Final Report Of The

Shi'h Ehtah Thelaa

Slavey for "Cluster of Mountains"

Geophysical Operations of 1998.

Ellesmere 2-D program EL364

Chevron Canada Resources

Robert Taerum *PGEOPH*

18 June, 1999

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Operator: Chevron Canada Resources
Contractors: Veritas; MWH Geo-Surveys Ltd.
Operations: Gravity & Seismic
Location: 40 km NNW of Fort Liard
Date: June 8, 1998 – September 1, 1998
NEB Authorization Number: 9229-C4-12E

Abstract

Seismic and gravity data were recorded in the mountains of the Liard Plateau during the summer of 1998. The operations were centred about 40 kilometres north-northwest of Fort Liard over the Flett anticline and Liard syncline. The purpose of the survey was to delineate a prospective thrust sheet that had been tapped by the P-66 discovery. A total of three seismic/gravity lines were acquired (lines 44X_11713, 46X_11713 and 54X_11712). The program was named Ellesmere. These operations are in partial requirement of the Work Commitment for EL364.

Seismic Operations

Seismic reflection data was recorded to image the subsurface structure. The program was designed as a 2-D high fold program. The purpose of the 2-D was to image the subsurface sufficiently to map out a possible subsurface structure. The rugged terrain and sensitive ground cover necessitated a low impact Heli-portable system. The high fold was an attempt to improve the signal-to-noise ratio. Older seismic often failed to image these subsurface structures and it was felt that this was due to weak reflection signal. The following is a summary of the seismic acquisition and processing parameters.

Chevron Canada Resources Program Name: Ellesmere

Contracting Crew: Veritas

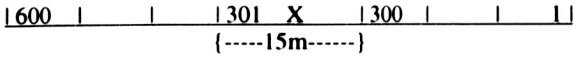
Acquisition Dates

- Start Survey: July 20, 1998
- Start Recording: August 22, 1998
- Finish Recording: September 1, 1998
- Length of Survey: 27.95 linear kilometres
- Average Acquisition Rate: 2.5 kilometres per day

Spread Parameters

- Number of Traces: 600
- Geophones per Group: 6
- Geophone spacing: 2.5 metres
- Shot Point Interval: 90 metres
- Group Interval: 15 metres
- Spread Geometry: Split Spread, Shot between groups
- Near Offset: 7.5 metres
- Far Offset: 4492.5 metres

Spread Diagram



Source Parameters

- Source: Dynamite
- Number of Holes: 1
- Hole Depth: 20 metres
- Charge Size: 20 kilograms
- Shot Point Location: Midway between Geophone Group
- Drilling Method: Heli-portable

Recording Equipment

- Recording System: I/O System Two
- Geophones: Geospace Model CT 10 Hz marsh phones

Surveying System

- Mix of Conventional and GPS survey techniques.
- Data collected in NAD83 and converted to NAD27.

Terrain

- Mountainous, Rugged, Variable
- Variable Ground Cover: Muskeg, Cliffs, Stunted Trees, Bush
- Isolated, Access by Helicopter and by foot.

Personnel

- 45 people on slashing, surveying and drilling
- 35 people on the seismic recording crew including 5 professional mountain climbers
- 4 people on 2 gravity crews

Weather

- Delays and work stoppages due to morning fog and afternoon winds

Processing Flow

Performed in-house on a ProMax platform

- Define Geometry
- Edit Dead, Noisy or Reverse Traces
- Compute Mutes
- Apply Emphasis Filter
- Pick First Breaks
- Apply Refraction Statics
- Set Final Datum Elevation = 1400m, Replacement Velocity = 4000m/s
- Processing Datum: Floating based on 51 point smoother
- True Amplitude Recovery 1/(time*velocity**)
- Surface Consistent Decon (Source, Receiver)
- Apply Residual Statics (Correlation Autostatics)
- Apply Residual Statics (Max. Power Autostatics)
- Apply Normal Moveout Correction
- Apply Time Variant Spectral Whitening
- Apply AGC 2000 ms.
- CDP Stack
- Apply Spectral Balancing
- Finite Difference Post Stack Time Migration

Datum - 1250m @ replacement velocity of 4000 m/sec.

Gravity Operations

The gravity data was acquired along side of the seismic program. A gravity reading was recorded every six receiver stations for a station spacing of 90 metres. The following is a summary of the gravity acquisition and processing parameters.

Chevron Canada Resources Program Name: Ellesmere

Contracting Crew: MWH Geo-Surveys Ltd.

Acquisition Dates

- Start Survey: August 9, 1998
- Finish Survey: August 14, 1998
- Length of Survey: 27.95 linear kilometres
- Average Acquisition Rate: 4.7 kilometres per day

Recording Equipment

- Three Lacoste & Romberg G model Gravity Meters
- Serial numbers 371, 332 & 689

Surveying System

- Mix of Conventional and GPS survey techniques.
- Data collected in NAD83 and converted to NAD27.

Field Procedures

- All Readings taken within closed loops
- All Loops tied to ISGN gravity monument in Fort Liard
- Inner Terrain Corrections (Annulus A to D) visually estimated
- 303 unique stations and 10 repeat stations recorded.
- Gravity Stations are located at the Geophone station
- Elevation and coordinates of Geophone station used for Gravity

Processing

- Bouguer Reduced with density = 2.55 gm/cm3
- Latitude correction uses 1967b Geodetic Reference System
- Outer Terrain Corrections from 170m to 37000m

Project Overview

Locality

The program was centred on the Liard Plateau that is situated between the Rocky Mountains to the southwest and the Mackenzie Mountains to the north. The gross location of the program is shown on figure 1. South of the 60th parallel the stratigraphy plunges to the south into the Liard Basin. North of the map the reservoir rock outcrops in the Mackenzie Mountains. To the west the reservoir shales out into a deep paleo-basin. To the east there is only minor structural deformation. Figure 2 shows a close-up of the Exploration License 364, wells, and the seismic and gravity program completed in 1998. The seismic and gravity program was named Ellesmere. Figure 3 shows the topography of the area and Figure 4 shows all of the seismic data Chevron currently possesses in the area.

Purpose

The purpose of the geophysical program was to delineate a subsurface structure that could form a trap and reservoir for hydrocarbons. The P-66 well to the east of the EL-364 had reportedly encountered hydrocarbons and tested them at significant rates. At surface, the structure near the P-66 well is a complexly folded and faulted anticlinorium, characterized by exposures of Mattson, Flett, and Besa River Formations. In the subsurface, thrust faulted and uplifted Besa River and Nahanni Formations core the structure the P-66 well encountered. The latter of which is Middle Devonian in age and forms the objective reservoir interval. Geophysical techniques such as gravity and seismic are necessary to image the subsurface structures that form the reservoir

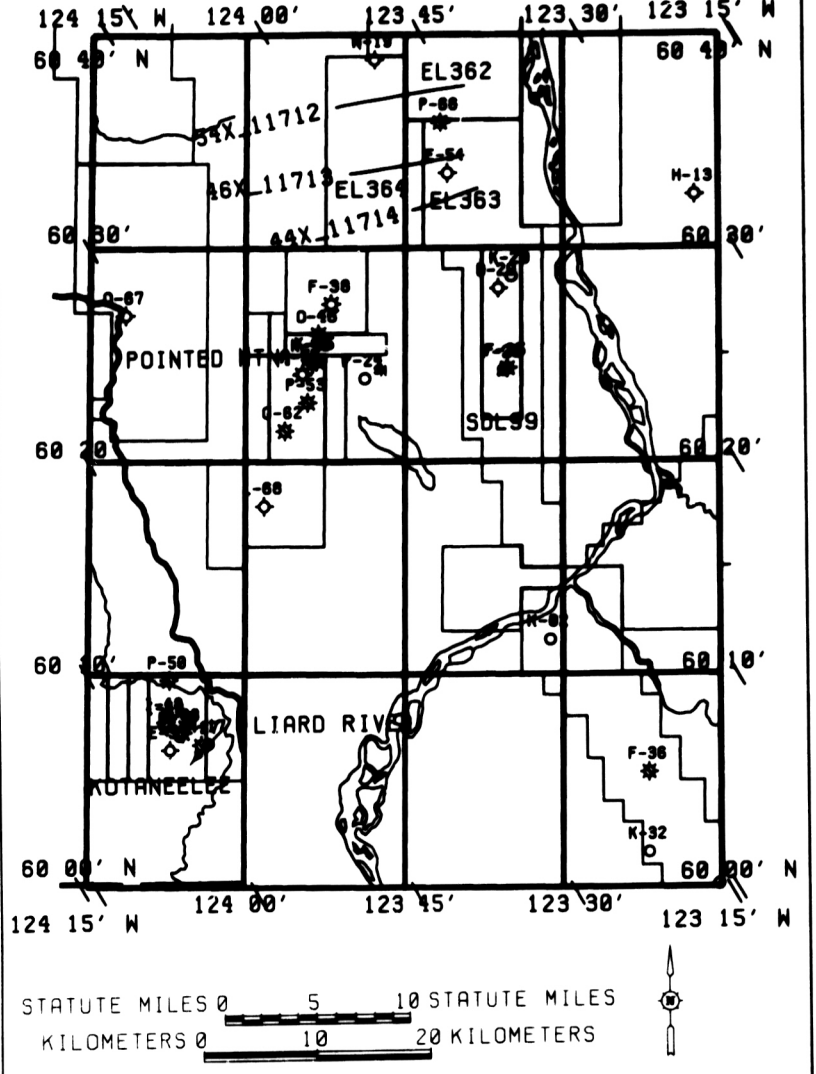


Figure 1

Map of the Liard Plateau area. Of interest on the map: producing fields Kotaneelee and Pointed Mountain, Wells P66 and K29, the Liard River, the EL's valid in the summer of 1998, the 3 seismic and gravity lines

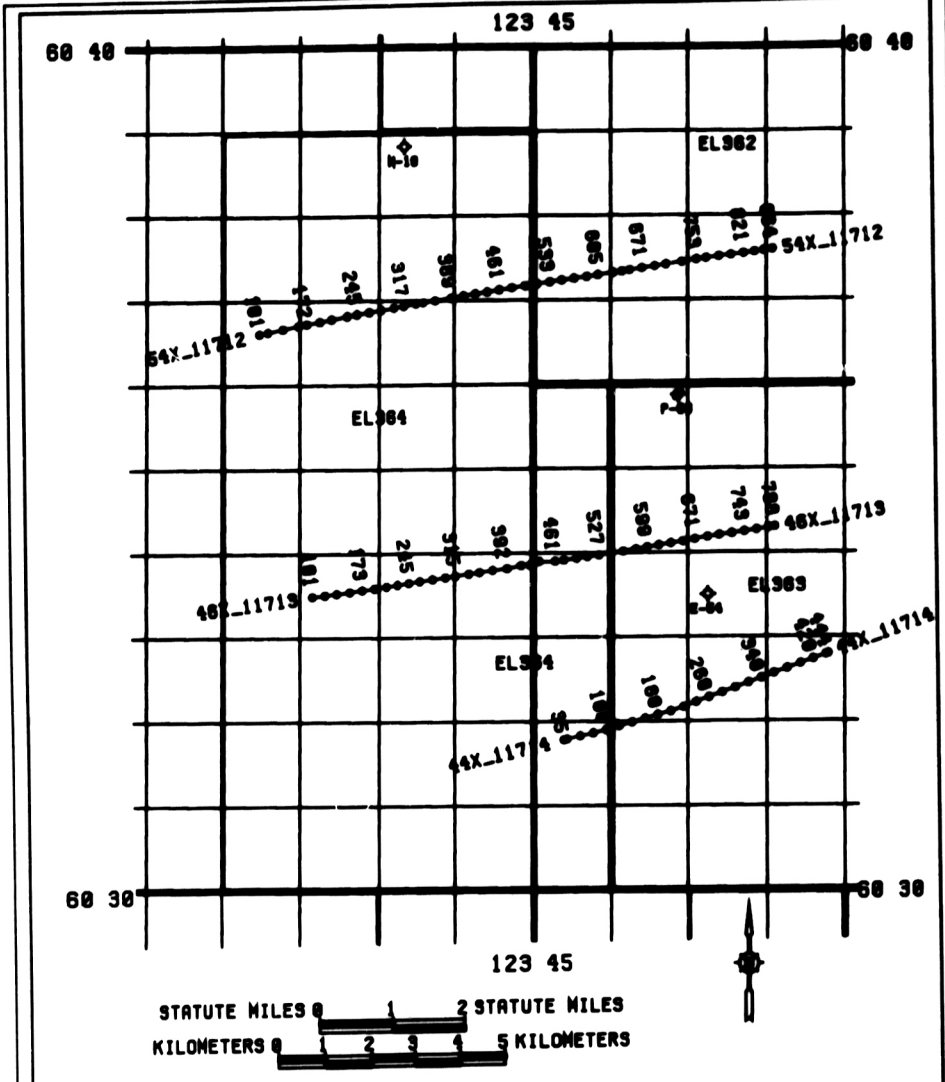


Figure 2
A close-up from Figure 1 showing EL364 and the 3 seismic and gravity lines.

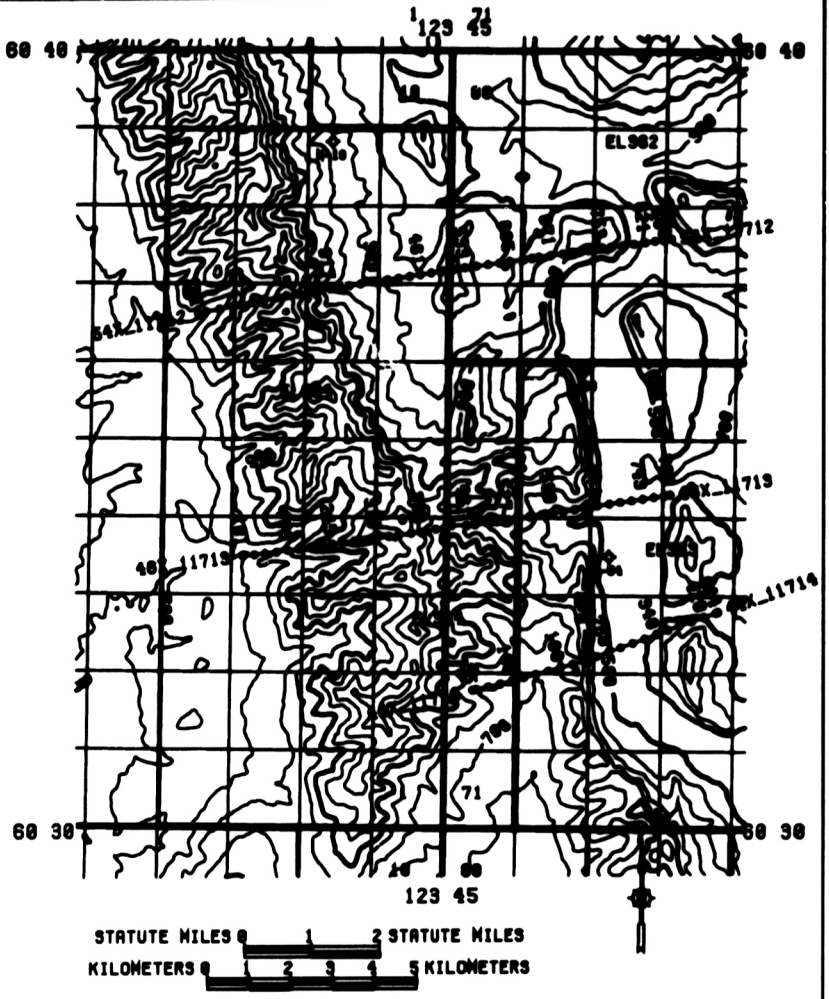


Figure 3
The map from figure 2 with topography superimposed.

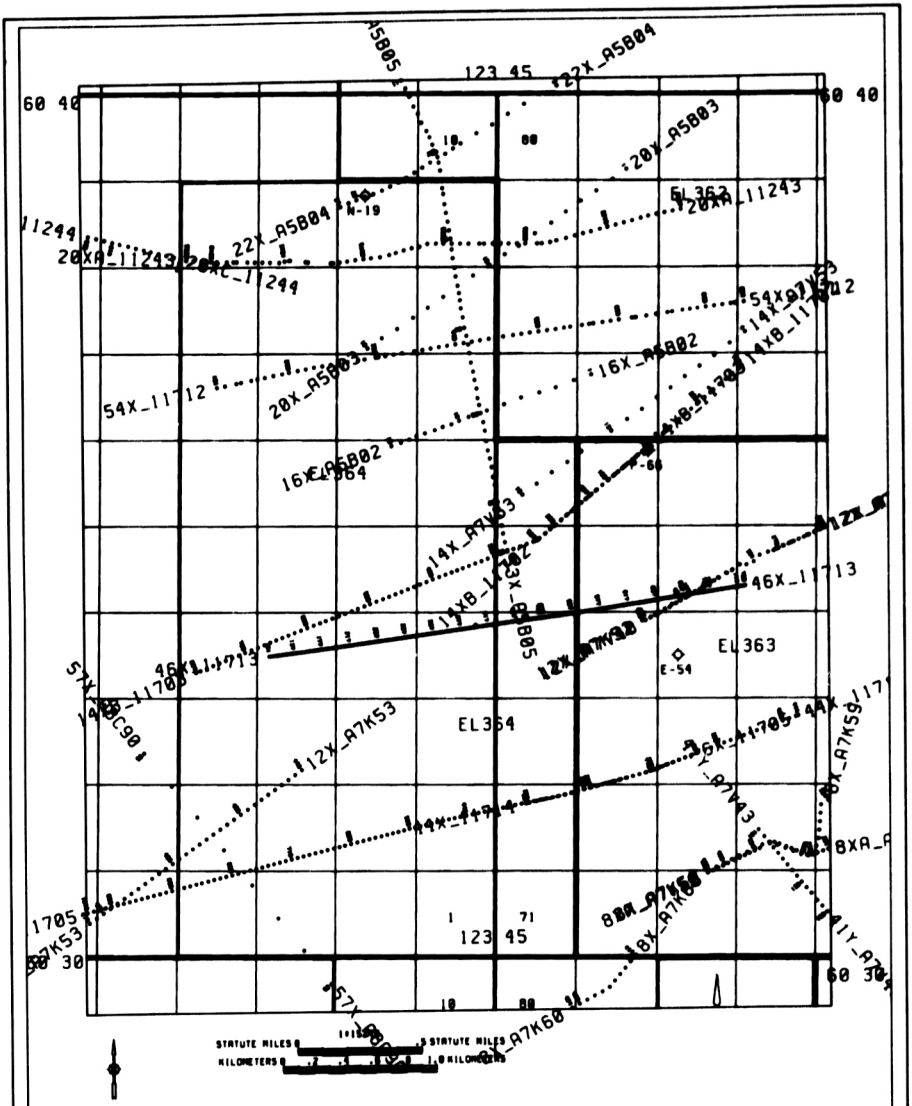


Figure 4
Map showing all of Chevron Seismic over EL364

Results and Interpretation

Stratigraphy

The stratigraphies discussed in this report are summarized in the stratigraphic chart that follows (figure 5). The stratigraphic column consists of three major packages. The youngest is the Mississippian through Cretaceous limestones, sandstones and interbedded shales. Structures in this upper package are responsible for most of the topographical variation in the region. The competent rocks of the Fantasque, Mattson and Flett form a resistive cap protecting mountaintops from erosion and adding to the rugged nature of the terrain. The second package is composed of a monotonous sequence of Middle Devonian through Mississippian shales and minor siltstones of the Besa River Formation. The uppermost portions of this package are exposed at the surface, locally only at surface anticlines where the upper packages has been breached. The N-19, P-66, E-54, K-29 and D-29 surface locations are all on breached anticlines where the upper-most Besa River is exposed. Due to the incompetent nature of the Besa River shales the rock is easily deformed. It acts as a major zone of structural detachment under EL-364 and EL-363. The oldest package is the Precambrian through Middle Devonian carbonates and clastics. This is the lowest and most competent package, the uppermost portion of which is the reservoir of interest.

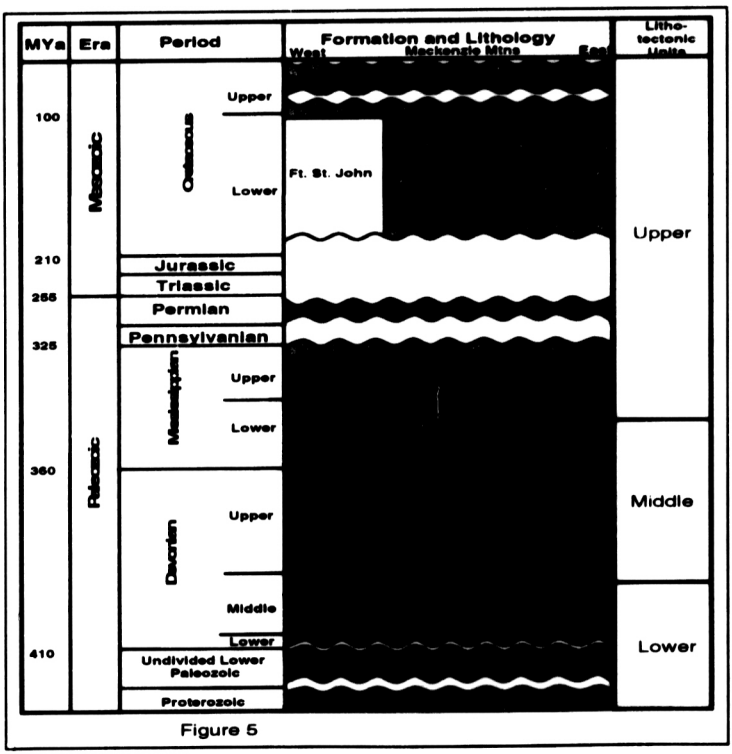


Figure 5

Structure

The gas pool the P-66 well penetrated is composed of a north-trending, uplifted thrust sheet of Middle Devonian carbonates. Uplift of the thrust sheet is interpreted to have occurred during the late stages of the Laramide orogeny, and is probably late Cretaceous or earliest Tertiary in age. The youngest strata involved in the deformation are the Wapiti Fm, believed to be Campanian-Maastrichtian in age. A west dipping thrust fault forms

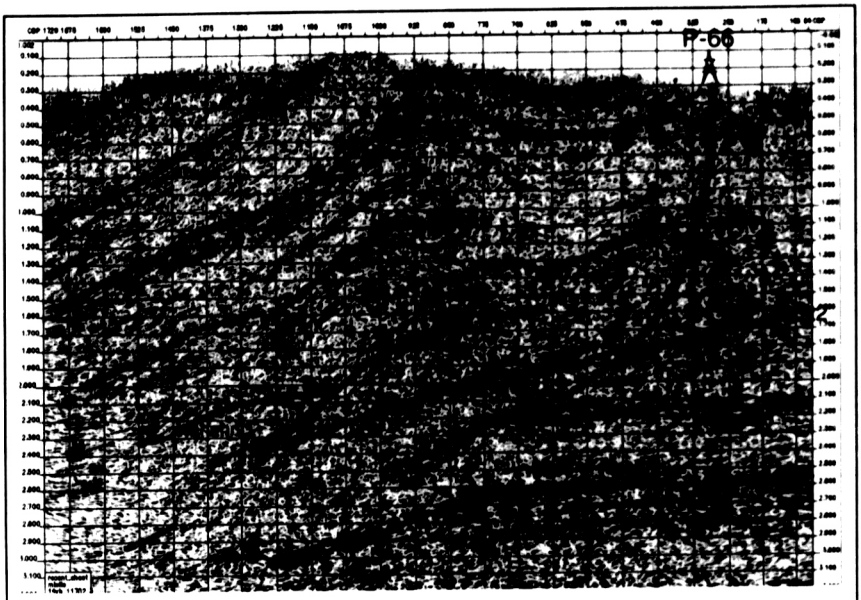


Figure6
Seismic line 14xb_11702 showing the Nahanni targeted by the P-66 well.

the eastern boundary of the gas reservoir as illustrated on the seismic section (Figure 6). The seismic section is Line 14xb_11702 as shown on the map (Figure 4). The borehole is plotted schematically since we do not currently have down-hole survey information. The reservoir in Figure 6 is labeled Nahanni2 and the fault carrying the reservoir is labeled Fault2.

Reservoir

Middle Devonian carbonates, presumed to be largely equivalents of the Nahanni, Arnica and Landry Formations (informally grouped as Nahanni or Middle Devonian Carbonates in this report), comprise the reservoir interval in this region. The interval is almost entirely dolomite and has been extensively altered both diagenetically and tectonically. Typical matrix porosities are low, ranging from 0 to 6%. Superimposed on the diagenetic fabric is a series of fractures that are probably associated with the regional Laramide

stress-field and the development of the P-66 structure. This fracture system forms the main permeability network within the Middle Devonian reservoir interval.

Nearby Analogies

Three nearby fields (Beaver River, Kotaneelee and Pointed Mountain) have produced significant quantities of gas from the Nahanni Formation since the early 1970's. A number of other nearby wells such as F-25 and D-29 had also encountered hydrocarbons, though their rates were not commercial. These known gas pools are found in thrust faulted and uplifted Nahanni Formations. A surface anticline is often associated with the thrust fault, however, there can be a significant amount of offset (in the dip direction) between the uplifted Nahanni and surface anticline.

Ellesmere Program

Figures 7, 8 and 9 show a low-resolution display of the seismic and gravity lines of the Ellesmere Program. The top half of the figure shows the seismic data while the lower half shows a geological cross section along with the observed gravity and the theoretical gravity response of the geological cross section. The original full-sized high-resolution displays are included with this report. The original seismic lines are wiggle trace variable area display, 20 traces per inch, every second trace decimated, 7.5 inches per second. The primary horizons and faults are interpreted on the seismic.

The two southern lines 46X_11713 and 44X_11714 both show thrust faulted and uplifted Besa River and Nahanni Formations. Two thrust faults cutting through the Nahanni Formation are visible on both lines and can be seen to dip to the west. The eastern thrust fault labeled Fault2 carries the Nahanni sheet (labeled Nahanni2) that the P-66 well drilled to the north. The western thrust fault labeled Fault1 is related to the structure that extends from Pointed Mountain up to the structure the N-19 well drilled. This western thrust structure grows in amplitude to the north and can be seen on the northern line 54X_11712. The eastern structure that is penetrated by the P-66 well appears to swing to the west as we look north and appears be the lower structure that is visible on the 54X line. The calculated gravity fits the observed gravity in a general sense. There appear some discrepancies in a few spots. For example the calculated gravity is typically too low in the breached anticlines. Variations in densities and repositioning of the Nahanni have improved the fit between the calculated and observed gravity, but there still remain differences of 1 mGal or so in some areas. The remaining discrepancies could be due to the restrictions of 2-D modeling in a 3-D world.

Figures 10 and 11 show a map view of the Nahanni2, Nahanni3 and Fault2 structures. Figure 10 is a time structure and Figure 11 is a depth structure. In both maps the warm colours are high and cold colours are low. All seismic data in EL364 and the local vicinity has been interpreted and included in the generation of these structure maps. The depth structure was derived from the time structure using a velocity of 3900 m/s. The original full-sized 1:50,000 structure maps are included with this report.

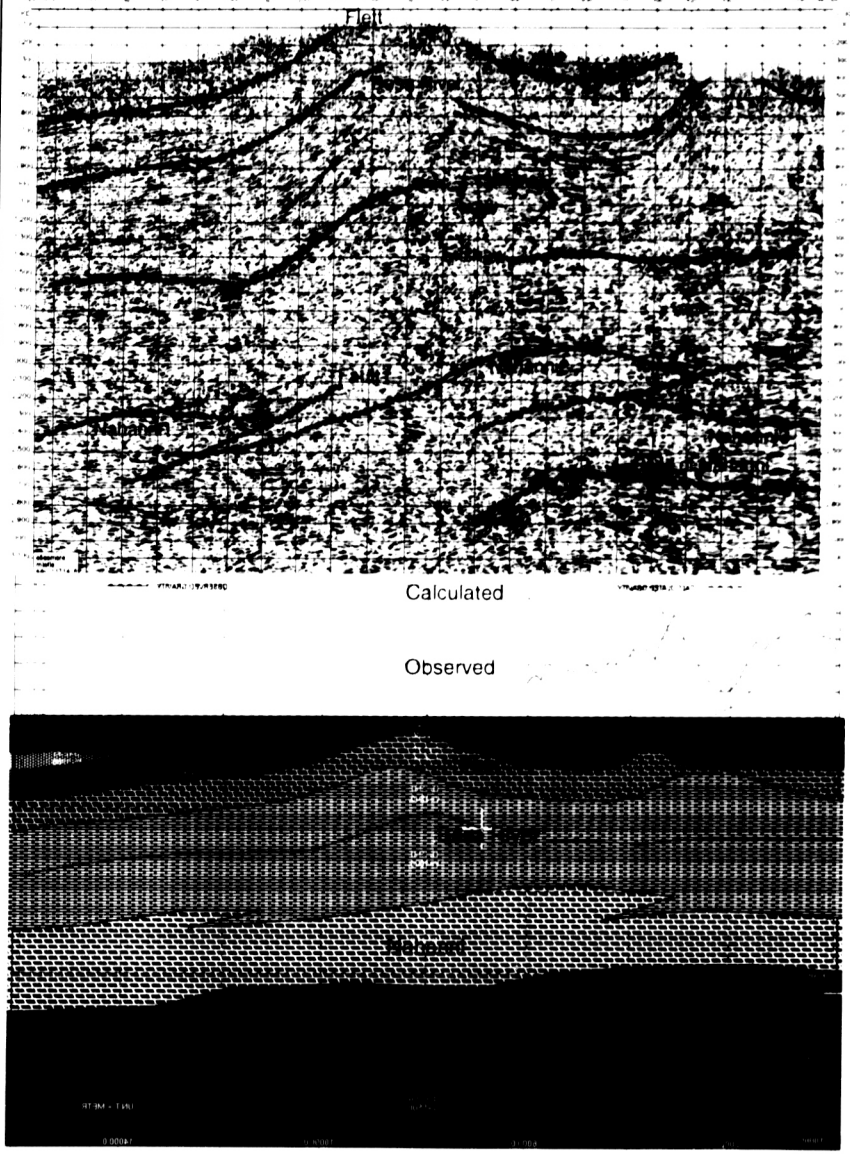


Figure 7 Line 44X

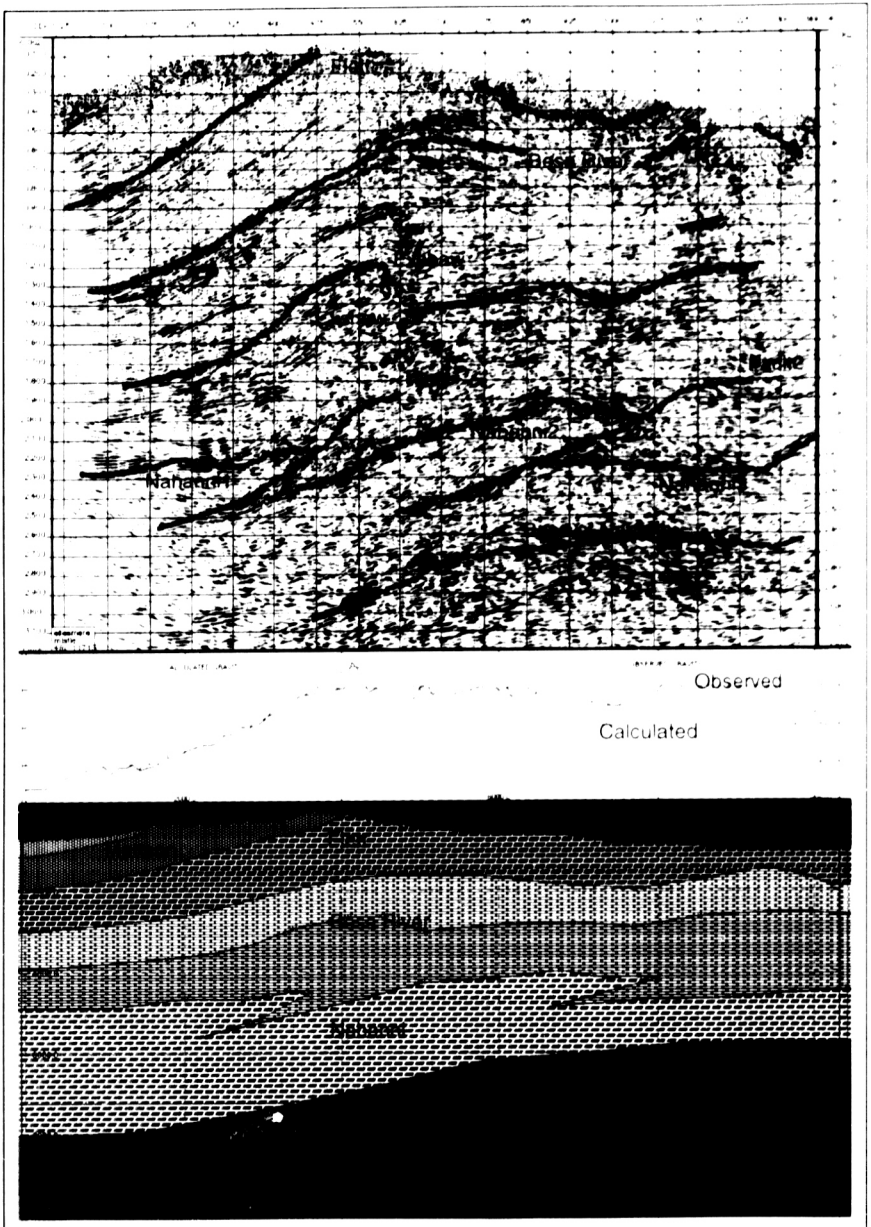


Figure 8 Line 46X

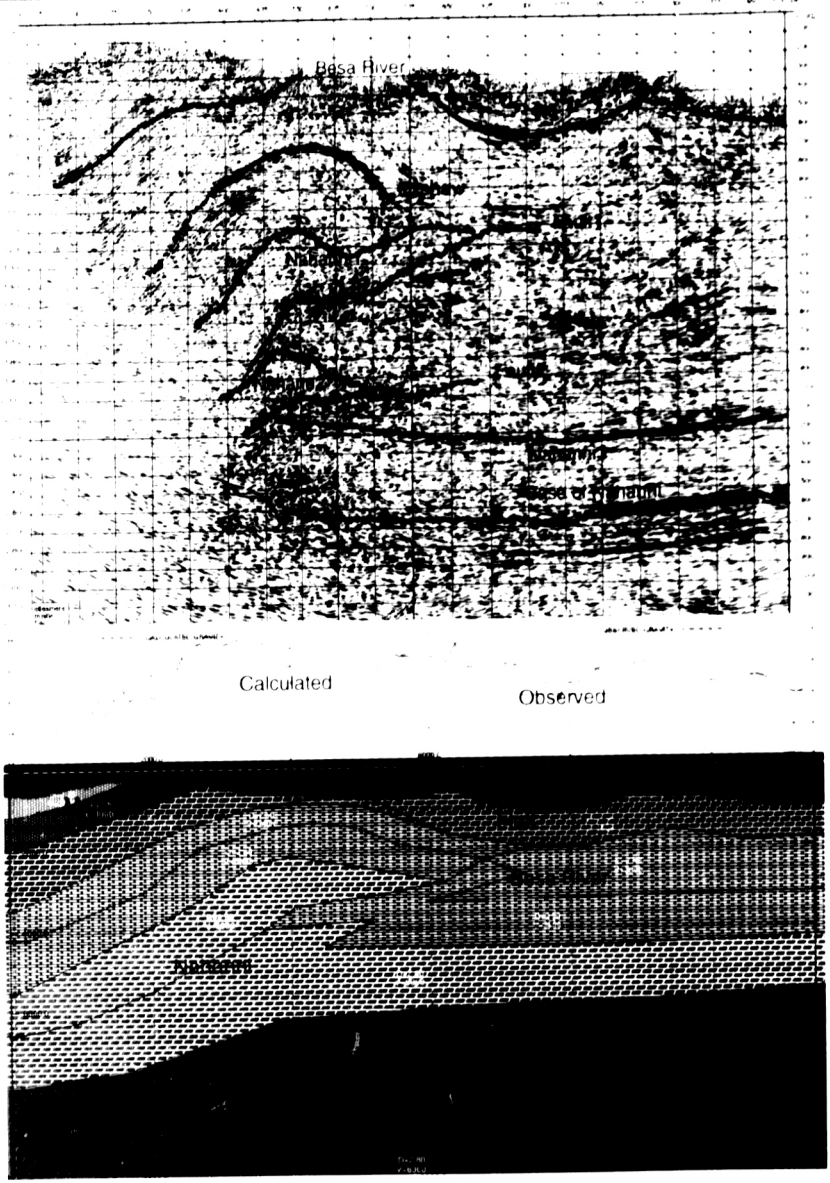


Figure 9 Line 54X

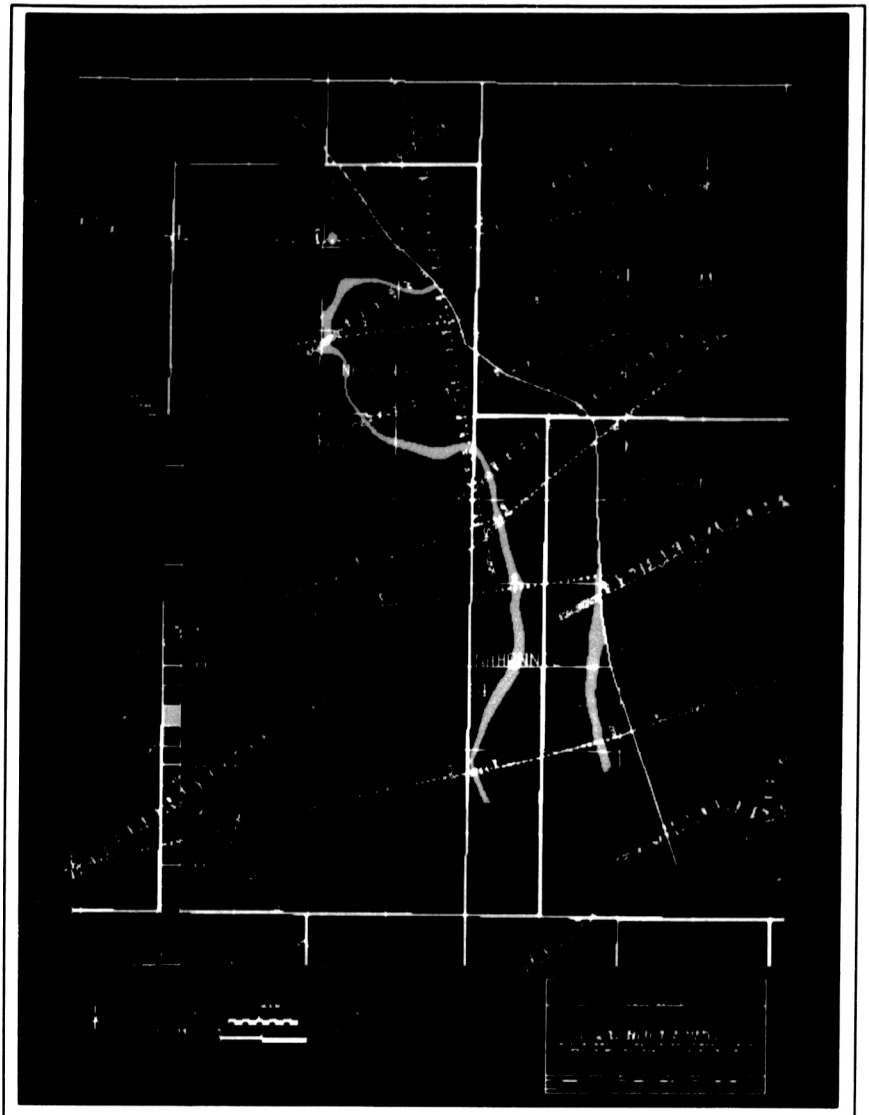


Figure 10 Time Structure of Nahanni

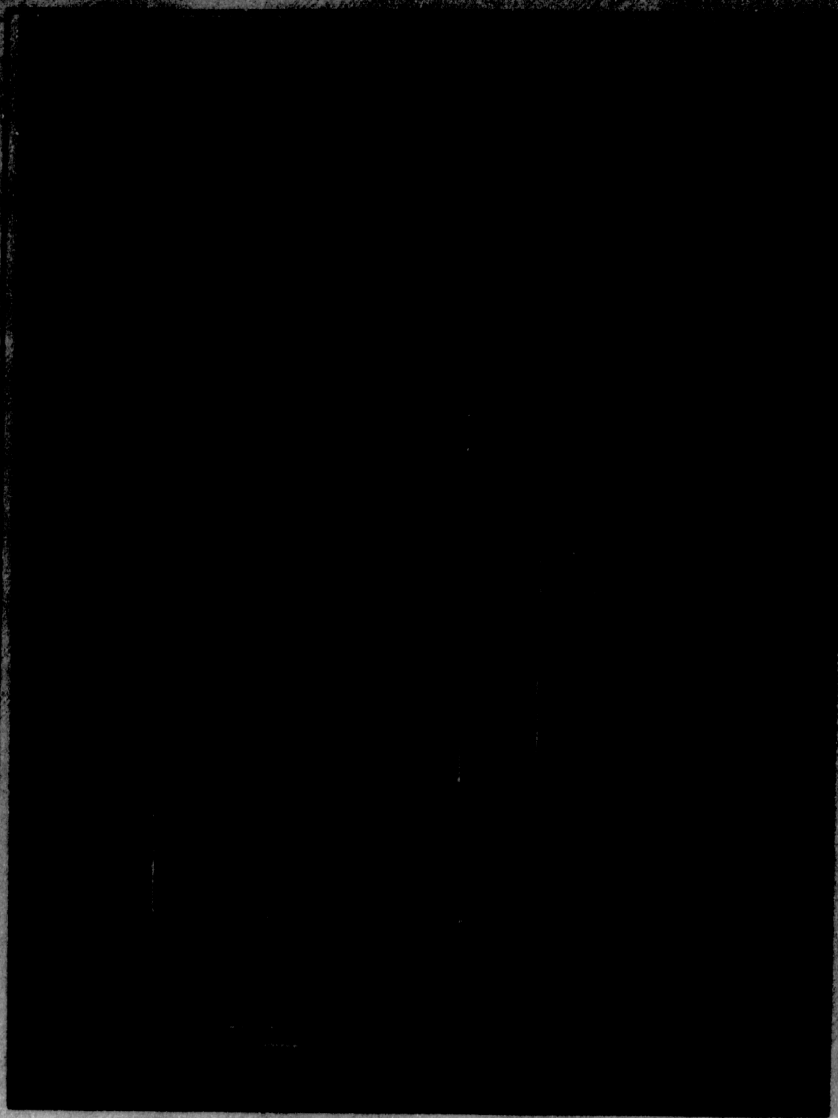


Figure 10 Time Structure of Nahonni

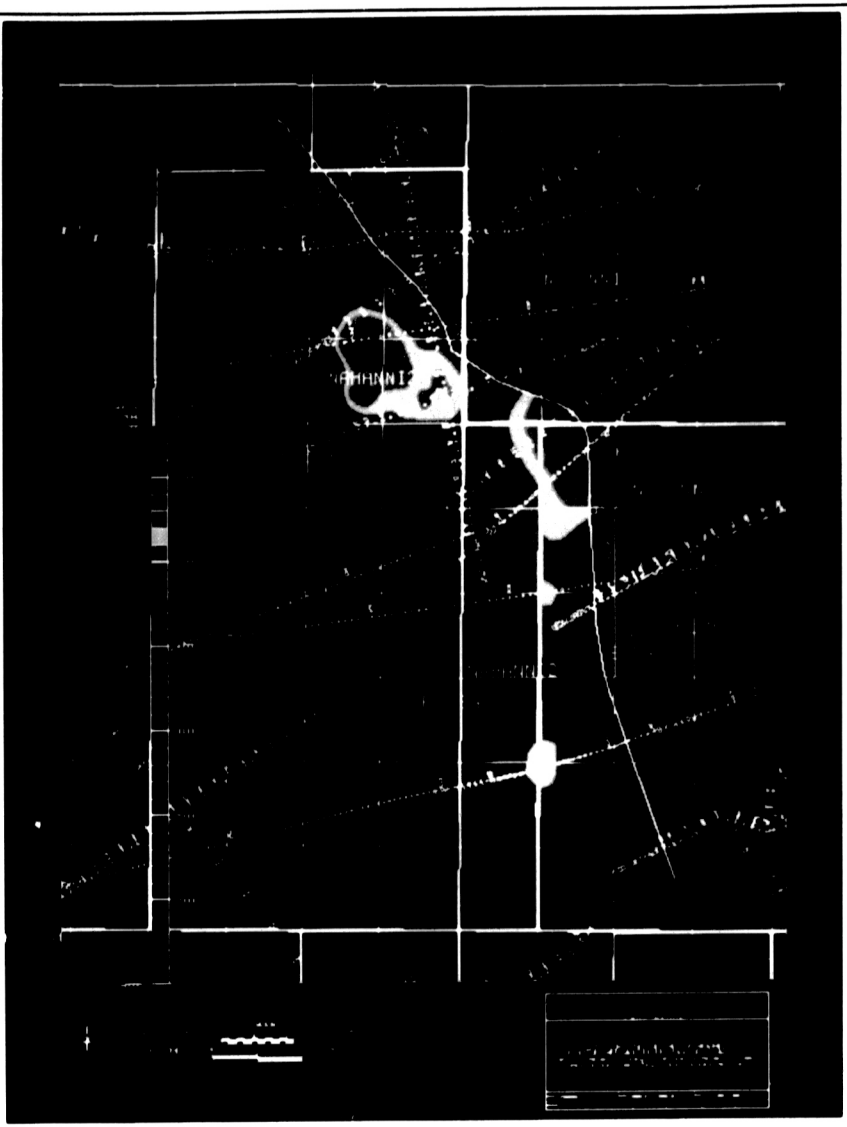


Figure 11 Depth Structure of Nahanni

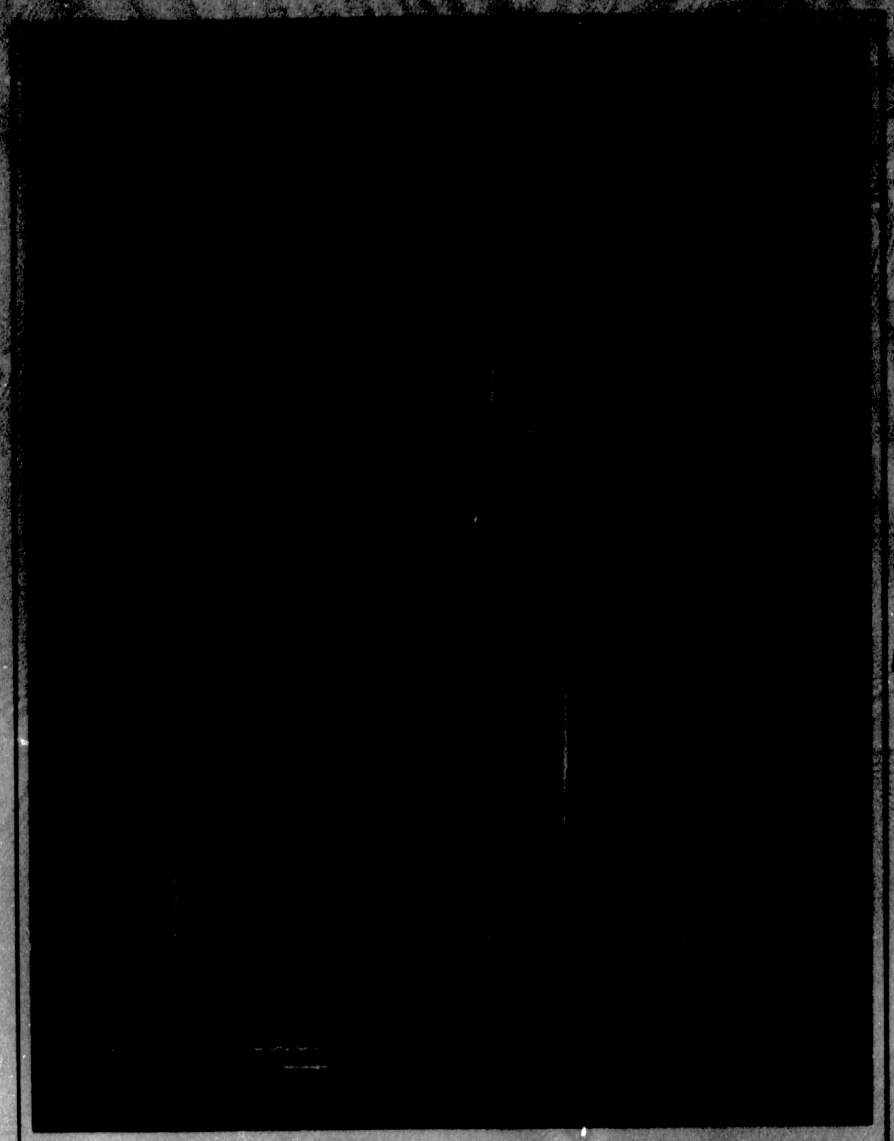


Figure 11 Depth Structure of Nahanni

Seismic Ties to Wells

Figures 12 and 13 show the logs for the well E-54. Figure 11 shows the logs in depth and Figure 13 shows the logs converted to time along with a synthetic seismogram. It should be noted that E-54 was drilled out in front of the Nahanni2 sheet and it did not penetrate the Nahanni. In addition the borehole conditions were poor and so the quality of the sonic log is poor. The Exshaw (First Black Shale) does not have a sharp trough and the Lower Besa River has a ratty appearance. It is unclear whether the logs show any Muskwa near the bottom. Typical seismic in the area shows a strong trough at the Exshaw, a few reflections in the Lower Besa River, a triplet in the Muskwa and a peak at the Nahanni. Figures 14 and 15 show the logs for the K-29 well. Figure 14 shows the logs in depth and Figure 15 shows the logs converted to time along with a synthetic seismogram. The K-29 well penetrated the Nahanni and the quality of the logs is excellent. It was found that the K-29 synthetic seismogram tie with seismic is excellent. The Exshaw has a clean trough, the Lower Besa River is clean and the Muskwa has a triple peak followed by the Nahanni peak. Full sized plots of Figures 12 to 15 are included with this report.

Additional Notes

A couple of things to note: line 44X_11714 was merged with line 6X that was recorded earlier in a separate program. Line 44X is on the east half of the merged line. The map on Figure 2 shows the seismic and gravity lines with station numbers. The seismic sections are labeled with CDP numbers. In general the CDP number is double the station number. All of the seismic and gravity lines are plotted west/left to east/right with the exception of the gravity plot for line 54X_11712.

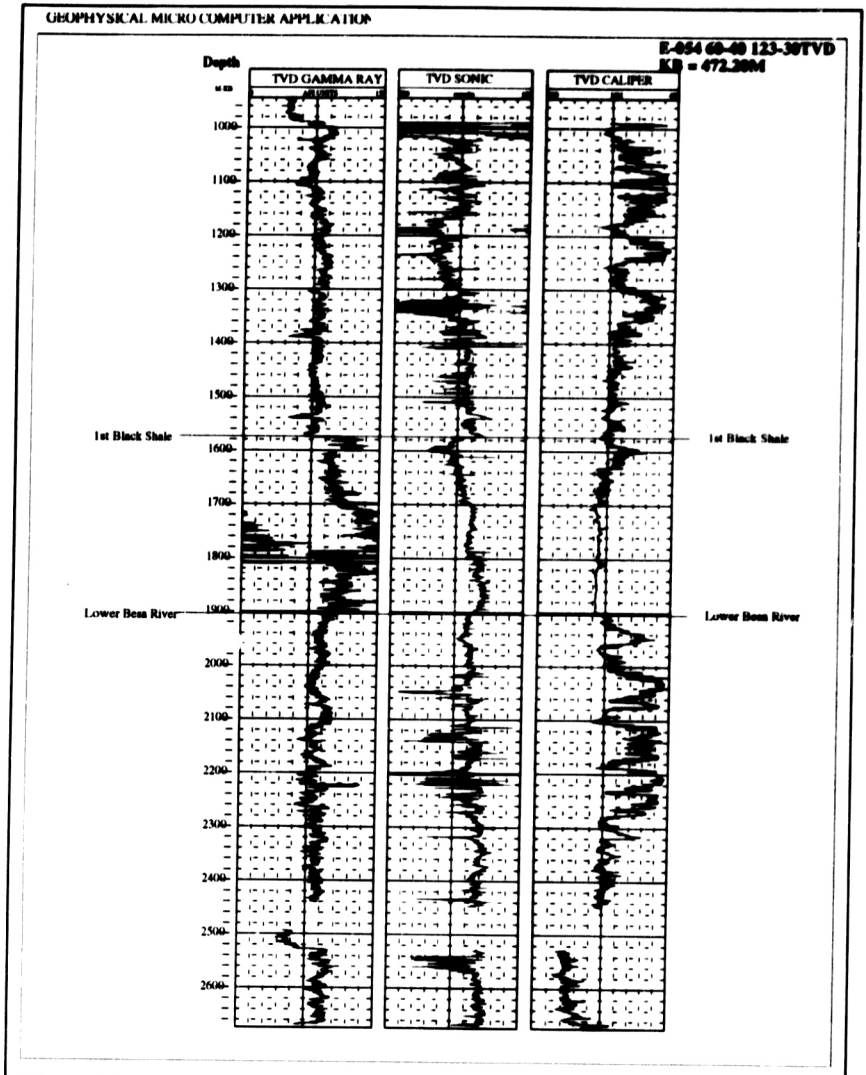


Figure 12 E-54 Logs

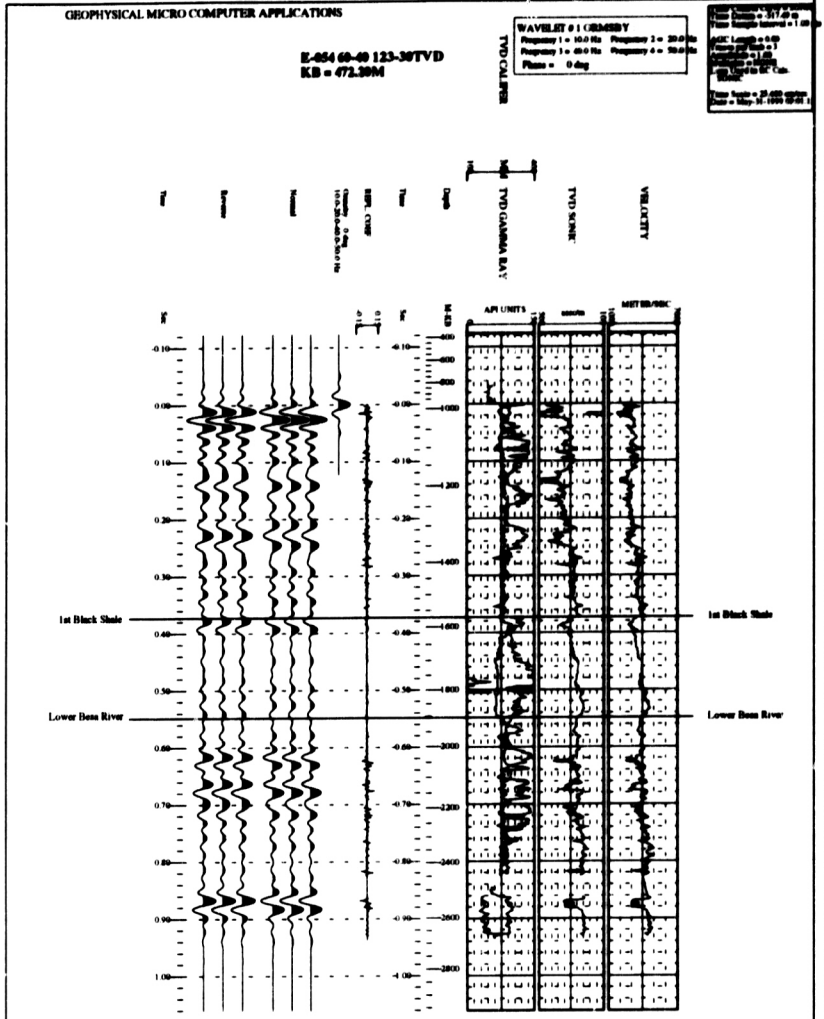


Figure 13 E-54 Synthetic Seismogram

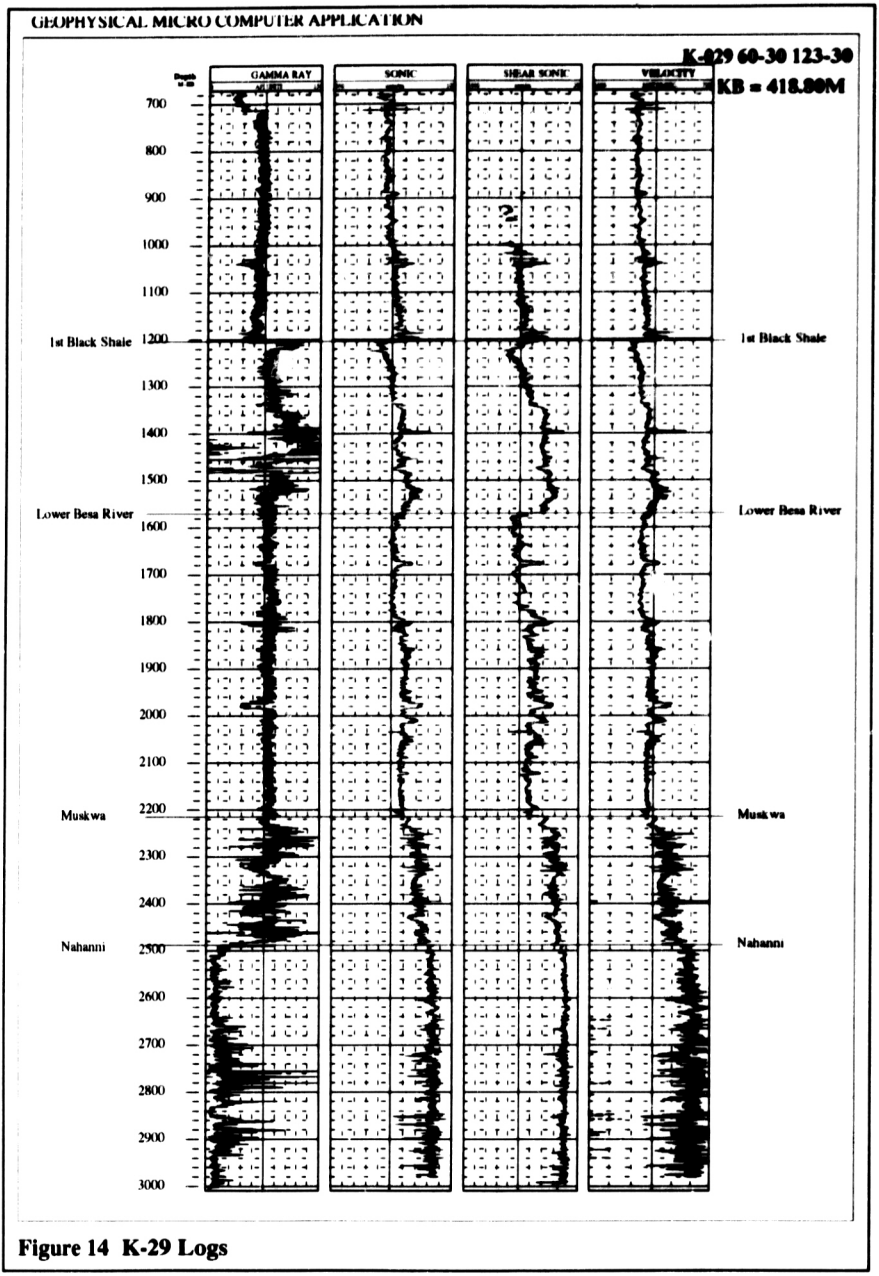


Figure 14 K-29 Logs

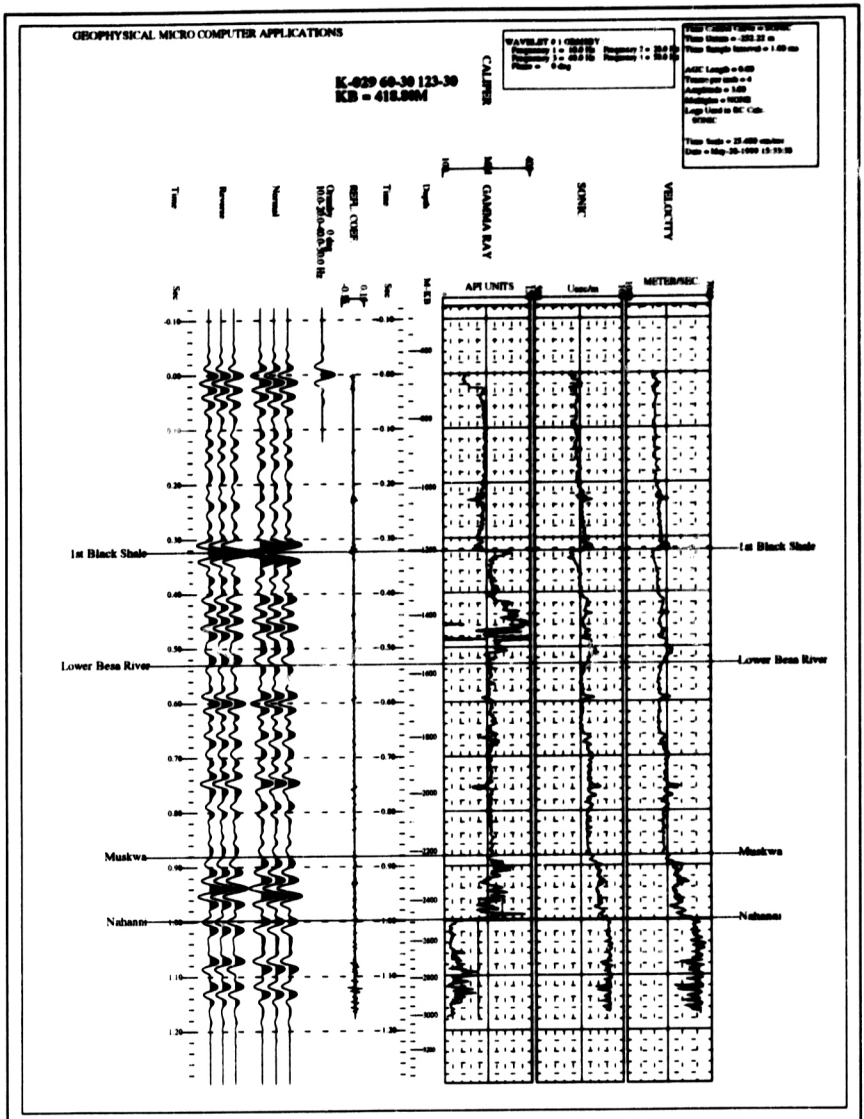


Figure 15 K-29 Synthetics Seismogram