HYDROCARBON SOURCE ROCK EVALUATION OF,
AUSTRA TEX NO. 1 EXXON MINERAL,
SEC. 23, T12N, R4W, CIBOLA COUNTY, NEW MEXICO

By G. S. Bayliss and R. R. Schwarzer

December 1987
NEW MEXICO HYDROCARBON SOURCE
ROCK EVALUATION PROJECT

AUSTRALIA TEX NO. 1 EXXON MINERAL
SEC. 23, T12N, R4W, CIBOLA CO., NEW MEXICO
API NO. 30-006-20007
NORTHWEST AREA
GEOCHEM JOB NO. 3601

Prepared
for
PROGRAM PARTICIPANTS

by

Dr. Geoffrey S. Bayliss
and
Dr. Rudy R. Schwarzer

GEOCHEM LABORATORIES, INC.
1143-C BRITTMORE ROAD
HOUSTON, TEXAS 77043
(713) 467-7011

CONFIDENTIAL
DECEMBER 1987
CORRECTED COPY
<table>
<thead>
<tr>
<th>GEOCHEM SAMPLE NUMBER</th>
<th>SAMPLE DEPTH</th>
<th>STRATIGRAPHIC INTERVAL</th>
<th>ANALYSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>San Andres</td>
<td>X</td>
</tr>
<tr>
<td>3601-002</td>
<td>3420-3440</td>
<td>Yeso</td>
<td>X</td>
</tr>
</tbody>
</table>

**NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION**

**WELL NAME:** AUSTRA TEX NO.1 EXXON MINERAL  
**API NO.:** 30-006-20007  
**AREA:** NORTHWEST  
**LOCATION:** CIBOLA COUNTY, NEW MEXICO  
**GEOCHEM JOB NO.:** 3601  
**TOTAL DEPTH:** 5723 ft.  
**INTERVAL SAMPLED:** 3170-3440 ft.  
**TOTAL NUMBER OF SAMPLES:** 2
# TABLE I

## RESULTS OF TOTAL ORGANIC CARBON

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

AUSTRA TEX NO.1 EXXON MINERAL
SEC.23, T12N, R4W, CIROLA COUNTY, NEW MEXICO
API NO. 30-006-20007

<table>
<thead>
<tr>
<th>GEOCHEM SAMPLE NUMBER</th>
<th>DEPTH INTERVAL (feet)</th>
<th>TOTAL ORGANIC * CARBON (% of Rock)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>0.18</td>
</tr>
<tr>
<td>3601-002</td>
<td>3420-3440</td>
<td>0.21/0.20</td>
</tr>
</tbody>
</table>

* SEE APPENDIX AT REAR OF REPORT
**TABLE II**

LITHOLOGICAL DESCRIPTIONS AND ORGANIC CARBON ANALYSES

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

AUSTRA TEX NO.1 EXXON MINERAL

SEC. 23, T12N, R4W, CIBOLA COUNTY, NEW MEXICO

API NO. 30-006-20007

<table>
<thead>
<tr>
<th>GEOCHEM SAMPLE NUMBER</th>
<th>DEPTH INTERVAL (feet)</th>
<th>LITHO DESCRIPTION</th>
<th>GSA CARBON NO.</th>
<th>ORGANIC *</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>40% Dolomite, fine crystalline, pale yellowish brown.</td>
<td>10YR-6/2</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60% Mudstone, calcareous, pale reddish brown to grayish red.</td>
<td>10R-5/4 to 10R-4/2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAVED Trace white sandstone (Glorieta type) and gray mudstone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3594-002</td>
<td>3420-3440</td>
<td>25% Dolomite, fine crystalline, moderate yellowish brown to dusky yellowish brown.</td>
<td>10YR-5/4 to 10YR-2/2</td>
<td>0.21/0.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% Mudstone, calcareous, medium gray.</td>
<td>N6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>70% Mudstone, calcareous, pale reddish brown to grayish red.</td>
<td>10R-5/4 to 10R-4/2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAVED (poor sample)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* SEE APPENDIX AT REAR OF REPORT
### TABLE III

**SUMMARY OF ORGANIC CARBON AND VISUAL KEROGEN DATA**

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

AUSTRA TEX NO.1 EXXON MINERAL
SEC.23, T12N, R4W, CIBOLA COUNTY, NEW MEXICO
API NO. 30-006-20007

<table>
<thead>
<tr>
<th>GEOCHEM SAMPLE NUMBER</th>
<th>DEPTH INTERVAL (feet)</th>
<th>TOTAL ORGANIC CARBON</th>
<th>ORGANIC MATTER TYPE</th>
<th>VISUAL ABUNDANCE NORMALIZED PERCENT</th>
<th>ALTERATION STAGE</th>
<th>THERMAL ALTERATION INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>0.18</td>
<td>H;I;Am-W</td>
<td>0 12 50 12 26</td>
<td>2- to 2</td>
<td>2.0</td>
</tr>
<tr>
<td>3601-002</td>
<td>3429-3440</td>
<td>0.21/0.20</td>
<td>H*;Am;I</td>
<td>0 38 50 0 12</td>
<td>2</td>
<td>2.2</td>
</tr>
</tbody>
</table>

**LEGEND:**

**KEROGEN KEY**

Predominant: Secondary: Trace

60-100% 20-40% 0-20%

- Al = Algal
- Am = Amorphous-Sapropel
- Am** = Relic Amorphous-Sapropel
- H = Herbaceous-Spore/Pollen
- H* = Degraded Herbaceous
- W = Woody-Structured
- U = Unidentified Material
- I = Inertinite
- C = Coaly
### TABLE IV
RESULTS OF ROCK-EVAL PYROLYSIS ANALYSIS *
NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

AUSTRA TEX NO.1 EXXON MINERAL
SEC.23, T12N, R4W, CIBOLA COUNTY, NEW MEXICO
API NO. 30-006-20007

<table>
<thead>
<tr>
<th>GEOCHEM. SAMPLE NUMBER</th>
<th>DEPTH INTERVAL (Feet)</th>
<th>TMAX (°C)</th>
<th>S1 (mg/g)</th>
<th>S2 (mg/g)</th>
<th>S3 (mg/g)</th>
<th>PI</th>
<th>PC*</th>
<th>T.O.C. (wt.%)</th>
<th>HYDROGEN INDEX</th>
<th>OXYGEN INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>383</td>
<td>0.05</td>
<td>0.10</td>
<td>0.61</td>
<td>0.36</td>
<td>0.01</td>
<td>0.18</td>
<td>55</td>
<td>338</td>
</tr>
<tr>
<td>3601-002</td>
<td>3420-3440</td>
<td>406</td>
<td>0.06</td>
<td>0.13</td>
<td>0.23</td>
<td>0.33</td>
<td>0.01</td>
<td>0.21</td>
<td>61</td>
<td>109</td>
</tr>
</tbody>
</table>

T.O.C. = Total organic carbon, wt.%
S1 = Free hydrocarbons, mg Hc/g of rock
S2 = Residual hydrocarbon potential (mg HC/g of rock)
S3 = CO2 produced from kerogen pyrolysis (mg CO2/g of rock)
PC* = 0.083 (S1 + S2)
Hydrogen Index = mg HC/g organic carbon
Oxygen Index = mg CO2/g organic carbon

* SEE APPENDIX AT REAR OF REPORT
### TABLE V

**VISUAL KEROGEN ASSESSMENT WORKSHEET**

**AUSTRA-TEX NO. 1 EXXON MINERAL**  
SEC. 23, T32N, R4W  
CISCOLA COUNTY, NEW MEXICO  
T.D. 5723'  
API 730-906-29007

<table>
<thead>
<tr>
<th>GEOCHEM NO.</th>
<th>DEPTH</th>
<th>INDIGENOUS POPULATION (INTERPRETED)</th>
<th>GENERAL CHARACTERISTICS</th>
<th>CAVED AND/OR REWORKED POPULATION(S)</th>
<th>SUMMARY ORGANIC MATTER TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1601-001</td>
<td>1170-3231</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1601-002</td>
<td>2420-2460</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**REMARKS:**  
Mud Additive: N1 Am-W  
Hw: Am-I
APPENDIX

*NOTE: These samples were mixtures of caved red mudstones and indigenous material. The picking of an indigenous sample was impractical so the sample was analyzed without picking. An "Adjusted TOC" value for indigenous material was calculated as follows:

\[
(F_I)(TOC_I) + (F_C)(TOC_C) = (1)(TOC_T)
\]

\[
TOC_I = \frac{TOC_T - (F_C)(TOC_C)}{F_I}
\]

Where $F_I$ = fraction of indigenous sample

$F_C$ = fraction of CAVED material

$TOC_I$ = TOC of indigenous sample

$TOC_C$ = TOC of CAVED material

$TOC_T$ = TOC of Total sample

The data are presented in Appendix A.

In like manner, adjusted values have been computed for the Rock-Eval data. These are shown in Appendix B.

No adjustments were needed for the visual kerogen data since the red beds do not contain any kerogen of any significance.
## APPENDIX A

### ORGANIC CARBON VALUES CORRECTED FOR CAVED MATERIAL

<table>
<thead>
<tr>
<th>GEOCHEM SAMPLE NUMBER</th>
<th>DEPTH INTERVAL (feet)</th>
<th>TOTAL ORGANIC CARBON (% of Rock)</th>
<th>BRIEF LITHOLOGIC DESCRIPTION</th>
<th>ADJUSTED TOC* Value allowing for non-separated caved material</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>0.18</td>
<td>40 Dol, 60 Red Mdat</td>
<td>0.21</td>
</tr>
<tr>
<td>3601-002</td>
<td>3420-3440</td>
<td>0.21/0.20</td>
<td>25 Dol, 5 Mdat, 70 Red Mdat</td>
<td>0.29</td>
</tr>
</tbody>
</table>

3601-003 Composite of caved red mudstone taken from both samples

0.16
APPENDIX B

ROCK-EVAL PYROLYSIS ANALYSIS CORRECTED FOR CAVED MATERIAL

NEW MEXICO HYDROCARBON SOURCE ROCK EVALUATION

AUSTRIA TEX NO.1 EXXON MINERAL
SEC.23, T12N, R4W, GIBOLA COUNTY, NEW MEXICO
API NO. 30-006-20007

<table>
<thead>
<tr>
<th>SAMPLE NUMBER</th>
<th>DEPTH INTERVAL (Feet)</th>
<th>TMAX (°c)</th>
<th>S1 (mg/g)</th>
<th>S2 (mg/g)</th>
<th>S3 (mg/g)</th>
<th>PI</th>
<th>FO</th>
<th>T.O.C. (wt.%)</th>
<th>HYDROGEN INDEX</th>
<th>OXYGEN INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>3601-001</td>
<td>3170-3231</td>
<td>383</td>
<td>0.06</td>
<td>0.12</td>
<td>0.71</td>
<td>0.33</td>
<td>0.01</td>
<td>0.21</td>
<td>55</td>
<td>338</td>
</tr>
<tr>
<td>3601-002</td>
<td>3420-3440</td>
<td>406</td>
<td>0.09</td>
<td>0.19</td>
<td>0.33</td>
<td>0.32</td>
<td>0.02</td>
<td>0.29</td>
<td>61</td>
<td>109</td>
</tr>
</tbody>
</table>

T.O.C. = Total organic carbon, wt.%
S1 = Free hydrocarbons, mg Hc/g of rock
S2 = Residual hydrocarbon potential (mg HC/g or rock)
S3 = CO2 produced from kerogen pyrolysis (mg CO2/g of rock)
FO = 0.083 (S1 + S2)
PI = S1/S1 + S2
TMAX = Temperature Index, degrees C.
**LEGEND FOR SUMMARY DIAGRAM**

**DEPTH:** in feet  
**LITHO LOG:** see lithology symbols  
**STRATIGRAPHY:** by age  
**% TOC:** percent total organic carbon  
**HI:** Rock-Eval, Hydrocarbon Index = 100 S2 (0/00 Wt)/TOC  
**OI:** Rock-Eval, Oxygen Index = 100 S3 (0/00 Wt)/TOC  
**HC YIELD:** Rock-Eval, S2 peak (ppm)  
**S2/S3:** Rock-Eval, Ratio of S2 to S3 peak  
**KEROGEN:** see Kerogen symbols  
**T-MAX:** Rock-Eval, maximum temperature of S2 peak, in degrees Centigrade  
**%RO (Δ):** Vitrinite Reflectance (scale 0 to 5)  
**TAI (**):** Thermal Alteration Index (scale 1 to 5)  
**FREE HC:** Rock-Eval, S1 peak (ppm)  
**PI:** Rock-Eval, Productivity Index = S1/(S1+S2)

### LITHOLOGIES

- **SHALE**
- **MUDSTONE**
- **SILTSTONE**
- **SANDSTONE**
- **CONGLOMERATE**
- **BRECCIA**
- **LIMESTONE**
- **DOLOMITE**
- **MARL**

### KEROGEN TYPES

- **AMORPHOUS**
- **HERBACEOUS**
- **WOODY**
- **INERTINITE**
- **MISSING SECTION**
APPENDIX A

Brief Description of Organic Geochemical analyses Carried Out by GeoChem

C₄-C₇ Hydrocarbon

The C₄-C₇ hydrocarbon content and composition of sediments reflects source type, source quality and thermal maturity. The C₄-C₇ hydrocarbon content of well cuttings is determined by analyzing both a sample of the cuttings and the air space at the top of the core. The results of the two analyses are summed to give an inventory of the C₄-C₇ hydrocarbon content of the well cuttings prior to any losses from the cuttings during the lapse time period between collection at the wellsite and laboratory analysis. The air space C₄-C₇ hydrocarbon analysis involves injecting a measured volume of the air space gas out of the can with a syringe and injecting same into a gas chromatograph. GeoChem uses a Varian Aerograph Model 1400 instrument equipped with a Porapak Q column. The gas sample is taken through the column by a carrier gas and before reaching the detector is separated into its various C₁ (methane), C₂ (ethane), C₃ (propane), C₄ (isobutane), nC₄ (normal butane), and C₅, C₆, C₇ hydrocarbon components. This particular analysis gives a complete separation of the C₁-C₂ gas-range hydrocarbons and a partial separation of the C₄-C₇ gasoline-range hydrocarbons. (A detailed C₁-C₇ analysis, to be discussed later, involving a capillary column, effects a complete separation of this molecular range into its several individual molecular species.) The electrical response of the various hydrocarbons as they reach the detector is recorded on a paper strip chart as a peak. This response is simultaneously led to an integrator which computes the area of each peak. The concentration of C₄-C₇ hydrocarbons in the air space, expressed as volumes of gas per million volumes of cuttings, is determined by a calculation involving the volume of cuttings, volume of air space in the can, volume of sample injected, volume of standard gas sample used in the calibration, calibration factor for C₁, C₂, C₃, C₄, etc. determined by gc analysis of a standard gas sample, and the gc peak response. The C₄-C₇ hydrocarbon content of the cuttings is determined by degasification of a measured volume of cuttings (in a medium of a measured volume of water) in a closed blender, sampling of the air space at the top of the blender, and injection of a measured volume of gas into the gas chromatograph. The C₄-C₇ hydrocarbon data from the air space and cuttings gas analyses are summed to give a "restored" C₁-C₇ hydrocarbon content of the cuttings.

Sample Washing and Hand-Picking of Uncored Lithology Samples

The cuttings samples are washed to remove all drilling mud from the cuttings. Care is taken in the washing procedure not to remove any soft clays, claystones, etc. and any loose fine sand and silt. The washed cuttings are usually kept under water over until picked, to prevent loss of any gasoline-range hydrocarbons. Using the C₄-C₇ hydrocarbon data profile and the electrical well log supplied to us and our visual examination of the cuttings material under the binocular microscope, we carefully hand-pick and describe a suite of uncored lithologies representative of the various stratigraphic zones penetrated by the well. The lithological data is used to compile a gross lithology log which is shown on all Figures. The 3-4 gram picked lithology samples are stored under water in small glass vials in those instances where we wish to run detailed C₄-C₇ hydrocarbon analyses. This sample set is not used only for the C₁-C₇ hydrocarbon analysis, but also for the visual kerogen and total organic carbon analyses. All remaining cuttings material is dried and packaged in labelled plastic bags for possible C₁₅₆ soxhlet extraction and/or eventual return to the client. Sample material from this study will be retained at GeoChem until advised of disposition.

Detailed C₄-C₇ Hydrocarbon

The C₄-C₇ gasoline-range hydrocarbon content of sediments reflects source quality, thermal maturation and organic facies. Compositional data can be used in crude oil-parent rock correlation work. The C₄-C₇ hydrocarbon content and detailed molecular composition of hydrocarbon, in hand-picked lithology, is determined by a gc analysis of the light hydrocarbon extracted from 1-2 gram cuttings samples macerated in a microblender. A measured volume of sample is placed in a sealed microblender along with a measured volume of hot water. The rock sample is pulsed by the blades of the blender. A sample of the liberated light hydrocarbons which collect in the air space at the top of the blender is injected into our Varian Aerograph 1400 gc unit which is equipped with a capillary column. Data recording, computations, etc. are comparable to those used for the C₁-C₇ analysis discussed previously in this report. Hydrocarbon concentration is expressed as volume gas per million volumes of cuttings.

Organic Carbon

The total organic carbon content of a rock is a measure of its total organic richness. This data is used, in conjunction with visual kerogen and C₁-C₄, C₅-C₇ and C₁₅₆, hydrocarbon content of a rock, to indicate the hydrocarbon source quality of rocks. The procedure for determining the total organic carbon content of a rock involves drying the sample, grinding to a powder, weighing out 0.5790 gram sample into a crucible, acidifying with hot and cold hydrochloric acid to remove calcium and magnesium carbonates, and carbon analysis by combustion in a Leco carbon analyzer. We run several blank crucibles, standards (from rings of known carbon content) and duplicate rock samples in this analysis at no additional charge to the client for purposes of data quality control.

C₁₅₆ Soxhlet Extraction, Desulfurization and Chromatographic Separation

The amount and composition of the organic matter which can be solvent-extracted from a rock reflects source quality and source type. C₁₅₆ carbon isotope, high mass spectrometric and go analyses of the paraffin-naphthalene and aromatic hydrocarbon fractions of the soluble extract gives data which is used in crude oil-parent rock correlations. This analysis involves grinding of a dry rock sample to a powder and removal of the soluble organic matter by soxhlet extraction using a co-distilled toluene-methanol mixture as solvent. Where the amount of available sample material permits, we like to use at least 100 grams of rock for this analysis.

The extracted bitumen is separated into an asphaltene (ASP) and a pentane soluble fraction by normal pentane precipitation. The pentane soluble components are separated into a C₁₅₆ paraffin-naphthalene (P-N) hydrocarbon, C₁₅₆ aromatic hydrocarbon (AROM) and C₁₅₆ nitrogen-sulfur-oxygen containing fraction (NSC) by adsorption chromatography on a silica gel-aluminum column using pentane, toluene and toluene-methanol extracts as solvents.
APPENDIX (continued)

**GC Analysis of C_{16+} Paraffin-Naphthene (P-N) Hydrocarbons**

The content and molecular composition of the heavy C_{16+} paraffin-naphthene (P-N) hydrocarbons of rocks, as determined by gc analysis, reflects source quality, source type and degree of thermal maturation.

In this analysis, we subject a very small fraction of the total amount of the P-N fraction extracted from a rock sample to gc analysis. The gas chromatograph is a Varian Aerograph Model 1400 equipped with a solid red injection system and a eucritic column.

The calculated C.P.I. (carbon preference index) values for the normal paraffin data is defined as the mean of two ratios which are determined by dividing the sum of concentrations of odd-carbon numbered n-paraffins by the sum of even-carbon numbered n-paraffins. The C.P. Indices A and B were obtained by the formulas:

\[
C.P. \text{ Index A} = \frac{C_{21} + C_{23} + C_{25} + C_{27}}{C_{22} + C_{24} + C_{26} + C_{28}} \quad \text{C.P. Index B} = \frac{C_{25} + C_{27} + C_{29} + C_{31}}{C_{26} + C_{28} + C_{30} + C_{32}}
\]

**Visual Kerogen**

A visual study of kerogen, the insahile organic matter in rocks, can include the relative abundance, size, and state of preservation of the various recognizable kerogen types and thereby indicate the hydrocarbon source character of a rock. The color of the kerogen can be used to indicate the state of thermal maturity of the sediments (i.e. their time-temperature history). Thermal maturation plays an important role in the generation of hydrocarbons from organic matter, and also affects the composition of reservoir hydrocarbons.

Our procedure for visual kerogen slide preparation involves isolation of the organic matter of a rock by removal of the rock material with hydrochloric and hydrofluoric acid treatment and heavy liquid separation. This procedure is comparable to that used by the palynologist except it does not include an oxidation stage. (The oxidation treatment is deleted from our procedure because it removes a great deal of kerogen and bleaches any remaining kerogen to an extent whereby it is useless for our kerogen color observations.) The kerogen residue is mounted on a glass slide and is examined visually under a high power microscope.

**Vitrinite Reflectance**

Measurement of the reflectivity of vitrinite particles (R_o) present in the kerogen isolated from sedimentary rocks provides a method of determining the state of maturation, and the diagenetic (time-temperature) history of the organic matter present in the sediments.

The kerogen, obtained from a 25 gram aliquot of crushed rock by the acid procedure previously discussed, is dried and embedded in a Bioplastig plug. The surface of the plug is polished using 0.05 micron alumina and the reflectivity determined under oil using a Zeiss high resolution microscope. A minimum of 40 values are required to adequately determine the Maturation Rank.

**Fluorescence Spectrophotometric Analysis**

Fluorescence spectrophotometry can be used to characterize and fingerprint crude oils, establish crude oil-source rock relationships, and to measure the hydrocarbon source potential of fine-grained sediments.

A one (1) micro克ler aliquot of either (a) a crude oil or (b) the solvent extractable rock bitumen is passed through an alumina/silica gel micro column and the C_{16+} aromatic hydrocarbons isolated. The aromatic hydrocarbon is diluted and the emission and excitation spectra determined at 240 nm and 420 nm using a Perkin-Elmer Model 512 Double Beam Fluorescence Spectrophotometer.

**Geothermal Diagenetic Criteria**

![Diagram of Geothermal Diagenetic Criteria (GeoChem Laboratories, Inc.)]