

08/09/97

DOE/BC/14938-6  
2Q/97

**TITLE: ADVANCED RESERVOIR CHARACTERIZATION IN THE ANTELOPE SHALE TO ESTABLISH THE VIABILITY OF CO<sub>2</sub> ENHANCED OIL RECOVERY IN CALIFORNIA'S MONTEREY FORMATION SILICEOUS SHALES**

Cooperative Agreement No.: DE-FC22-95BC14938

Contractor Name and Address: **Chevron USA Production Company (CPDN), 5001 California Avenue, Bakersfield, California 93309**

Award Date: **February 7, 1996**

Date of Report: **July 25, 1997**

Anticipated Completion Date: **June 11, 1998**

Government Award for Budget Period # 1: **\$2,334,048**

Principal Investigator: **Michael F. Morea, CPDN**

Project Manager: **Jerry F. Casteel, Bartlesville Project Office**

Reporting Period: **April 1, 1997 - June 30, 1997**

**RECEIVED**

**OCT 02 1997**

**OST**

**Objective**

The primary objective of this research is to conduct advanced reservoir characterization and modeling studies in the Antelope Shale reservoir. Characterization studies will be used to determine the technical feasibility of implementing a CO<sub>2</sub> enhanced oil recovery project in the Antelope Shale in Buena Vista Hills Field. The Buena Vista Hills pilot CO<sub>2</sub> project will demonstrate the economic viability and widespread applicability of CO<sub>2</sub> flooding in fractured siliceous shale reservoirs of the San Joaquin Valley. The research consists of four primary work processes: Reservoir Matrix and Fluid Characterization; Fracture Characterization; Reservoir Modeling and Simulation; and CO<sub>2</sub> Pilot Flood and Evaluation. Work done in these areas is subdivided into two phases or budget periods. The first phase of the project will focus on the application of a variety of advanced reservoir characterization techniques to determine the production characteristics of the Antelope Shale reservoir. Reservoir models based on the results of the characterization work will be used to evaluate how the reservoir will respond to secondary recovery and EOR processes. The second phase of the project will include the implementation and evaluation of an advanced enhanced oil recovery (EOR) pilot in the United Anticline (West Dome) of the Buena Vista Hills Field.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

**MASTER**

### **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

# **DISCLAIMER**

**Portions of this document may be illegible  
in electronic image products. Images are  
produced from the best available original  
document.**

## **Summary of Technical Progress**

Outlined below is a status report on the tasks that were performed during the 2nd quarter of 1997.

### **Task A. Characterize the Brown Shale and Antelope Shale**

#### **Task A.1. Collect and Analyze Data from Existing Wells**

##### **Task A.1.B. Carbon Oxygen Logging**

A Carbon/Oxygen log was run in the 653Z well on May 16, 1997 for the purpose of measuring oil saturation. Two logging passes of the Schlumberger Reservoir Saturation Tool (RST) were run at a speed of 170 ft/hr to ensure a repeatability of five saturation units (87% certainty level). Schlumberger is currently processing the data for oil saturation.

We attempted to run the log to TD (4907 ft MD), but repeatedly encountered an obstruction at 4700 ft MD. Therefore the C/O data was acquired from 3700 ft to 4700 ft. The well will be cleaned out to TD the next time a rig is set on it.

#### **Task A.3. Perform Core Analysis**

##### **Task A.3.A. Wettability Testing - Laboratory**

All samples except those from depths of 4288.2 and 4414.3 feet have been miscibly cleaned and saturated with formation brine at Core Laboratories, Bakersfield. Samples from depths of 3989.2, 4315.6 and 4355.95 feet have undergone the forced oil, spontaneous water and forced water drainage processes. Anticipated time of completion of all testing on these samples is late July 1997. The remaining samples, including 4288.2 and 4414.3 are deemed too tight for analysis.

##### **Task A.3.E. Core Description**

The core has been described and subdivided into seven lithologies by Karen De Louraille (Chevron Petroleum Technology Co.). Out of 952 feet of continuous core there is only a total of 55 feet of sand (5% of cored interval). However there are 748 beds of sand in the core with an average bed thickness of 0.073 feet. Except for a 1 foot sand bed in the Brown Shale, all the sand is from the cored interval of the upper Antelope Shale.

##### **Task A.3.G. Extracted Oil Geochemical Fingerprinting**

Work is in progress at Chevron Petroleum Technology Co. on the 25 core plug samples for oil extraction, along with produced oil samples from nearby wells. Comparing the extracted oil samples with the produced oils will help identify what zones in the Antelope Shale are contributing to oil production.

##### **Task A.3.H. Mineralogical Analysis**

The preliminary work for the Buena Vista Hills siliceous shale mineral-model has been completed. The mineral model is being built to enhance estimates of porosity, oil saturation, lithology, permeability, etc. from log data. Three 80-foot intervals of core were selected for analysis on the basis of log signature and core photos. A thin continuous slab was cut from each interval and cut into approximately 1-foot segments. Each core segment was crushed and divided with a riffle splitter to obtain subsamples of the desired weight. A subsample from each segment has been extracted and the matrix density has been measured

after extraction. Chemical analysis for major elements and key trace elements (Th, U, B, and Gd) for each extracted subsample will begin approximately July 28, 1997. Slabbing, extraction, and determination of matrix density was conducted by Core Laboratories, Bakersfield. Core Laboratories expects to complete their chemical analysis (Mineralog®) portion of this task in August, 1997. The Chevron Petroleum Technology Co. chemical analysis (ESTMIN) portion of this task is expected to be completed in the fourth quarter of this year.

#### **Task A.3.J. NMR Scan of Core Plug**

The first phase of the nuclear magnetic resonance (NMR) measurements has been completed together with all liquid permeability measurements. NMR data will be reported upon completion of the phase II NMR measurements. NMR measurements are to be performed before and after fluid extraction from the specific permeability core plugs in order to compare NMR log and core responses and create a log-core transform. Core Laboratories, Bakersfield estimates completion of this task by July 31, 1997.

#### **Task A.3.K. Rock Mechanics Analysis**

Rock mechanics analyses (compressibility, Poisson's ratio, and Young's modulus) needed for fracture modeling are underway at Core Laboratories, Dallas on 22 selected samples. Anticipated completion of this task is early August, 1997.

#### **Task A.3.L. Specific Gas, Oil and Water Permeability**

Analyses have been completed by Core Laboratories, Bakersfield. The results show 7 sand core plugs to have liquid permeabilities ranging from 0.004 to 75.2 millidarcies (hydrostatic test method). The 8 siliceous shale core plugs show ranges from 1.64 to 6.74 microdarcies (liquid pulse decay test method).

#### **Task A.3.O. Core Imaging**

Digital core image analysis for quantifying lithology types and net pay intervals is almost complete. Mike Morea visited Core Laboratories, Houston to assist in quantifying lithology types. Estimated completion of this task is August 31, 1997.

### **Task A.4. Fracture Characterization**

#### **Task A.4.B. Crosswell Seismic**

TomoSeis has completed processing crosswell data from 4 surveys acquired in late February and early March in the pilot area. Two of the profiles are oriented roughly parallel to strike while the other two are roughly parallel to the dip. Both reflection and velocity images were obtained from each of four crosswell surveys. We believe the crosswell reflection images are the first to be obtained in any oil field in the San Joaquin Valley.

The following observations have been made from the crosswell products by Bob Langan (Chevron Petroleum Technology Co.):

- 1). The general structure and dip of data within the four profiles is consistent with the known geologic structure.

2). The upper Brown Shale is seismically "opaque" in all of the reflection images while the lower Brown Shale and upper Antelope Shale have a considerable number of reflection events. The velocity tomograms tend to support this observation. The velocity contrasts are more numerous and greater in magnitude in the lower Brown Shale and upper Antelope Shale than in the upper Brown Shale.

3). The characteristic wavelengths of the reflection events in all 4 images is on the order of 20 ft.

4). Two of the profiles have systematic disruptions in the reflection continuity which may be interpreted as near-vertical fracture or fault zones. These fracture zones were not previously known to exist within the pilot area. It is possible that the fracture zones are correlative in which case they represent a single east-west trending fracture zone that crosses the pilot area.

5). The velocity and reflection images display poor ties at the wells. This can be attributed to three factors: (a) the crude treatment of deviated wells in the imaging, (b) P-wave anisotropy which has been ignored, and (c) the poor angular coverage in the crosswell data, which limits the lateral velocity resolution.

6). In portions of two of the profiles, the distance between source and receivers grew large enough that the signal-to-noise ratio fell to near zero. In these regions, reflection imaging is not possible.

TomoSeis is presently working on software modifications that will address the 3-D problem with deviated wells. Currently, their software requires that during the processing of both velocity images (tomograms) and reflection images that involve deviated wells, the images must first be projected onto a 2-D imaging plane, and then straightened to the vertical. Since all 4 profiles at Buena Vista Hills were shot with the source in a vertical well and the receivers in a deviated well (the 653Z well dips at about a 16 degree angle to the vertical), all 4 profiles suffer at least some degradation in quality due to the required projections. Plans call for reprocessing the Buena Vista Hills crosswell data once TomoSeis completes their software modifications.

TomoSeis and Chevron Petroleum Technology Co. are presently devising a strategy to deal with anisotropy. The effect, though, can be seen in the Buena Vista Hills data upon comparison of crosswell velocities from the 4 profiles with sonic log velocities from 653Z: the crosswell velocities are roughly 7 to 11 percent faster. This discrepancy has been observed in most other crosswell surveys in clastic rocks and may be attributable to velocity anisotropy (vertical vs. horizontal). Crosswell survey raypaths travel at small angles (0 to 35 degrees) relative to the horizontal and therefore are largely effected by horizontal velocities. In contrast, sonic log velocities are derived from near-vertical travel-time measurements. Since crosswell seismic raypaths contain varying degrees of horizontal and vertical components they will be variably effected by anisotropy. Undoubtedly, correcting for this effect would improve data quality at Buena Vista Hills. However, it isn't clear at the present time when TomoSeis will have the software modifications in place to apply such corrections.

#### **Task A.4.K. Attenuation Imaging**

Jerry M. Harris (Stanford University) has received the crosswell data from TomoSeis and has picked direct arrivals in all 4 profiles (~45,000 traces total). He also has set up the 3D geometry for joint tomographic travelttime inversion of the data and for obtaining attenuation images. The joint travelttime inversion is a way of obtaining a quasi 3-D velocity model from the crosswell data and is an important step in assessing the need to process the data using 3D methods. Preliminary observations indicate that the effect of the deviation in 653Z is quite significant suggesting that the 3D method will be necessary. The attenuation images will hopefully identify "soft", or highly attenuative areas that are associated with fracturing. The first results should be ready by the end of August, 1997.

#### **Task A.4.D. High Resolution Structural Mapping**

During the 2nd quarter, the task of log correlating in the Brown Shale and Antelope Shale using StratWorks was completed. A total of 7 Brown Shale and 15 Antelope Shale geologic markers were correlated and a list of observed fault cuts was tabulated. Preliminary grids for 16 of the horizons have been generated using Z-Map+. Final grids will be constructed once the fault interpretations are completed.

#### **Task A.4.E. Core Fracture Analysis**

In the past three months, Atilla Aydin and Judson Jacobs (Stanford University) have been studying the characterization and formation of en echelon fracture arrays in the 952 feet of core from the 653Z-26B well. Preliminary conclusions from their study are: (1) the echelon fractures filled by fine grained material are tectonic in origin, and (2) they appear to have higher permeability than the matrix rock. Further details are discussed below.

The Brown Shale member of the Monterey Formation, as observed in core and outcrops, reveals a number of systematic fractures. These fractures occur as en echelon sigmoidal-shaped features within clearly defined zones. This distinct form is characterized by opening-mode fractures with regular spacing. In previous studies, these features were attributed to "slope instability" and "dewatering". Based on their geometrical properties, lithology controlled formation and a knowledge of the structural processes which have occurred in the Monterey, an alternate method of formation is proposed. This mechanism is based on bed-parallel shear deformation which was demonstrated to occur within the Monterey Formation.

The 653Z-26B well, located on the northwestern edge of the Buena Vista Hills Field, was continuously cored from 3955 ft to 4907 ft. Stanford's fracture study is focused on the Brown Shale from 3990 ft to 4200 ft. The Brown Shale at this location is composed of a spectrum of siliceous rocks: siliceous shales and more detrital-rich brown shales predominate, but there are occurrences of thin porcelanite beds. Due to the high temperatures related to depth of burial, all silica components of the core sample have undergone complete diagenesis to Opal-CT phase silica.

The fractures contained within an individual zone have distinct characteristics. Fracture spacing and height are consistent for an en echelon array. Spacing varies from 0.2 mm to

1.0 cm with some divergence, while fracture height ranges from 2 to 5 cm and is remarkably uniform for a given zone. All fractures have opened to some extent and are filled with a fine-grained dark brown clay-rich material. Opening dilation ranges from minimal to 3 mm. There is also evidence for rotation of beds within deformed zones. Though the beds containing the fractures are generally homogeneous throughout, some do contain thin layers of alternating lithologies which have been offset by the fractures. The disrupted layers have often rotated in a systematic manner relative to one another and to the boundary of the shear zone.

It is apparent that there are multiple processes by which en echelon arrays of fractures can form. Development due to a shear couple seems to be the most appropriate mechanism for the fractures observed in the Brown Shale. There is abundant evidence of bed-parallel shear deformation in the Monterey Formation. In addition, there are many bedding surfaces with slickensides in the Buena Vista Hills core, which show evidence of shearing. The observation that all fracture tips have similar orientations indicates a common sense of shear along the entire core interval. The consistent fracture strikes throughout the section of oriented core support the notion that a more or less uniformly oriented shear stress acted across all the beds with fracture arrays. It is difficult to determine the orientation the direction of movement in all cases, nonetheless, bed-parallel shear is established as a common occurrence in the Monterey Formation.

Initial mini-permeameter studies indicate that the filled fractures enhance the ability of the Brown Shale to transmit fluids. There is some question as to whether these permeability tests reflect the values which are found in the subsurface. The core samples were eight months out of the ground when the tests were performed and have dried completely. It is thought that parting had possibly occurred along the pre-existing fractures. No evidence for this parting is present in the core and most likely would be accompanied by unusually high results. Further observations that support the concept of fracture-enhanced permeability are core black-light photographs, which are used to indicate the presence of hydrocarbons. The zones which contain the en echelon arrays are routinely shown to contain hydrocarbons in these photographs, whereas the more detrital-rich shales do not. As the permeabilities of the siliceous and detrital-rich shale layers are approximately the same, it is possible that the fractures are responsible for the increased transmissivity of hydrocarbons in the en echelon fracture zones.

Further study by Atilla Aydin and Jud Jacobs will try to verify both the method of deformation observed in the samples, as well as to more accurately determine the effect that the clay-filled sigmoidal fractures have on the permeability structure of the formation.

It should be mentioned that the preliminary conclusions discussed above, particularly relating to how and when the fractures developed and whether the fractures enhance permeability, are not shared by all participants working on this project. An alternative view is that the fractures formed early on in the sediment's history as a result of dewatering and downslope sediment creep (bed-parallel shearing), and that the clay-filled fractures act as permeability barriers. Additional core work hopefully will clarify the origin of the fractures and their effects on permeability.



#### **Task A.4.F. Core Microfracture Analysis**

Twelve core plugs were sent to TerraTek for confocal microscopy analysis. This study is designed to determine presence of microfractures and micropermeability. Work is in progress.

#### **Task A.4.H. Regional Tectonic Synthesis**

Advanced Resources International (ARI) continues their work on the regional tectonic synthesis of the southern San Joaquin basin. Specifically, the study area extends from the South Dome of Kettleman Hills, southeastward to the Maricopa-Wheeler Ridge-Tehachapi Mountains-Garlock Fault area, and includes the Buena Vista Hills, Elk Hills, and the other surrounding major oil-producing structures of western Kern County, California. The "Regional Tectonic Synthesis" is a two-part effort. Part I, "Synopsis of Previous Investigations," was completed earlier this year. Part II, "Structural Analysis and Natural Fracture Characterization," should be completed by the end of August, 1997.

During the second quarter, ARI completed the structural analyses of the satellite and aircraft image data. These data sets include multispectral Landsat Thematic Mapper (TM) imagery and high-resolution ATLAS imagery over the Buena Vista Hills. The image analysis involved the structural and tectonic interpretation of linear geomorphic features mapped from the TM and ATLAS image data. An important part of the interpretation of these mapped features includes their local and regional alignments within the study area.

Although the structural interpretation and tectonic synthesis is ongoing, ARI presents two preliminary findings. First, straight drainage features tend to be aligned and form regional geomorphic features oriented roughly NE and perpendicular to the folds in the study area. These features may represent fracture zones developed nearly parallel to the direction of greatest principal crustal stress in the region. Second, most of the straight escarpments (scarps) form NW-oriented alignments which parallel or sub-parallel the strike of the San Andreas Fault, and may represent the active fault systems in the region.

Many of the regional NW-trending alignments of straight topographic scarps are curvilinear, rotating counterclockwise in orientation from NW near the San Andreas Fault to WNW at their eastern terminations. These alignments appear to be bounded by the NE-trending alignments. It appears that the NE-trending alignments also intersect the axes of most of the NW-trending oil-producing folds. The intersections of NW-oriented regional alignments (including fold axes) and the NE regional curvilinear features, appears to compartmentalize the major oil-producing anticlines. More detailed local investigations would reveal additional information regarding fracturing within the structural compartments. The density of fractures mapped within each compartment may or may not be an important indicator of future petroleum production in the compartment. However, the presence and preferred orientations of two or more intersecting fracture trends within one mapped compartment would be important, and could be compared to the characteristics of numerous existing wells spread across the southern San Joaquin Basin.

Structural mapping with the high-resolution (5 meter pixel size) ATLAS airborne image

data is revealing much greater fracture detail than apparent in the medium-resolution (30 meter pixel size) Landsat TM satellite imagery. In general, three pervasive fracture trends appear on the ATLAS mosaic: N, NE, and NW to NNW. Local variation in the relative density and distribution of these fractures may define structural compartments that correspond with results from the Landsat TM imagery.

The final phases of the structural interpretation are underway and include the integration of isostatic gravity anomaly data obtained from the USGS, and a comparison of the features mapped from the TM data at 1:100,000 scale to features mapped from the ATLAS data at 1:50,000 scale. The gravity data should help further define and emphasize regional structures that may define structural compartments. The different resolutions of the image data sets will provide information regarding the effects of scale on structural photointerpretation. The remaining work will focus on the quality of fracture, geological, and regional structural mapping using the two different data sets, and will address the concerns of identifying local fracture networks within a regional structural framework.

#### **Task A.4.J. Acoustic Anisotropy**

Five oriented core samples from the 653Z well were selected and analyzed for acoustic anisotropy at Core Laboratories, Bakersfield. The results show that there is a 54 degree clockwise rotation of maximum horizontal stress from N30W at 4565 ft (upper Antelope Shale) to N24E at 4031 ft (Brown Shale). However results from other fracture characterization and orientation tasks in this project show varied results. The formation micro imager log indicated a fracture strike of N45-50E based on limited fractures in the core. The dipole sonic log showed a fast shear wave azimuth of N60W. Anelastic strain recovery showed a maximum principal stress of N40E and the shear wave birefringence VSP implied that the rocks are isotropic. In addition, the crosswell seismic, microfracture analysis, and core fracture studies are not completed at this time. Further analysis of the data will be required to understand the differences in the results of the various methodologies.

#### **Task A.7. Develop 3D Earth Model**

##### **Task A.7.B. Geostatistically Populate Model**

Efforts to assess correlations between open-hole logs and core data were completed during the second quarter. Since more than 95% of the wells in the Buena Vista Hills Field have limited open-hole log data (usually 1950's to 1960's vintage electric logs with spontaneous potential (SP) only), most of the effort focused on correlating SP to either permeability or porosity. Although we were unsuccessful in our attempts to establish a correlation between SP and permeability, a porosity transform using SP log data (with 0.65 correlation coefficient) was successfully derived. This transform was subsequently applied to all wells in the field with SP logs. Dale Beeson (Chevron Petroleum Technology Co.) has begun to generate facies volume realizations in FaciesFinder (Chevron application) using this new porosity transform. The FaciesFinder application relates reservoir property data (transformed porosity in this case) to "facies" based on log pattern recognition. Initial results are too preliminary for any confident conclusions, but do suggest that porosity-related trends will be relatively subtle.

A spreadsheet that tabulates information from descriptions of whole core taken in the Brown Shale and Antelope Shale was also completed this quarter. These cores were cut in the 1950's and 1960's and most have subsequently been destroyed. The spreadsheet captures details regarding the occurrence of sandstone, siltstone, and siliceous shale (based on original core descriptions) and also notes where fractures were observed. Dale Beeson is presently using this information to generate a neural-net transform of log data to lithofacies. If successful, this transform will be used to characterize spatial variations in lithology. The data captured in the spreadsheet will also be used to better constrain the distribution of fractures and possibly oil saturations in the geologic model.

Chuck Magnani (Chevron Petroleum Technology Co.) has been reviewing old DST data from Buena Vista Hills to determine its utility for estimating permeability in the Brown Shale and Antelope Shale. The data set consisted of more than 400 DST's, though it was determined early on that the majority were of too short a duration to provide useful information about formation permeability. Chuck is presently completing his analysis of the DST data and should be issuing a summary during the third quarter.

#### **Task A.7.C. Visualize Reservoir Property Distribution**

Dale Beeson and Dale Julander obtained Chevron GOCAD++/G2 training in May. The G2 geostatistical functionality and GOCAD visualization environment will be used simultaneously with Stratamodel where it adds value in a complementary fashion. Sixteen structure surfaces (TMC down to P2) gridded in Z-Map+ by Dale Julander were quality controlled in GOCAD for conformity.

### **Task B. Preliminary Preparation for CO2 Injection**

#### **Task B.1. Re-evaluate Pre-1994 Production Performance**

##### **Task B.1.C. Analyze Recovery, Pressure and Saturation Data**

A *Production Analyst* (PA) database was created for the Buena Vista Hills Field for all Antelope Shale wells. This PA software program allows historical oil, water, and gas production and injection data to be analyzed to better understand the mechanisms at work in producing this asset. A bubble map of cumulative production and a production rate vs. time plot for every well in the field was generated using this database. This data will also be useful for input into a reservoir simulation model during the history matching phase of the study.

In addition, a reservoir study is underway in which original oil-in-place (OOIP) will be calculated by three independent methods: material balance, decline curve analysis, and volumetric calculation.

#### **Task B.2. Initiate Fluid Characterization and Lab Displacement Tests**

##### **Task B.2.B. Perform CO2 Corefloods at Reservoir Conditions**

The protocol for special core analysis and the selection of samples for testing has been completed. Considering the available core material and our current understanding of the fine layering, the CO2 diffusion related tests have been modified for the "mixed lithology" samples. The original proposal included tests on samples that contained adjacent cycles of sand and siliceous shale layers ("mixed lithology"). However, the difficulty of plugging

usable samples that contain both siliceous shale and sand layers required a modification in our procedure. The mixed lithology test will now be conducted on a whole core where the slabbed portion is replaced by a Berea sand to represent fast flow paths in the reservoir. The recovery mechanism investigated in this test will be mass transfer caused by the diffusion of CO<sub>2</sub> from fast to slow paths. We think this test will be qualitatively representative of any potential mass transfer mechanisms between the high and low permeability layers in the reservoir. Protocols for the other tests are as envisioned originally. Core preparation and core holder construction are in progress.

#### **Task B.2.C. Perform Water Injection and Imbibition Studies**

All samples have been miscibly cleaned and saturated with synthetic brine. In addition, gas-oil relative permeability and the subsequent re-saturation with test oil have been completed on all samples except depths 4512.35 and 4518.55 feet, which are deemed too tight for analysis. This portion of the task is estimated to be completed by July, 1997.

#### **Task D. Technology Transfer**

##### **Publications:**

Aydin, A., 1997, Fault Control on Hydrocarbon Migration and Fluid Flow in Neogene Basins and Related Reservoirs of Central and Coastal California, USA: An Overview. In, Pollard, D. D. and Aydin, A. eds., Proceedings of the Rock Fracture Project Workshop, Volume VIII, p. A-1 to A-7, Stanford University, Stanford, California.

Jacobs, J. L., 1997, Characterization and Formation of En Echelon Fracture Arrays in the Monterey Formation, California. In, Pollard, D. D. and Aydin, A. eds., Proceedings of the Rock Fracture Project Workshop, Volume VIII, p. P-D-1 to P-D-11, Stanford University, Stanford, California.

##### **Oral Presentations:**

Oral presentations were given at the May, 1997 Pacific Section AAPG/SEPM Convention in Bakersfield, CA. The session titled "Reservoir Characterization and Improving Recovery in Monterey-type Siliceous Shales" was chaired by Bruce Bilodeau and Steve Smith of Chevron. Speakers and titles are given below.

Bilodeau, B. J., S. C. Smith, and D. R. Julander, Comprehensive Reservoir Characterization Using Open-Hole Wireline Logs, Core, and Downhole Video, Buena Vista Hills Field, California.

Britton, A.W., J. L. Smith, and D. Chapman, Continuous Permeability and Porosity Determinations in the Chevron 653Z-26B Well, Buena Vista Field, Kern County, CA.

Carpenter, A. B., and T. S. Moore, Origin of Boron-Rich Pore Water in the Monterey Formation, San Joaquin Valley, CA.

Decker, D. And B. J. Bilodeau, Antrim Shale Resource and Reservoir Characterization as an Analog for Diffusion Controlled Gas Production from the Monterey Formation.

**Dholakia, S. K., A. Aydin, D. D. Pollard, M. D. Zoback, C. Barton, and B. J. Bilodeau, Integration of Surface Geology and Borehole Geophysics for Reservoir Characterization in the Monterey Siliceous Shales for the Purpose of Facilitating Improved Recovery Designs.**

**Fargo, D., Advanced Coring and Wellsite Handling Add Pizazz to Buena Vista Hills Core!**

**Kuuskraa, V., Incorporating Reservoir Characterization into Optimized Production of Siliceous Shales and Other Gas Bearing Shales.**

**Short Course:**

**Morea, M. F., T. A. Zalan, and J. L. Jacobs, 1997, Buena Vista Hills Reservoir Characterization Study, Chevron/DOE Class III Reservoir Project. In, Advances in Reservoir Description Techniques, as Applied to California Oil and Gas Fields, 1997 Pacific Section AAPG/SEPM Convention, Bakersfield, CA.**

**DOE Program Review Meeting:**

**Morea, M. F., Advanced Reservoir Characterization in the Antelope Shale to Establish the Viability of CO<sub>2</sub> Enhanced Oil Recovery in California's Monterey Formation Siliceous Shales, Oil Technology and Gas Environmental Program Review Meeting in Houston, TX, June, 1997.**