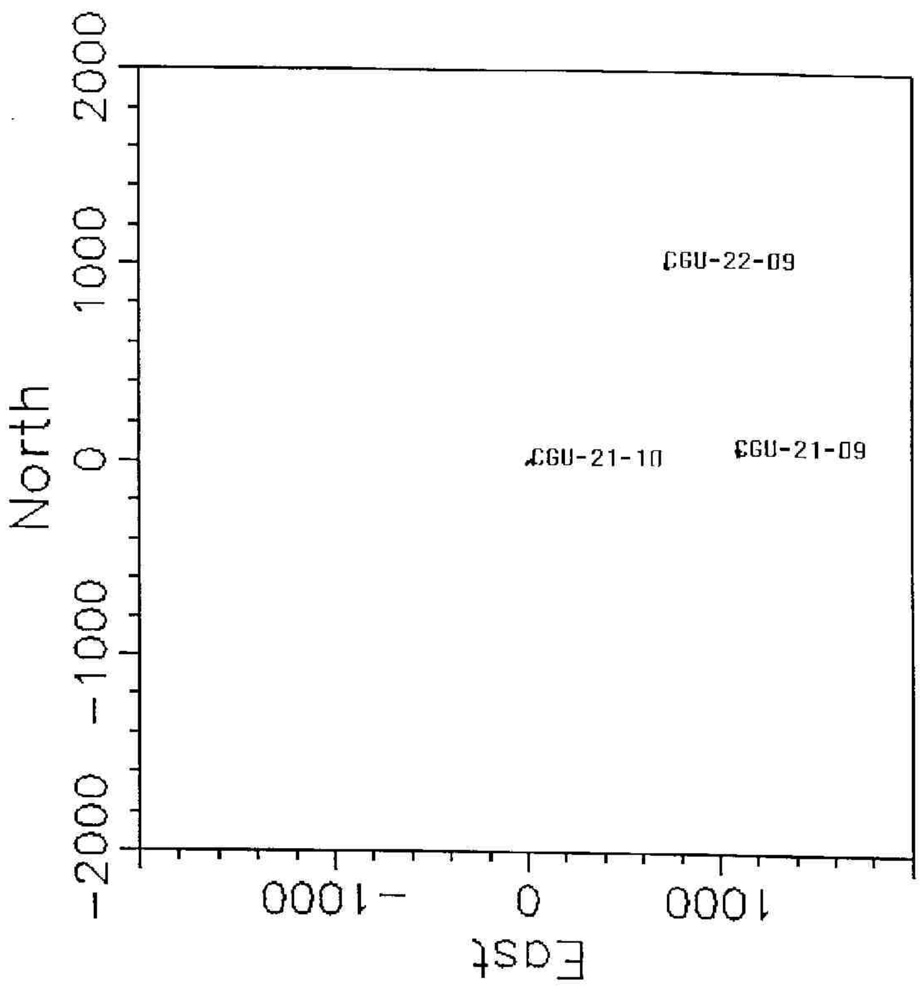


Figure 1

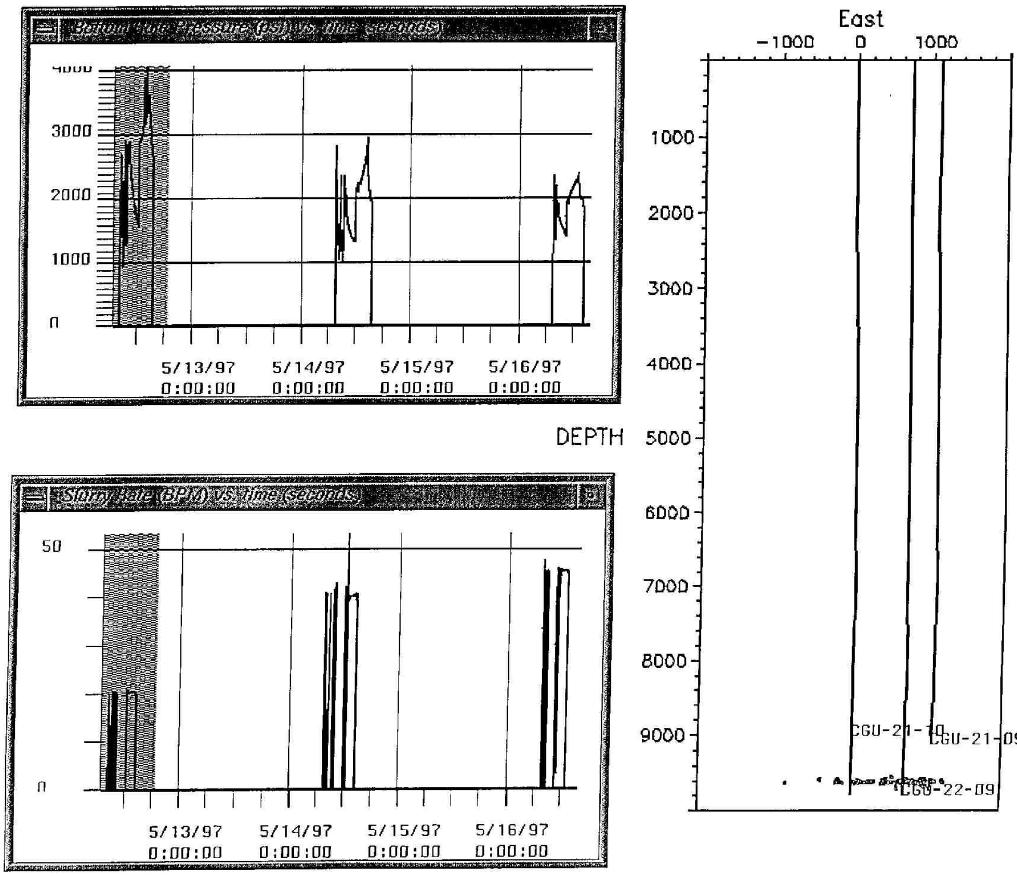
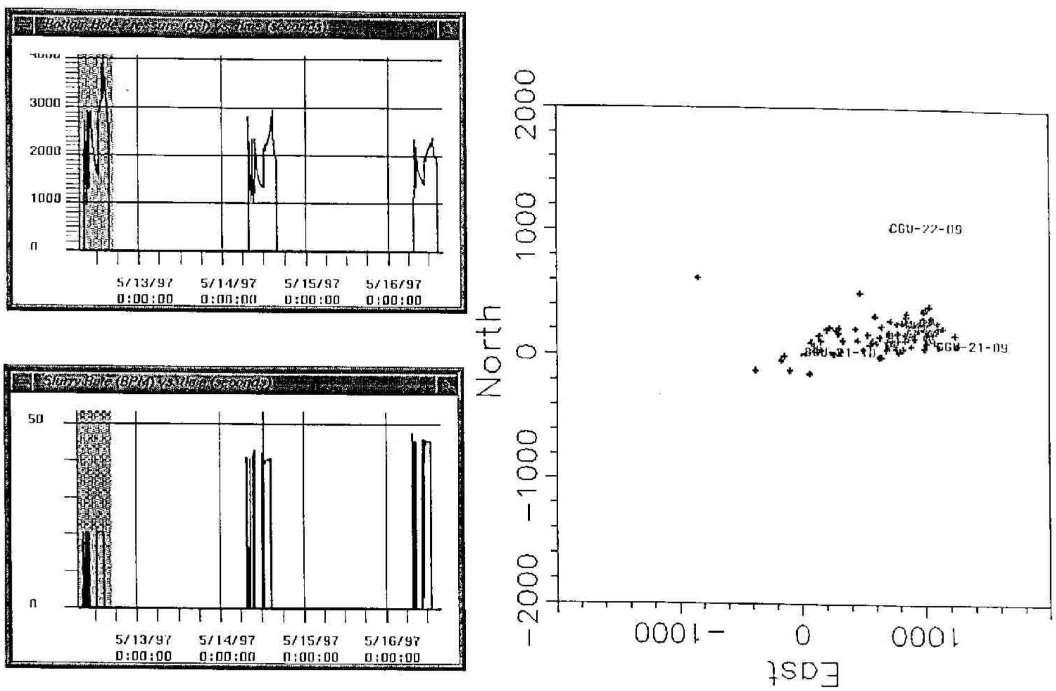

3000
2000
1000
0
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
50
0
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
East
-1000
0
1000
DEPTH
1000
2000
3000
4000
5000
6000
7000
8000
9000
CGU-21-10
CGU-21-09
CGU-22-09

Figure 5



3000
2000
1000
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
50
2000
1000
0
−1000
−2000
North
East
CGU-22-09
CGU-21-09

Figure 6

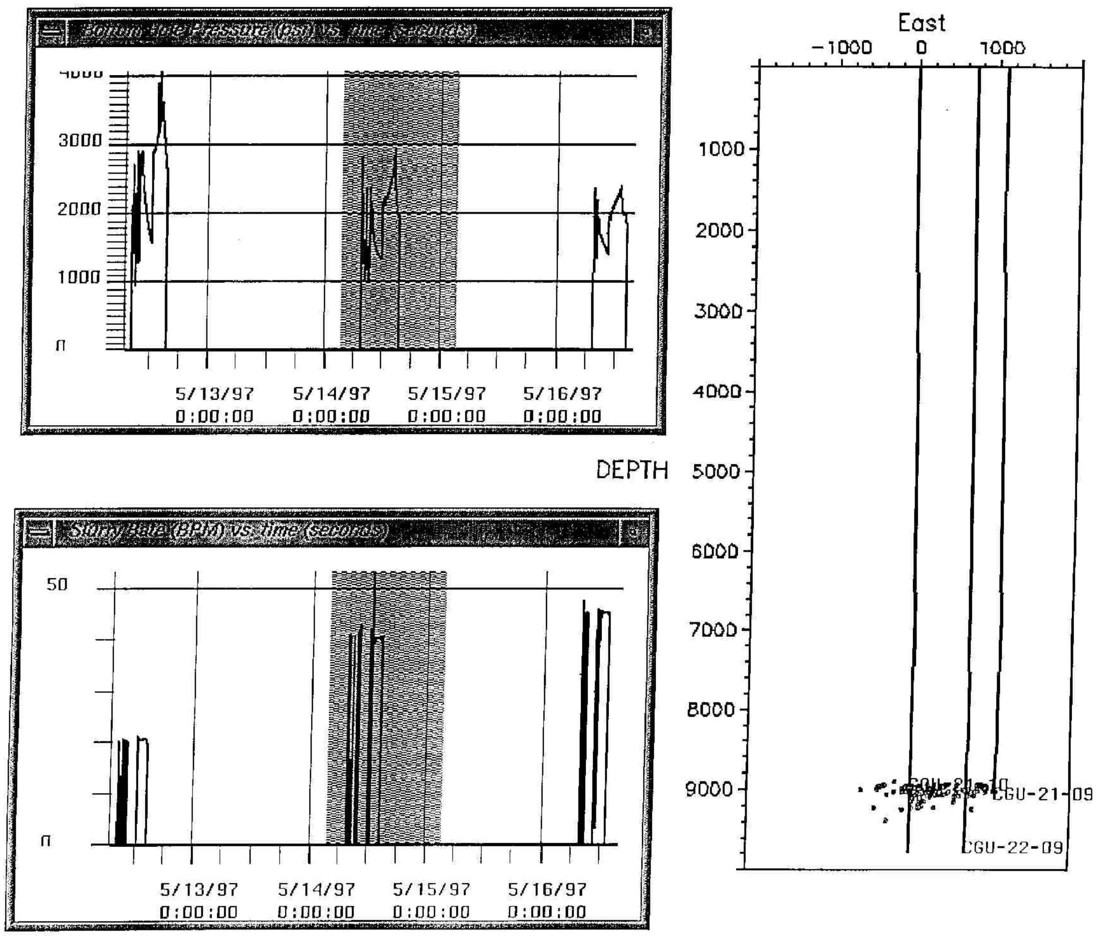
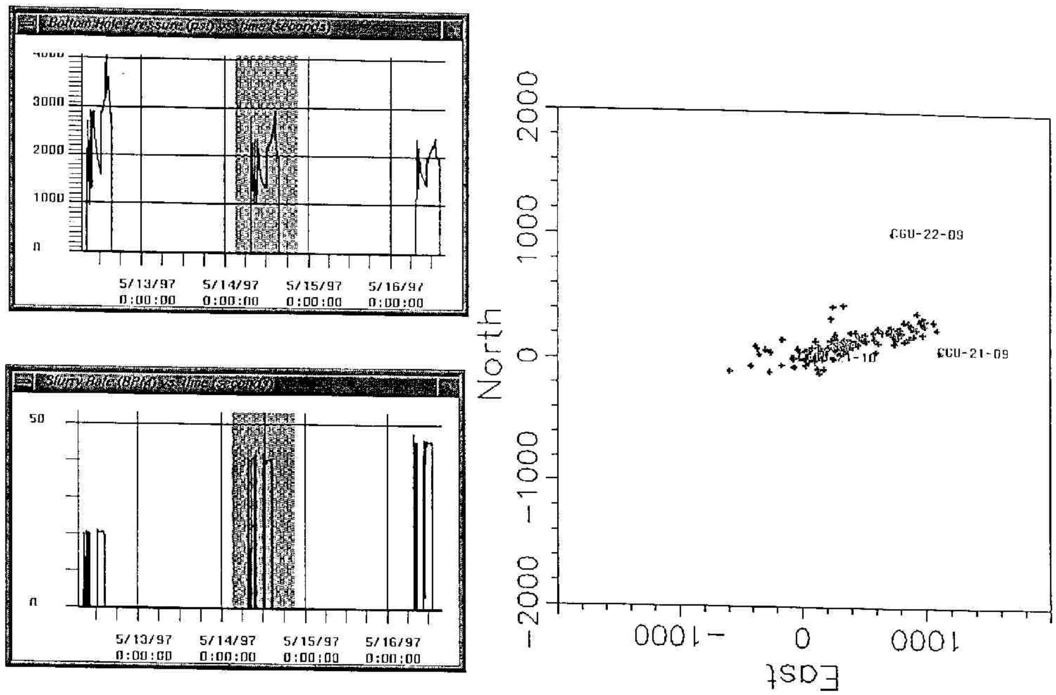

Bottom Hole Pressure (psi) vs. time (seconds)
4000
3000
2000
1000
0
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
Slurry Rate (BPM) vs. time (seconds)
50
0
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
East
−1000
0
1000
DEPTH
1000
2000
3000
4000
5000
6000
7000
8000
9000
CGU-21-09
CGU-22-09

Figure 7



Bottom Hole Pressure (psi) vs Time (seconds)
3000
2000
1000
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
50
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
North
2000
1000
0
−1000
−2000
East
−1000
0
1000
CGU-22-09
CGU-21-09

Figure 8

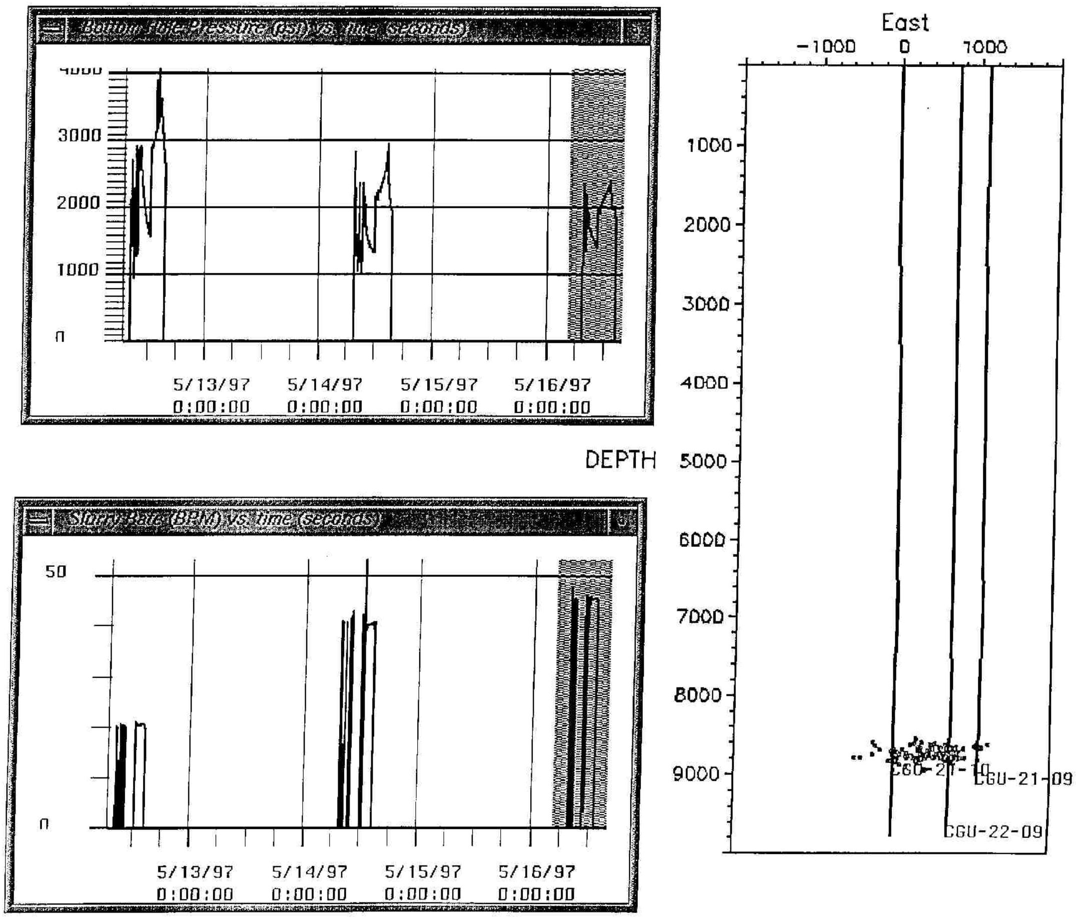
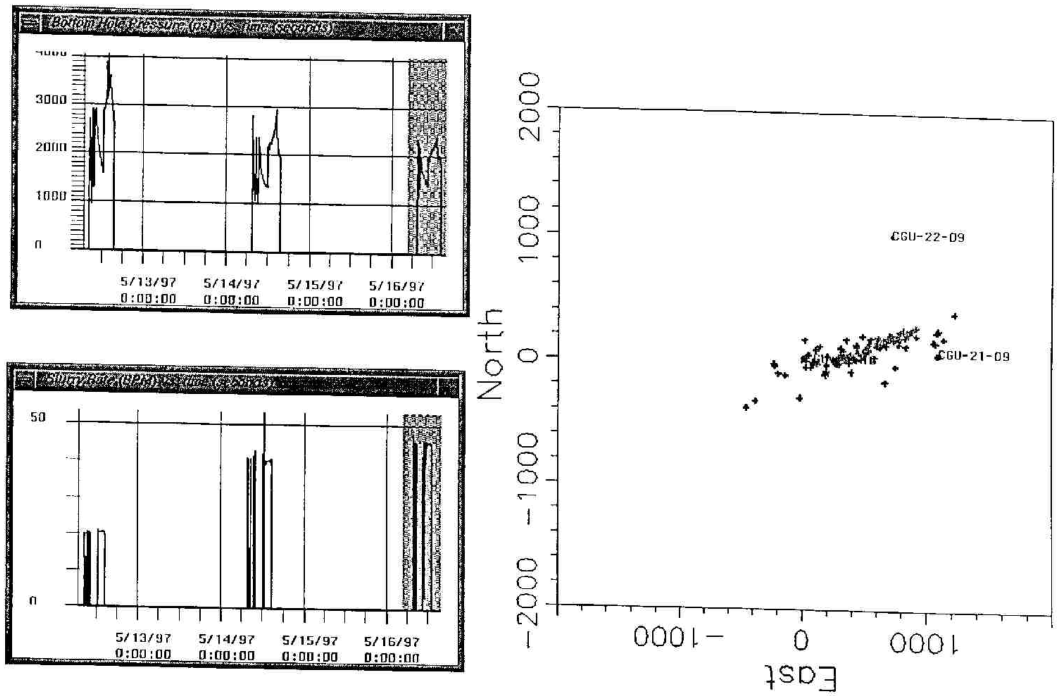

Bottom Hole Pressure (psi) vs. time (seconds)
3000
2000
1000
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
Slurry Rate (BPM) vs. time (seconds)
50
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
East
-1000
0
1000
DEPTH
1000
2000
3000
4000
5000
6000
7000
8000
9000
CGU-21-09
CGU-22-09

Figure 9



Bottom Hole Pressure (psi) vs. time (seconds)
3000
2000
1000
0
5/13/97 0:00:00
5/14/97 0:00:00
5/15/97 0:00:00
5/16/97 0:00:00
50
0
North
East
2000
1000
0
−1000
−2000
CGU-22-09
CGU-21-09

Figure 10

Appendix 1

Cotton Valley Fracture Imaging

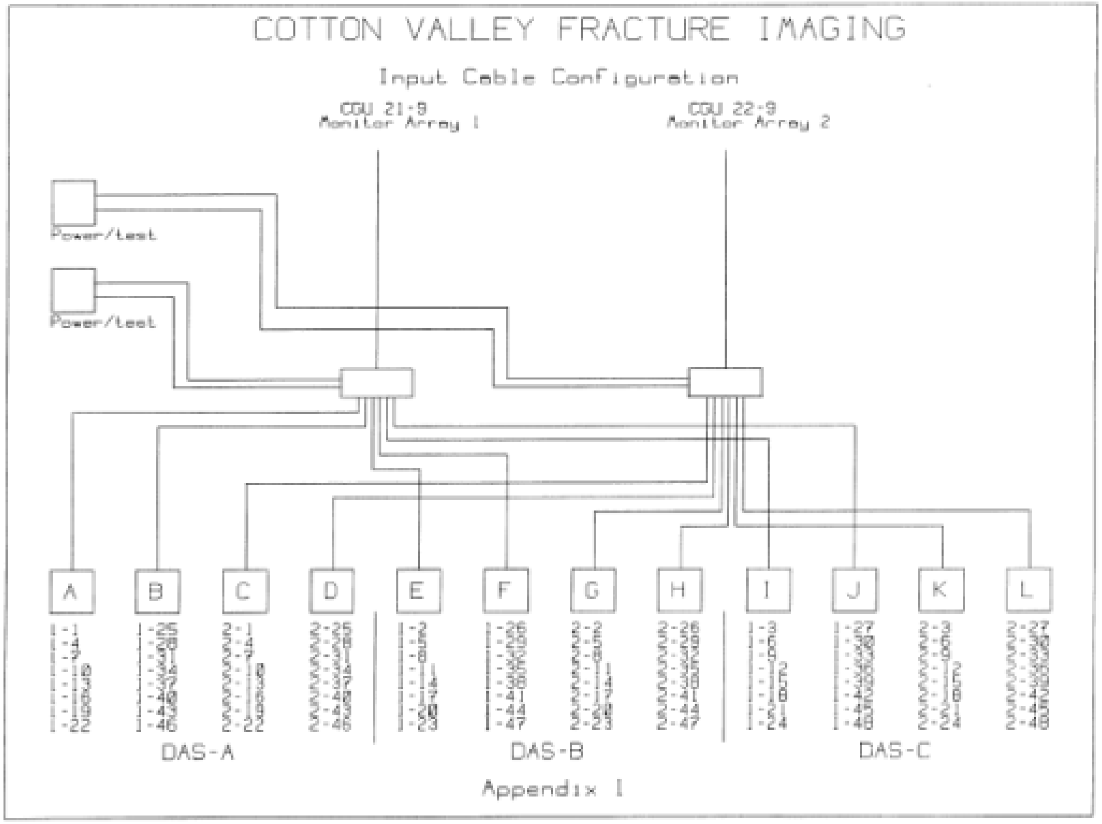
Input Cable Configuration

	DAS-A
Block A	Input Channels 1-24
Block B	Input Channels 25-48
Block C	Input Channels 49-72
Block D	Input Channels 73-96
	DAS-B
Block E	Input Channels 1-24
Block F	Input Channels 25-48
Block G	Input Channels 49-72
Block H	Input Channels 73-96
	DAS-C
Block I	Input Channels 1-24
Block J	Input Channels 25-48
Block K	Input Channels 49-72
Block L	Input Channels 73-96

Input Source Nomenclature

a-pp	a = Monitor array 1/2
	pp = Pod number within array

The above information refers to preceding drawing of input cables



COTTON VALLEY FRACTURE IMAGING
Input Cable Configuration
CGU 21-9
Monitor Array 1
CGU 22-9
Monitor Array 2
Power/test
Power/test
A
B
C
D
E
F
G
H
I
J
K
L
DAS-A
DAS-B
DAS-C
Appendix I

Appendix 2
Cotton Valley Fracture Imaging - Input Channel Map

INPUT CHAN	DAS-A Input Src	Output Ch	SGI Ch	DAS-B Input Src	Output Ch	SGI Ch	DAS-C Input Scr	Output Ch	SGI Ch
1	1-01-H2	OFF		1-02-H2	1	70	1-03-H2	OFF	
2	1-01-H1	OFF		1-02-H1	2	71	1-03-H1	OFF	
3	1-01-V	OFF		1-02-V	3	72	1-03-V	OFF	
4	1-04-VH2	OFF		1-05-H2	4	73	1-06-H2	1	148
5	1-04-H1	OFF		1-05-H1	5	74	1-06-H1	2	149
6	1-04-V	OFF		1-05-V	6	75	1-06-V	OFF	
7	1-07-H2	1	1	1-08-H2	7	76	1-09-H2	OFF	
8	1-07-H1	2	2	1-08-H1	OFF		1-09-H1	OFF	
9	1-07-V	3	3	1-08-V	8	77	1-09-V	OFF	
10	1-10-H2	4	4	1-11-H2	9	78	1-12-H2	OFF	
11	1-10-H1	5	5	1-11-H1	10	79	1-12-H1	OFF	
12	1-10-V	6	6	1-11-V	11	80	1-12-V	OFF	
13	1-13-H2	7	7	1-14-H2	OFF		1-15-H2	3	150
14	1-13-H1	8	8	1-14-H1	12	81	1-15-H1	OFF	
15	1-13-V	9	9	1-14-V	13	82	1-15-V	4	151
16	1-16-H2	OFF		1-17-H2	14	83	1-18-H2	5	152
17	1-16-H1	10	10	1-17-H1	15	84	1-18-H1	OFF	
18	1-16-V	11		1-17-V	16	85	1-18-V	OFF	
19	1-19-H2	12	12	1-20-H2	OFF		1-21-H2	6	153
20	1-19-H1	13	13	1-20-H1	17	86	1-21-H1	7	154
21	1-19-V	14	14	1-20-V	18	87	1-21-V	8	155
22	1-22-H2	15	15	1-23-H2	19	88	1-24-H2	9	156
23	1-22-H1	OFF		1-23-H1	20	89	1-24-H1	10	157
24	1-22-V	16	16	1-23-V	21	90	1-24-V	OFF	
25	1-25-H2	OFF		1-26-H2	OFF		1-27-H2	OFF	
26	1-25-H1	OFF		1-26-H1	OFF		1-27-H1	OFF	
27	1-25-V	OFF		1-26-V	OFF		1-27-V	OFF	
28	1-28-H2	OFF		1-29-H2	OFF		1-30-H2	OFF	
29	1-28-H1	OFF		1-29-H1	OFF		1-30-H1	OFF	
30	1-28-V	OFF		1-29-V	OFF		1-30-V	OFF	
31	1-31-H2	OFF		1-32-H2	OFF		1-33-H2	OFF	
32	1-31-H1	OFF		1-32-H1	OFF		1-33-H1	OFF	
33	1-31-V	OFF		1-32-V	OFF		1-33-V	OFF	
34	1-34-H2	17	17	1-35-H2	OFF		1-36-H2	OFF	
35	1-34-H1	18	18	1-35-H1	OFF		1-36-H1	OFF	
36	1-34-V	19	19	1-35-V	OFF		1-36-V	OFF	
37	1-37-H2	OFF		1-38-H2	22	91	1-39-H2	OFF	
38	1-37-H1	OFF		1-38-H1	23	92	1-39-H1	OFF	
39	1-37-V	OFF		1-38-V	24	93	1-39-V	OFF	
40	1-40-H2	OFF		1-41-H2	25	94	1-42-H2	OFF	
41	1-40-H1	OFF		1-41-H1	26	95	1-42-H1	OFF	
42	1-40-V	OFF		1-41-V	27	96	1-42-V	OFF	
43	1-43-H2	OFF		1-44-H2	OFF		1-45-H2	OFF	
44	1-43-H1	OFF		1-44-H1	28	97	1-45-H1	OFF	
45	1-43-V	OFF		1-44-V	OFF		1-45-V	OFF	
46	1-46-H2	OFF		1-47-H2	OFF		1-48-H2	OFF	
47	1-46-H1	OFF		1-47-H1	OFF		1-48-H1	OFF	
48	1-46-V	OFF		1-47-V	OFF		1-48-V	OFF	

CHAN	Input Src	Output Ch	SGI Ch	Input Src	Output Ch	SGI Ch	Input Scr	Output Ch	SGI Ch
49	2-01-H2	20	20	2-02-H2	29	98	2-03-H2	11	158
50	2-01-H1	21	21	2-02-H1	30	99	2-03-H1	12	159
51	2-01-V	22	22	2-02-V	31	100	2-03-V	13	160
52	2-04-H2	23	23	2-05-H2	32	101	2-06-H2	14	161
53	2-04-H1	24	24	2-05-H1	33	102	2-06-H1	15	162
54	2-04-V	25	25	2-05-V	34	103	2-06-V	16	163
55	2-07-H2	26	26	2-08-H2	35	104	2-09-H2	17	164
56	2-07-H1	27	27	2-08-H1	36	105	2-09-H1	18	165
57	2-07-V	28	28	2-08-V	37	106	2-09-V	19	166
58	2-10-H2	29	29	2-11-H2	38	107	2-12-H2	20	167
59	2-10-H1	30	30	2-11-H1	39	108	2-12-H1	21	168
60	2-10-V	31	31	2-11-V	40	109	2-12-V	22	169
61	2-13-H2	32	32	2-14-H2	41	110	2-15-H2	23	170
62	2-13-H1	33	33	2-14-H1	42	111	2-15-H1	24	171
63	2-13-V	34	34	2-14-V	43	112	2-15-V	25	172
64	2-16-H2	35	35	2-17-H2	44	113	2-18-H2	26	173
65	2-16-H1	36	36	2-17-H1	45	114	2-18-H1	27	174
66	2-16-V	37	37	2-17-V	46	115	2-18-V	28	175
67	2-19-H2	38	38	2-20-H2	47	116	2-21-H2	29	176
68	2-19-H1	39	39	2-20-H1	48	117	2-21-H1	30	177
69	2-19-V	40	40	2-20-V	49	118	2-21-V	31	178
70	2-22-H2	41	41	2-23-H2	50	119	2-24-H2	32	179
71	2-22-H1	42	42	2-23-H1	51	120	2-24-H1	33	180
72	2-22-V	43	43	2-23-V	52	121	2-24-V	34	181
73	2-25-H2	44	44	2-26-H2	53	122	2-27-H2	35	182
74	2-25-H1	45	45	2-26-H1	54	123	2-27-H1	36	183
75	2-25-V	46	46	2-26-V	55	124	2-27-V	37	184
76	2-28-H2	47	47	2-29-H2	56	125	2-30-H2	38	185
77	2-28-H1	48	48	2-29-H1	57	126	2-30-H1	39	186
78	2-28-V	49	49	2-29-V	58	127	2-30-V	40	187
79	2-31-H2	50	50	2-32-H2	59	128	2-33-H2	41	188
80	2-31-H1	51	51	2-32-H1	60	129	2-33-H1	42	189
81	2-31-V	52	52	2-32-V	61	130	2-33-V	43	190
82	2-34-H2	53	53	2-35-H2	62	131	2-36-H2	44	191
83	2-34-H1	54	54	2-35-H1	63	132	2-36-H1	45	192
84	2-34-V	55	55	2-35-V	64	133	2-36-V	46	193
85	2-37-H2	56	56	2-38-H2	65	134	2-39-H2	47	194
86	2-37-H1	57	57	2-38-H1	66	135	2-39-H1	48	195
87	2-37-V	58	58	2-38-V	67	136	2-39-V	49	196
88	2-40-H2	59	59	2-41-H2	68	137	2-42-H2	50	197
89	2-40-H1	60	60	2-41-H1	69	138	2-42-H1	51	198
90	2-40-V	61	61	2-41-V	70	139	2-42-V	52	199
91	2-43-H2	62	62	2-44-H2	71	140	2-45-H2	53	200
92	2-43-H1	63	63	2-44-H1	72	141	2-45-H1	54	201
93	2-43-V	64	64	2-44-V	73	142	2-45-V	55	202
94	2-46-H2	65	65	2-47-H2	74	143	2-48-H2	56	203
95	2-46-H1	66	66	2-47-H1	75	144	2-48-H1	57	204
96	2-46-V	67	67	2-47-V	76	145	2-48-V	58	205

DAS-A: 67 Data Channels + 2 Auxiliary
DAS-B: 76 Data Channels + 2 Auxiliary
DAS-C: 58 Data Channels + 2 Auxiliary

Total Recorded Channels = 207

Input Source Naming Convention: a-pp-cc

- a = Monitor Array Number
  - Array 1 = CGU 21-9
  - Array 2 = CGU 22-9
- pp = Pod Number Within Array
  - Pod 1 at top of array
  - Pod 48 at bottom of array
- cc = Component Axis Within Pod
  - V = Vertical
  - H1 = Horizontal 1
  - H2 = Horizontal 2

DAS-A Auxiliary Channel 1 Recorded on SGI Channel 68
DAS-A Auxiliary Channel 2 Recorded on SGI Channel 69
DAS-B Auxiliary Channel 1 Recorded on SGI Channel 146
DAS-B Auxiliary Channel 2 Recorded on SGI Channel 147
DAS-C Auxiliary Channel 1 Recorded on SGI Channel 206
DAS-C Auxiliary Channel 2 Recorded on SGI Channel 207

Appendix 3
Cotton Valley Fracture Imaging - Event Location Summary

Summary of Fracdata/0512frac/stage1

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970512083036.05596.short	3036	12-May-97	8:30:36 AM	224.92	231.39	9615.70	**	Good event
970512083140.05207.short	3140	12-May-97	8:31:40 AM	206.32	210.04	9610.70	**	Good event

Summary of Fracdata/0512frac/stage2

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970512094638.03368.short	4638	12-May-97	9:46:38 AM	104.03	83.89	9613.70	*	weak event
970512094814.03775.short	4814	12-May-97	9:48:14 AM	41.52	128.16	9588.70	*	Single well -
970512094830.06798.short	4830	12-May-97	9:48:31 AM	13.41	262.45	9600.70	*	Single well -
970512094958.04801.short	4958	12-May-97	9:49:58 AM	-143.10	69.02	9600.70	**	Two well - weak
970512095102.04977.short	512	12-May-97	9:51:02 AM	216.92	441.54	9630.70	*	One well, event
	512	12-May-97	9:51:02 AM	150.00	635.71	9605.70		
970512095222.04995.short		12-May-97					*	One well, good
970512095342.05357.short	5342	12-May-97	9:53:42 AM	91.19	556.60	9620.70	*	Single well -
970512095710.05985.short	5710	12-May-97	9:57:10 AM	90.41	714.02	9640.70	*	Weak event
970512095734.01229.short	5734	12-May-97	9:57:34 AM	95.89	705.48	9620.70	*	Weak event
970512095806.00584.short	586	12-May-97	9:58:06 AM	78.57	110.71	9620.70	*	Very weak event
970512095822.03996.short	5822	12-May-97	9:58:22 AM	-7.14	632.14	9625.70	*	Moderate event
970512095902.04986.short	592	12-May-97	9:59:02 AM	166.67	713.48	9620.70	*	Moderate single
970512095942.05578.short	5942	12-May-97	9:59:42 AM	172.00	540.00	9620.70	*	Weak event
970512100030.05375.short	30	12-May-97	10:00:30 AM	115.87	700.00	9595.70	*	Weak event
970512100054.03386.short	54	12-May-97	10:00:54 AM	187.70	711.36	9635.70	*	Weak event
970512100110.00186.short	110	12-May-97	10:01:11 AM	177.63	782.89	9610.70	*	Weak event
970512100142.02776.short	142	12-May-97	10:01:42 AM	56.96	825.95	9620.70	*	Poor solutionn
970512100310.05985.short		12-May-97						Too weak for a
970512100534.02370.short	534	12-May-97	10:05:34 AM	202.51	284.95	9620.70	*	Two possible
970512100550.05799.short	550	12-May-97	10:05:50 AM	85.37	556.91	9610.70	*	Moderate event -
970512100814.04792.short	814	12-May-97	10:08:14 AM	223.58	308.94	9620.70	*	Moderate event -
970512100950.07162.short	950	12-May-97	10:09:50 AM	31.37	791.51	9595.70	*	Moderate single
970512101006.01786.short	106	12-May-97	10:10:06 AM	120.21	336.24	9600.70	*	Moderate single
970512101030.04995.short		12-May-97						Very weak
970512101126.05375.short	1126	12-May-97	10:11:26 AM	114.84	160.78	9620.70	*	Moderate event
970512101206.03970.short	126	12-May-97	10:12:06 AM	255.85	998.33	9600.70	**	Double well
970512101606.05004.short	166	12-May-97	10:16:06 AM	173.08	839.74	9620.70	**	location

Summary of Fracdata/0512frac/stage2

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970512101630.06984.short	1630	12-May-97	10:16:30 AM	208.33	1003.47	9620.70	**	event
970512101726.06197.short	1726	12-May-97	10:17:27 AM	286.76	988.97	9610.70	*	Single well -
970512101830.02378.short	1830	12-May-97	10:18:30 AM	400.31	1032.71	9620.70	**	Weak event -
970512101830.05605.short	1830	12-May-97	10:18:30 AM	214.29	950.00	9620.70	*	Single well data
970512102158.06958.short	2158	12-May-97	10:21:59 AM	124.16	1023.49	9620.70	**	Possible double
970512102406.01998.short	246	12-May-97	10:24:06 AM	280.00	1032.00	9620.70	**	Good double
970512102542.06966.short	2542	12-May-97	10:25:42 AM	115.82	1079.10	9690.70	*	Single
970512102846.02361.short	2846	12-May-97	10:28:46 AM	170.52	1066.47	9620.70	*	Single well -
970512103326.03192.short	3326	12-May-97	10:33:26 AM	166.67	1010.51	9620.70	**	Possible double
970512103614.04191.short	3614	12-May-97	10:36:14 AM	295.03	987.58	9620.70	*	possible double

Summary of Fracdata/0512frac/stage3

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970512123756.07162.short	3756	12-May-97	12:37:57 PM	286.61	1048.12	9620.70	*	- weak
970512124004.01556.short	404	12-May-97	12:40:04 PM	207.90	950.17	9580.70	*	Weak event
970512124020.01654.short	4020	12-May-97	12:40:20 PM	146.46	1015.15	9580.70	*	Weak event -
970512124244.00018.short	4244	12-May-97	12:42:44 PM	219.70	1015.15	9600.70	**	
970512124316.01742.short	4316	12-May-97	12:43:16 PM	191.28	916.11	9610.70	*	Nice location -
970512124340.06383.short	4340	12-May-97	12:43:40 PM	268.00	964.00	9580.70	*	Weak p recently
970512124356.00416.short	4356	12-May-97	12:43:56 PM	618.96	-842.01	9615.70	***	Event from
	4356	12-May-97	12:43:56 PM	-117.10	-373.61	9575.70		
970512124524.02396.short	4524	12-May-97	12:45:24 PM	379.31	1004.31	9565.70	**	
970512124652.03757.short	4652	12-May-97	12:46:52 PM	210.19	1103.50	9585.70	**	Complicated
970512124708.00999.short	478	12-May-97	12:47:08 PM	190.27	1048.67	9608.70	*	Doublet
970512124732.05384.short	4732	12-May-97	12:47:32 PM	236.84	872.81	9605.70	*	
970512124812.03996.short	4812	12-May-97	12:48:12 PM	276.00	966.00	9570.70	**	
970512124844.03996.short	4844	12-May-97	12:48:44 PM	49.83	503.32	9565.70	**	
970512124844.05994.short	4844	12-May-97	12:48:44 PM	186.27	862.75	9590.70	**	
970512124908.05172.short	498	12-May-97	12:49:08 PM	162.00	876.00	9598.70	*	
970512125108.07135.short	518	12-May-97	12:51:09 PM	259.88	775.08	9620.70	*	
970512125308.03961.short	538	12-May-97	12:53:08 PM	143.96	919.50	9630.70	*	
970512125524.02980.short	5524	12-May-97	12:55:24 PM	34.20	322.48	9595.70	**	
970512125628.03368.short	5628	12-May-97	12:56:28 PM	173.91	739.13	9625.70	**	

Summary of Fracdata/0512frac/stage3

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970512125708.02555.short	578	12-May-97	12:57:08 PM	47.70	159.01	9605.70	**	
970512125740.05587.short	5740	12-May-97	12:57:40 PM	-4.48	649.25	9595.70	**	
970512125916.02591.short	5916	12-May-97	12:59:16 PM	267.68	1095.96	9590.70	**	
	5916	12-May-97	12:59:16 PM	104.86	1012.16	9670.70		
970512130132.04182.short		12-May-97					**	Still relying on a
970512130420.03006.short		12-May-97					*	Weak event
970512130516.01998.short	516	12-May-97	1:05:16 PM	-38.96	-165.58	9618.70	**	Perhaps on
970512130620.00602.short	620	12-May-97	1:06:20 PM	179.58	301.06	9620.70	*	
970512130636.02820.short	636	12-May-97	1:06:36 PM	102.61	757.33	9565.70	**	
970512131036.02414.short	1036	12-May-97	1:10:36 PM	236.30	652.40	9690.70	*	
970512131109.04562.short	119	12-May-97	1:11:09 PM	310.17	849.15	9590.70	*	All shear -
970512131133.06012.short	1133	12-May-97	1:11:33 PM	281.25	721.87	9615.70	**	Second well
970512131141.04995.short	1141	12-May-97	1:11:41 PM	223.68	1140.35	9603.70	**	Complex event
970512131301.02591.short	131	12-May-97	1:13:01 PM	171.59	863.47	9620.70	**	Good solution -
970512131301.04597.short	131	12-May-97	1:13:01 PM	267.37	815.71	9580.70	*	Weak P , good
970512131301.06595.short	131	12-May-97	1:13:01 PM	37.10	74.20	9625.70	***	Good event
970512131341.06984.short	1341	12-May-97	1:13:41 PM	123.66	580.65	9540.70	**	
970512131549.03006.short	1549	12-May-97	1:15:49 PM	103.64	610.91	9620.70	*	
970512131805.06789.short	185	12-May-97	1:18:05 PM	126.26	742.42	9620.70	**	
970512131909.06003.short	199	12-May-97	1:19:09 PM	58.82	774.51	9575.70	*	
	2341	12-May-97	1:23:45 PM	208.77	1096.49	9625.70		
970512132341.04597.short	2341	12-May-97	1:23:45 PM	124.56	457.89	9590.50	****	Major event
970512132341.48340.short	2341	12-May-97	1:23:45 PM	124.56	457.89	9590.50	***	Big event
	2341	12-May-97	1:23:41 PM	80.54	890.94	9620.70		
970512132733.03996.short	2733	12-May-97	1:27:33 PM	340.68	854.24	9585.70	*	
970512132917.01335.short	2917	12-May-97	1:29:17 PM	121.62	780.41	9580.70	**	
970512133325.01194.short	3325	12-May-97	1:33:25 PM	-115.38	-93.41	9620.70	*	Near injector -
970512133933.01998.short	3933	12-May-97	1:39:33 PM	506.69	476.59	9630.70	**	Event to
970512133933.03978.short	3933	12-May-97	1:39:33 PM	270.00	890.00	9615.70	*	
970512134157.07134.short	4157	12-May-97	1:41:57 PM	261.57	854.09	9605.70	*	
970512134341.03970.short	4341	12-May-97	1:43:41 PM	86.83	1254.49	9610.70	**	
970512134605.05402.short	465	12-May-97	1:46:05 PM	247.31	946.24	9590.70	*	
970512134821.04995.short	4821	12-May-97	1:48:21 PM	168.83	1240.26	9590.70	*	
970512134909.01989.short	499	12-May-97	1:49:09 PM	157.72	147.65	9615.70	*	Near injector

Summary of Fracdata/0512frac/stage3

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970512135117.01786.short	5117	12-May-97	1:51:17 PM	304.35	1049.69	9620.70	*	Doublets
970512135405.02317.short	545	12-May-97	1:54:05 PM	363.64	994.32	9625.70	*	
970512135517.02529.short	5517	12-May-97	1:55:17 PM	125.00	841.91	9605.70	**	
970512135517.05083.short	5517	12-May-97	1:55:17 PM	90.91	1118.88	9600.70	*	
970512135701.04862.short	571	12-May-97	1:57:01 PM	48.44	692.04	9590.70	*	
970512140021.06383.short	21	12-May-97	2:00:21 PM	319.22	597.72	9610.70	*	Anomalous
970512140253.01989.short	253	12-May-97	2:02:53 PM	174.38	884.34	9620.70	**	Possible second
970512141116.06020.short	1116	12-May-97	2:11:16 PM	62.73	998.15	9620.70	**	Weak
970512142300.05110.short	230	12-May-97	2:23:00 PM	-3.77	-139.62	9575.70	*	Near injector
970512142636.07267.short	2636	12-May-97	2:26:36 PM	258.39	912.75	9620.70	**	

Summary of Fracdata/0514frac/stage1

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514073330.01282.short	3330	14-May-97	7:33:30 AM	28.96	51.83	9218.70	**	
970514073642.06188.short	3642	14-May-97	7:36:42 AM	2.00	164.00	9093.70	***	
970514073642.07196.short	3642	14-May-97	7:36:42 AM	-72.73	131.82	9188.70	***	
970514073826.06188.short	3826	14-May-97	7:38:26 AM	114.29	414.29	9023.70	*	
970514074210.00186.short	4210	14-May-97	7:42:10 AM	207.43	272.45	9038.70	*	
970514074418.61030.short		14-May-97					**	
970514074434.06692.short	4434	14-May-97	7:44:34 AM	26.79	71.43	8963.70	***	
	4418	14-May-97	7:44:24 AM	164.71	526.47	9008.70		
970514074546.05711.short	4546	14-May-97	7:45:46 AM	37.67	135.27	8948.70	**	
970514074850.03298.short	4850	14-May-97	7:48:50 AM	82.84	313.61	9058.70	**	
970514075106.14530.short	516	14-May-97	7:51:07 AM	144.41	418.26	9043.70	***	
970514075202.06409.short	522	14-May-97	7:52:02 AM	59.94	315.46	9063.70	**	
970514075730.05799.short	5730	14-May-97	7:57:30 AM	144.23	355.77	9023.70	**	

Summary of Fracdata/0514frac/stage2

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514082138.42280.short	2138	14-May-97	8:21:42 AM	58.82	289.22	9058.70	***	
970514082810.64310.short	2810	14-May-97	8:28:16 AM	136.79	358.49	9038.70	***	
970514083002.04067.short	302	14-May-97	8:30:02 AM	138.69	379.56	9048.70	***	
970514083426.54440.short	3426	14-May-97	8:34:31 AM	134.26	370.37	9053.70	**	
970514083842.05402.short	3842	14-May-97	8:38:42 AM	154.61	292.76	9058.70	***	
970514084058.01424.short	4058	14-May-97	8:40:58 AM	157.14	234.29	9023.70	***	
970514084114.04544.short		14-May-97					***	
	4346	14-May-97	8:43:53 AM	112.24	362.24	9048.70		
970514084346.70650.short	4450	14-May-97	8:44:54 AM	108.28	366.24	9003.70	***	
970514084906.40030.short	496	14-May-97	8:49:10 AM	121.50	397.20	9033.70	***	
970514085506.47460.short	556	14-May-97	8:55:10 AM	84.11	355.14	9058.70	***	

Summary of Fracdata/0514frac/stage3a

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514091827.09480.short	1827	14-May-97	9:18:27 AM	22.73	139.61	9223.70	*	
970514092521.50170.short	2521	14-May-97	9:25:25 AM	101.82	150.91	9138.70	*	
970514092617.26630.short	2617	14-May-97	9:26:19 AM	91.87	208.48	9138.70	*	
970514092657.50650.short	2657	14-May-97	9:27:02 AM	82.14	60.71	8953.70	***	
	2657	14-May-97	9:27:02 AM	71.43	-14.29	8953.70		
970514092729.60450.short	2729	14-May-97	9:27:35 AM	67.96	150.49	9068.70	***	
970514092745.31520.short	2745	14-May-97	9:27:48 AM	52.08	197.92	9043.70	**	
970514092809.27180.short	289	14-May-97	9:28:11 AM	129.03	456.99	9053.70	***	
970514092841.70430.short	2841	14-May-97	9:28:48 AM	-44.07	32.20	8968.70	**	
970514092913.03570.short	2913	14-May-97	9:29:13 AM	117.74	316.13	9023.70	***	
970514092945.15240.short	2945	14-May-97	9:29:46 AM	58.82	173.01	8978.70	**	
970514093001.25410.short	301	14-May-97	9:30:03 AM	110.00	320.00	9028.70	****	Multiple good
970514093025.72390.short	3025	14-May-97	9:30:32 AM	91.74	321.10	9048.70	***	
970514093105.07910.short	315	14-May-97	9:31:05 AM	-16.08	104.50	8978.70	**	
970514093121.31350.short	3121	14-May-97	9:31:24 AM	153.85	111.89	9013.70	*	Weak p - shear
970514093145.74000.short	3145	14-May-97	9:31:52 AM	133.78	309.36	9033.70	**	
970514093217.06440.short	3217	14-May-97	9:32:17 AM	76.66	343.21	9068.70	**	Velocity model
970514093233.64820.short	3233	14-May-97	9:32:39 AM	107.01	217.71	9038.70	***	
970514093321.03060.short	3321	14-May-97	9:33:21 AM	105.26	263.16	8988.70	***	

Summary of Fracdata/0514frac/stage3a

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514093345.18710.short	3345	14-May-97	9:33:46 AM	148.73	286.39	9023.70	***	
970514093417.55460.short	3417	14-May-97	9:34:22 AM	336.96	239.13	9038.70	*	Weak location,
970514093505.76440.short	355	14-May-97	9:35:12 AM	162.06	250.99	9038.70	**	
970514093601.05039.short	361	14-May-97	9:36:01 AM	-41.94	-162.90	9023.70	**	Weak second
970514093729.18300.short	3729	14-May-97	9:37:30 AM	225.35	399.65	9003.70	**	Weak event
970514093929.08490.short	3929	14-May-97	9:39:29 AM	4.81	38.46	8943.70	***	

Summary of Fracdata/0514frac/stage3b

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514093953.20450.short	3953	14-May-97	9:39:55 AM	120.13	295.45	9048.70	**	
970514094041.59750.short	4041	14-May-97	9:40:46 AM	12.74	251.59	8938.70	***	
970514094323.36870.short	4323	14-May-97	9:43:26 AM	110.32	307.83	9058.70	***	
970514094643.18360.short	4643	14-May-97	9:46:44 AM	14.85	-19.80	8958.70	**	Weak event
970514094731.43000.short	4731	14-May-97	9:47:35 AM	255.32	797.87	9033.70	**	Perhaps double
970514094811.66730.short		14-May-97					**	Shear velocity
970514094843.78420.short	4843	14-May-97	9:48:50 AM	83.03	348.38	9048.70	***	
970514094915.77190.short	4915	14-May-97	9:49:22 AM	208.33	515.62	8923.70	***	
970514095019.18250.short	5019	14-May-97	9:50:20 AM	47.95	150.68	9103.70	**	
970514095107.08720.short	517	14-May-97	9:51:07 AM	287.10	882.26	9003.70	*	Weak event -
970514095203.34310.short	523	14-May-97	9:52:06 AM	136.36	418.18	8948.70	**	
970514095251.44550.short	5251	14-May-97	9:52:55 AM	167.86	505.36	9038.70	*	
970514095659.01060.short	5659	14-May-97	9:56:59 AM	140.45	438.20	8963.70	*	Weak no P
970514095859.22020.short	5859	14-May-97	9:59:01 AM	281.25	989.58	8983.70	*	
970514100051.07280.short	51	14-May-97	10:00:51 AM	317.31	985.58	8953.70	**	
970514101626.04482.short		14-May-97						One well S only -
970514102213.01486.short		14-May-97						non-unique

Summary of Fracdata/0514frac/stage4a

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514115751.01044.short	5751	14-May-97	11:57:51 AM	71.43	42.21	9008.70	***	
970514120103.03121.short	13	14-May-97	12:01:03 PM	103.57	135.71	9043.70	**	
970514120511.07382.short	511	14-May-97	12:05:11 PM	0.00	56.52	9138.70	**	
970514120832.00009.short	832	14-May-97	12:08:32 PM	127.52	338.93	9043.70	**	
970514121024.05499.short	1024	14-May-97	12:10:24 PM	258.68	618.30	9033.70	**	Weak only shear
970514121320.07329.short	1320	14-May-97	12:13:20 PM	83.94	275.55	9083.70	***	
970514121504.03713.short	154	14-May-97	12:15:04 PM	84.46	322.64	9073.70	***	
970514121744.04862.short	1744	14-May-97	12:17:44 PM	62.50	333.33	9053.70	***	
970514121928.37530.short	1928	14-May-97	12:19:31 PM	313.06	824.93	9063.70	**	Weak shear only
970514122232.01689.short	2232	14-May-97	12:22:32 PM	17.52	-73.25	9023.70	**	
970514122416.32320.short	2416	14-May-97	12:24:19 PM	156.05	394.90	9058.70	****	
970514122656.68780.short	2656	14-May-97	12:27:02 PM	107.38	273.49	9033.70	***	
970514122832.06720.short	2832	14-May-97	12:28:32 PM	337.70	967.21	9023.70	**	
970514123136.29320.short	3136	14-May-97	12:31:38 PM	254.90	705.88	8988.70	***	
970514123528.05552.short	3528	14-May-97	12:35:28 PM	145.63	621.36	8938.70	**	Double event
970514123832.01520.short	3832	14-May-97	12:38:32 PM	221.28	581.08	9143.70	***	
970514124136.53660.short	4136	14-May-97	12:41:41 PM	305.26	863.16	8988.70	**	
970514124520.14380.short	4520	14-May-97	12:45:21 PM	327.48	993.61	8968.70	**	
970514124840.30100.short	4840	14-May-97	12:48:42 PM	250.76	776.44	8988.70	**	
970514125136.02591.short	5136	14-May-97	12:51:36 PM	-48.17	-411.96	9218.70	***	Far wing
970514125352.20690.short	5352	14-May-97	12:53:54 PM	188.68	466.98	8953.70	**	
970514125728.08710.short	5728	14-May-97	12:57:28 PM	159.09	831.17	9023.70	**	Weak on array 1

Summary of Fracdata/0514frac/stage4b

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514130000.18640.short	0	14-May-97	1:00:01 PM	51.45	167.20	9056.80	***	
970514130320.02210.short	320	14-May-97	1:03:20 PM	163.27	346.94	9028.70	***	
970514130544.21280.short		14-May-97						No p, weak
970514130720.-0600.short	720	14-May-97	1:07:27 PM	9.62	72.12	9103.70	****	Very large event
970514130800.59220.short		14-May-97						Very weak,
970514130832.00938.short		14-May-97						Compound of 2
970514130904.05799.short	94	14-May-97	1:09:04 PM	10.10	257.58	9073.70	**	
970514131400.49950.short	140	14-May-97	1:14:04 PM	-55.94	-61.19	9238.70	**	
970514131640.55730.short	1640	14-May-97	1:16:45 PM	-96.39	-259.04	9373.70	**	Suggests
970514131840.78500.short	1840	14-May-97	1:18:47 PM	196.43	785.71	9033.70	**	
970514132104.63260.short	214	14-May-97	1:21:10 PM	433.54	253.16	9053.70	**	To the north?
970514132232.77190.short	2232	14-May-97	1:22:39 PM	70.80	26.55	9038.70	***	
970514132424.73360.short	2424	14-May-97	1:24:31 PM	445.07	339.44	9213.70	**	
970514132640.04470.short	2640	14-May-97	1:26:40 PM	137.58	751.68	8993.70	***	
	274	14-May-97	1:27:07 PM	-104.92	140.98	9213.70		
970514132936.37820.short	2936	14-May-97	1:29:39 PM	315.61	1063.12	9008.70	**	
970514133400.03784.short	340	14-May-97	1:34:00 PM	176.47	588.24	9078.70	**	
970514133544.26400.short	3544	14-May-97	1:35:46 PM	266.67	723.81	9008.70	**	
970514133712.70470.short	3712	14-May-97	1:37:19 PM	228.12	650.00	9073.70	**	
970514133944.63200.short	3944	14-May-97	1:39:50 PM	224.08	725.75	9003.70	**	
970514134128.62880.short	4128	14-May-97	1:41:34 PM	156.15	375.42	9023.70	***	
970514134536.68180.short	4536	14-May-97	1:45:42 PM	62.70	-252.35	9048.70	****	
970514134952.44140.short	4952	14-May-97	1:49:56 PM	72.92	604.17	8983.70	***	
970514135200.48100.short	520	14-May-97	1:52:04 PM	234.78	686.96	8988.70	***	
970514135448.24440.short	5448	14-May-97	1:54:50 PM	208.63	737.41	9053.70	**	
970514135648.69970.short	5648	14-May-97	1:56:54 PM	223.30	805.83	9233.70	***	
970514135912.06130.short	5912	14-May-97	1:59:12 PM	89.11	-29.70	9018.70	***	

Summary of Fracdata/0514frac/stage4c

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970514140552.02378.short		14-May-97						recording only
970514140808.72560.short	88	14-May-97	2:08:15 PM	253.87	1089.78	9008.70	**	
970514141024.71120.short	1024	14-May-97	2:10:31 PM	-7.99	35.14	8968.70	***	
970514141232.01733.short	1232	14-May-97	2:12:32 PM	195.73	265.12	8973.70	**	Doublet of
970514141520.63720.short	1520	14-May-97	2:15:26 PM	225.86	437.93	9058.70	***	
970514141925.18280.short	1925	14-May-97	2:19:26 PM	82.14	-292.86	8938.70	***	Second wing
970514142117.23140.short	2117	14-May-97	2:21:19 PM	101.16	83.82	9068.70	**	
970514142509.05437.short	259	14-May-97	2:25:09 PM	174.34	490.13	8933.70	**	
970514142942.04544.short	2942	14-May-97	2:29:42 PM	68.11	337.46	8938.70	**	Weak event with
970514143437.64120.short	3437	14-May-97	2:34:43 PM	186.27	867.65	8938.70	**	Not a good
970514143926.00699.short	3926	14-May-97	2:39:26 PM	215.19	974.68	8983.70	**	
970514144414.59020.short	4414	14-May-97	2:44:19 PM	265.62	884.37	8978.70	**	
970514144918.05075.short	4918	14-May-97	2:49:18 PM	385.29	932.35	8958.70	**	Weak solution
970514145430.02096.short	5430	14-May-97	2:54:30 PM	167.61	-156.25	8903.70	***	
970514150054.21640.short	54	14-May-97	3:00:56 PM	255.38	924.62	8933.70	***	
970514150638.06109.short	638	14-May-97	3:06:38 PM	201.81	902.11	8938.70	**	
970514151134.75360.short	1134	14-May-97	3:11:41 PM	171.43	761.90	9073.70	**	
970514151758.05225.short	1758	14-May-97	3:17:58 PM	112.58	-374.17	8988.70	***	
970514152326.12450.short	2326	14-May-97	3:23:27 PM	44.30	-344.94	8953.70	***	
970514152950.38910.short	2950	14-May-97	3:29:53 PM	10.10	-65.66	8978.70	**	
970514153606.49730.short	366	14-May-97	3:36:10 PM	93.02	-360.47	8956.80	***	
970514155254.41660.short	5254	14-May-97	3:52:58 PM	316.33	959.18	8988.70	**	
970514161638.65270.short	1638	14-May-97	4:16:44 PM	-92.59	-587.96	8998.70	***	arrivals -

Summary of Fracdata/0516frac/stage1

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970516073441.06595.short	3441	16-May-97	7:34:41 AM	-321.86	-380.24	8788.70	**	second wing
970516073753.05092.short	3753	16-May-97	7:37:53 AM	-376.00	-454.00	8788.70	**	Second wing
970516074121.02599.short	4121	16-May-97	7:41:21 AM	-69.28	197.29	8903.70	*	Weak event
970516074345.03483.short	4345	16-May-97	7:43:46 AM	-39.15	72.95	8818.70	**	Near well
970516074513.44100.short	4513	16-May-97	7:45:17 AM	30.40	253.80	8618.70	**	Near well
970516074801.11360.short	481	16-May-97	7:48:02 AM	-11.49	287.36	8788.70	**	

Summary of Fracdata/0516frac/stage2

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970516080857.00389.short	857	16-May-97	8:08:57 AM	-94.16	-191.56	8631.80	***	
970516081137.02175.short	1137	16-May-97	8:11:37 AM	-23.26	201.00	8768.70	**	
970516081353.40080.short	1353	16-May-97	8:13:56 AM	53.29	57.99	8843.70	**	
970516081617.29370.short		16-May-97						Poor location - 1
970516081753.01061.short	1753	16-May-97	8:17:53 AM	-18.80	-227.44	8746.80	**	
970516081937.03033.short	1937	16-May-97	8:19:37 AM	-11.24	123.60	8748.70	**	
970516082041.67920.short	2041	16-May-97	8:20:47 AM	-39.63	38.11	8666.80	**	Missed first p
970516082257.70910.short		16-May-97					*	Weak event -
970516082433.03678.short	2433	16-May-97	8:24:33 AM	-105.96	-135.76	8686.80	***	
970516082609.05870.short	269	16-May-97	8:26:09 AM	27.27	354.55	8651.80	***	
970516082705.61490.short	275	16-May-97	8:27:11 AM	-101.17	190.66	8726.80	**	Weak
970516082817.13280.short	2817	16-May-97	8:28:18 AM	40.72	387.62	8743.70	**	weak event -
970516082905.16600.short	295	16-May-97	8:29:06 AM	-35.34	-220.85	8591.80	**	shear arrivals
970516082937.16250.short	2937	16-May-97	8:29:38 AM	9.80	259.80	8758.70	**	
970516083025.03846.short	3025	16-May-97	8:30:25 AM	178.18	25.45	8746.80	**	Weak
970516083137.05623.short	3137	16-May-97	8:31:37 AM	-72.73	400.00	8798.70	*	Very weak event
970516083233.07270.short	3233	16-May-97	8:32:33 AM	43.71	353.15	8663.70	**	
970516083329.43650.short		16-May-97					**	
970516083401.56140.short	341	16-May-97	8:34:06 AM	0.00	275.70	8773.70	**	
970516083529.39880.short	3529	16-May-97	8:35:32 AM	-151.32	672.70	8791.80	*	Weak arrivals -
970516083633.73910.short	3633	16-May-97	8:36:40 AM	29.41	480.39	8696.80	***	
970516083937.18320.short	3937	16-May-97	8:39:38 AM	97.56	541.81	8781.80	***	
970516084305.25880.short		16-May-97						Insufficient data

Summary of Fracdata/0516frac/stage3a

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970516084337.06772.short	4337	16-May-97	8:43:37 AM	9.71	82.52	8716.80	**	
970516104050.05349.short	4050	16-May-97	10:40:50 AM	28.57	14.29	8702.70	**	
970516104442.59190.short	4442	16-May-97	10:44:47 AM	-291.80	-16.39	8823.70	*	Poor solution?
970516104810.57260.short	4810	16-May-97	10:48:15 AM	82.47	494.85	8751.80	**	
970516104954.49260.short	4954	16-May-97	10:49:58 AM	129.03	446.24	8788.70	***	
970516105210.53860.short	5210	16-May-97	10:52:15 AM	0.00	383.33	8686.80	***	
970516105322.55950.short	5322	16-May-97	10:53:27 AM	153.85	546.15	8788.70	**	
970516105506.48260.short	556	16-May-97	10:55:10 AM	-15.09	86.79	8788.70	**	
970516105610.15570.short	5610	16-May-97	10:56:11 AM	32.79	426.23	8751.70	**	
970516105650.01459.short	5650	16-May-97	10:56:50 AM	67.31	500.00	8618.70	**	
970516105802.72900.short	582	16-May-97	10:58:09 AM	113.07	515.90	8683.70	**	
970516105914.00708.short	5914	16-May-97	10:59:14 AM	3.18	380.57	8661.80	**	Weak but clean
970516110050.71570.short	50	16-May-97	11:00:57 AM	42.11	584.21	8738.70	***	
970516110226.45230.short	226	16-May-97	11:02:30 AM	192.31	557.69	8608.70	**	
970516110338.-1150.short	338	16-May-97	11:03:38 AM	43.05	301.32	8788.70	**	
970516110522.38860.short	522	16-May-97	11:05:25 AM	24.14	437.93	8763.70	**	Slowed shear
970516110658.37180.short	658	16-May-97	11:07:01 AM	221.05	726.32	8737.70	**	
970516110854.03147.short		16-May-97						3 small events
970516110918.60530.short	918	16-May-97	11:09:24 AM	129.75	148.73	8678.70	**	
970516111038.51380.short	1038	16-May-97	11:10:43 AM	133.33	628.57	8661.80	***	
970516111254.60980.short	1254	16-May-97	11:13:00 AM	227.27	767.86	8653.70	***	
970516111526.40400.short	1526	16-May-97	11:15:30 AM	241.55	844.59	8708.70	**	No p present
970516111742.29490.short	1742	16-May-97	11:17:45 AM	119.72	315.14	8546.80	****	
970516111934.21070.short	1934	16-May-97	11:19:36 AM	46.98	208.05	8788.70	***	
970516112054.07152.short		16-May-97						Three multiple
970516112230.21430.short	2230	16-May-97	11:22:32 AM	136.84	836.84	8728.70	***	
970516112430.01800.short	2430	16-May-97	11:24:30 AM	31.58	347.37	8703.70	**	No p observed
970516112542.18350.short	2542	16-May-97	11:25:43 AM	143.97	680.93	8813.70	**	Poor solution
970516112710.59580.short	2710	16-May-97	11:27:16 AM	289.06	916.02	8673.70	**	Changing shear
970516113006.22130.short	306	16-May-97	11:30:08 AM	137.93	608.62	8748.70	***	
970516113158.49270.short	3158	16-May-97	11:32:02 AM	100.72	116.91	8873.70	***	
970516113406.29480.short	346	16-May-97	11:34:09 AM	143.81	630.43	8783.70	**	
970516113558.78050.short	3558	16-May-97	11:36:05 AM	67.19	393.28	8593.70	***	

Summary of Fracdata/0516frac/stage3b

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970516113534.01512.short	3534	16-May-97	11:35:34 AM	275.51	821.43	8658.70	**	
	3534	16-May-97	11:35:34 AM	226.35	712.84	8673.70		
970516113806.66590.short	386	16-May-97	11:38:12 AM	109.47	539.94	8673.70	***	
	386	16-May-97	11:38:12 AM	167.50	613.59	8643.70		
970516114126.60480.short	4126	16-May-97	11:41:32 AM	216.87	493.98	8748.70	**	
970516114142.60230.short		16-May-97						Unlocateable
970516114539.63670.short	4539	16-May-97	11:45:45 AM	406.25	1226.56	8618.70	**	
970516114944.63500.short	4944	16-May-97	11:49:50 AM	60.61	318.18	8813.70	**	Velocities slower
970516115104.59800.short	514	16-May-97	11:51:10 AM	93.55	335.48	8788.70	***	
970516115248.60990.short	5248	16-May-97	11:52:54 AM	185.00	660.00	8728.70	**	
970516115528.77390.short	5528	16-May-97	11:55:35 AM	183.23	779.50	8728.70	**	
970516115640.41300.short	5640	16-May-97	11:56:44 AM	47.62	404.76	8768.70	**	
970516115832.17160.short	5832	16-May-97	11:58:33 AM	221.85	713.58	8813.70	**	
970516115928.76320.short	5928	16-May-97	11:59:35 AM	-26.42	754.72	8783.70	**	Could be a
970516120048.40360.short	48	16-May-97	12:00:52 PM	252.63	794.74	8783.70	**	
970516120208.68740.short	28	16-May-97	12:02:14 PM	40.40	35.35	8943.70	***	
970516120504.41610.short	54	16-May-97	12:05:08 PM	141.87	442.91	8938.70	***	
970516120744.74370.short	744	16-May-97	12:07:51 PM	213.00	835.74	8798.70	***	
970516120912.64230.short	912	16-May-97	12:09:18 PM	180.15	742.65	8763.70	**	
970516121024.58830.short	1024	16-May-97	12:10:29 PM	266.00	884.00	8788.70	***	
970516121208.32110.short	128	16-May-97	12:12:11 PM	224.00	920.00	8783.70	***	
970516121304.18590.short	134	16-May-97	12:13:05 PM	152.00	782.00	8853.70	**	No p arrivals
970516121352.71330.short	1352	16-May-97	12:13:59 PM	80.00	458.00	8748.70	**	
970516121456.72390.short	1456	16-May-97	12:15:03 PM	202.13	1138.30	8658.70	***	
970516121624.19780.short	1624	16-May-97	12:16:26 PM	206.52	614.13	8723.70	***	
970516121728.21160.short	1728	16-May-97	12:17:30 PM	185.81	363.18	8848.70	**	
970516121816.71230.short	1816	16-May-97	12:18:23 PM	66.90	1086.27	8893.70	**	Poor solution
970516121912.57570.short	1912	16-May-97	12:19:17 PM	269.23	1094.23	8808.70	**	Weak energy
970516122008.31400.short	208	16-May-97	12:20:11 PM	206.19	695.88	8618.70	**	Poor solution
970516122128.11710.short		16-May-97						Single well
970516122240.15330.short	2240	16-May-97	12:22:41 PM	174.83	683.57	8733.70	***	
970516122320.27980.short	2320	16-May-97	12:23:22 PM	256.60	1083.02	8633.70	**	
970516122544.63390.short	2544	16-May-97	12:25:50 PM	215.69	759.80	8663.70	**	
970516122824.57870.short	2824	16-May-97	12:28:29 PM	169.12	1073.53	8623.70	***	

Summary of Fracdata/0516frac/stage3b

Filename	Event #	Date	Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
970516122952.24930.short	2952	16-May-97	12:29:54 PM	175.16	1058.92	8643.70	**	
970516123136.13760.short	3136	16-May-97	12:31:37 PM	-10.00	302.00	8598.70	****	
970516123344.53230.short	3344	16-May-97	12:33:49 PM	201.89	783.91	8708.70	***	
970516123600.31310.short	360	16-May-97	12:36:03 PM	48.95	389.86	8743.70	***	

Summary of Fracdata/0516frac/stage3c

Filename	Event #		Event Time	X-Coord	Y-Coord	Depth	Quality	Comments
No Events Analyzed At This Time								