The Lower Abo Horizontal Oil Play of Southeast New Mexico*

Ted Gawloski

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Abstract

The Lower Abo Horizontal Oil Play (LAHOP) began in February, 2007 when the Reindeer “21” Fed. #1 was kicked off and drilled a 3412’ lateral to target the Lower Abo carbonate reservoirs. After a relatively small frac by today’s standards, the well came in for 174 BOPD and 182 MCFGPD and continues to produce a steady 35 BOPD & 150 MCFGPD. The LAHOP now extends across 3 southeast New Mexico counties in a trend roughly 15 miles wide by 60 miles long. At present, the play has approximately 140 completed horizontal wells and several hundred potential locations yet to be drilled. Geologically, the LAHOP is located along the Northern Shelf of the Delaware Basin where Lower Abo sediments were deposited within shallow shelf, intertidal, lagoonal and sabkha environments. The porosity is mostly secondary, the result of dissolution of dolomite rhombs (intercystalline to vuggy porosity), skeletal fragments (moldic porosity) and cement (interparticle and intercrystalline porosity). The best production is primarily from the secondary dolomite lenses which have much better porosity and permeability. New horizontal drilling, properly steered through the pay section, connects these scattered and discontinuous porosity zones creating a much greater and more effective drainage area. Production numbers for some of the horizontal wells are as much as 10 to 15 times that of the average vertical Lower Abo completion. Several of the new horizontal wells have practical initial rates over 1000 BOEPD and have produced as much as 345 MBOE in just 2 years. The play is slowly expanding from the more established Crow Flats-High Lonesome area in Eddy County to the Caprock area of southern Chaves County east and northeastward into central Lea County.

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THE LOWER ABO HORIZONTAL OIL PLAY OF SOUTHEAST NEW MEXICO (10 TIMES THE FUN)

TED GAWLOSKI
SENIOR STAFF GEOLOGIST
APACHE CORPORATION

A LOOK FROM PAVO MESA AT LOWER ABO DRILLING ACTIVITY IN THE CROW FLATS AREA OF EDDY COUNTY, NEW MEXICO
TALK OUTLINE

• INTRODUCTION
• AREA SETTING
• STRATIGRAPHY AND ZONE DEFINITION
• FACTS & FIGURES
• LITHOLOGY, LITHOFACIES & DEPOSITIONAL ENVIRONMENTS
• PETROGRAPHY
• THE LOWER ABO RESERVOIR
• TRAP TYPES
• DIAGENESIS – THE GOOD, THE BAD AND THE UGLY
• EXPLORING FOR THE LOWER ABO – SIMPLE WORKS BEST
• SUMMATION AND CONCLUSIONS
LOWER ABO HORIZONTAL OIL PLAY INDEX MAP

- CROW FLATS AREA
- HIGH LONESOME AREA
- CAPROCK AREA
- HIGH PLAINS AREA
- CHAVES
- EDDY
- LEA
- EDDY
- LEA
- CROW FLATS AREA
- HIGH LONESOME AREA
- CAPROCK AREA
- HIGH PLAINS AREA
- CHAVES
- EDDY
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- HIGH LONESOME AREA
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- HIGH LONESOME AREA
- CAPROCK AREA
- HIGH PLAINS AREA
- CHAVES
- EDDY
- LEA
STRATIGRAPHIC COLUMN SOUTHEAST NEW MEXICO

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FOR THE PURPOSE OF THIS TALK THE TOP OF THE LOWER ABO WILL BE AT THE BASE OF THE REGIONAL ANHYDRITE. THE LOWER ABO RESERVOIR WILL BE CONSIDERED THE TOP 100-125 FEET OF SECTION IMMEDIATELY BELOW THE ANHYDRITE SECTION.

COG OPERATING
COMET “22” FED. #4
COMP. 11-2008
(LOWER ABO) HORIZONTAL
F 1539 BOPD & 1616 MCFGPD
1808 BOEPD
CUM. 127MBO & 491 MMCFG
(210 MBOE)
LT (5-2011) P 11 BOPD & 239 MCFPD
FACTS & FIGURES

THE LOWER ABO HORIZONTAL OIL PLAY BEGAN IN FEB. 2007 WITH THE DRILLING OF A 3412’ LATERAL HOLE IN THE REINDEER FED.”21” #1 IN THE CROW FLATS AREA IN EDDY CO. NEW MEXICO.

THE PLAY NOW STRETCHES ACROSS THREE SOUTHEAST NEW MEXICO COUNTIES IN A SE-NW TREND ROUGHLY 60 MILES LONG BY 15 MILES WIDE.

UPDIP WIDESPREAD ANHYDRITE DEPOSITS PROVIDE A REGIONAL SEAL AND TRAP

VERTICAL COMPLETIONS WERE MOSTLY UNSUCCESSFUL BECAUSE THE RESERVOIR IS DISCONTINUOUS HORIZONTALLY AND VERTICALLY LIMITED. PROPERLY STEERED HORIZONTAL DRILLING CONNECTS THESE DISCONTINUOUS POROSITY LENSES.

THRU MAY 2011 THE PLAY HAS PRODUCED 8.4 MMBOE WITH THE LAST MONTH’S PRODUCTION AT 402 MBOE. MANY WELLS HAVE IP’S OVER 1000 BOEPD AND EUR’S RANGE UP TO 1.2 MMBOE/WELL.

HIGH BTU ASSOCIATED GAS (>1500 BTU) GETS PREMIUM PRICE (4-2011) $10.50/MCF
FACTS & FIGURES CONTINUED...

PRODUCTION IS USUALLY LOCATED WITHIN POROUS AND PERMEABLE DOLOMITE LENSES FOUND SCATTERED THRU THE FIRST 125´ OF LOWER ABO ROCKS.

THE AVERAGE LATERAL IS SLIGHTLY UNDER 5000´ AND ARE USUALLY FRAC’D IN STAGES (UP TO 12) USING 800,000 – 1,500,000 # OF PROPPANT.

STEERING OF THE LATERAL HOLE AND KEEPING WITHIN THE PAY ZONES (GOOD MUDLOG SHOWS) IS VERY IMPORTANT AND USUALLY LEADS TO BETTER PRODUCTIVITY.
MACK ENERGY
ELK 22 FED. COM. #1
SEC.22-16S-28E
660’ FNL & 660’ FWL
VERTICAL COMPLETION
CUM. 58 MBO, LT 6 BOPD
EUR = 105 MBO &
GAS NOT REPORTED

TOP LOWER ABO

THIS IS THE BEST LOWER ABO VERTICAL COMPLETION
COG OPERATING
REINDEER “21” FEDERAL # 3
SECTION 21-T16S – R28E
HORIZONTAL L. ABO OIL PRODUCER
CUM. 226 MBO & 821 MMCFG. (363 MBOE)
LT 5-2011, P127 BOPD & 1120 MCFGPD.

EUR = 391 MBO & 4.4 BCFG OR
1125 MBOE

HOW ABOUT AN EUR
GREATER THAN 10X
THAT OF A NEARBY
VERTICAL COMPLETION
LOWER ABO LITHOFACIES AND DEPOSITIONAL ENVIRONMENTS

FACIES 1 – SKELETAL MUDSTONE TO WACKESTONE (SHALLOW SHELF)

FACIES 2 - SKELETAL AND PELOIDAL PACKSTONE TO GRAINSTONE (CARBONATE BANK OR SHOAL)

FACIES 3 - SKELETAL AND BURROWED DOLOMITIC PACKSTONE (RESTRICTED SHELF)

FACIES 4 - FINE CRYSSTALLINE DOLOMITE WITH SCATTERED GRAIN DISSOLUTION, SOME DOLOMITE INFILLING AND PORE OCLUCLING ANHYDRITE (RESTRICTED SHELF OR LAGOON)

FACIES 5 - FINE – V/FINE CRYSSTALLINE DOLOMITE (SEMI-RESTRICTED SHELF)

FACIES 6 - FINE - V/FINE CRYSSTALLINE CHERTY PELOIDAL/BIOCLASTIC DOLOPACKSTONE (RESTRICTED – SEMI RESTRICTED SHELF)

FACIES 7 - ANHYDRITE/ANHYDRITIC DOLOMITE (SABKHA)
THE DIVERSE LITHOFACIES REPRESENTED SUGGEST DEPOSITION WITHIN SHALLOW SUBTIDAL CARBONATE PLATFORM ENVIRONMENTS SUBJECTED TO EPISODIC PERIODS OF RESTRICTION AND DEVELOPMENT OF EVAPORITIC CONDITIONS.
LOWER ABO CARBONATE PLATFORM FACIES MODEL

- Inner Shelf
- Middle Shelf
- Outer Shelf
- Slope

- Mudstones
- Peloidal wackestone-packstones
- Skeletal wackestone-packstones
- Skeletal grainstones
- Fusulinids

- Peritidal
- Restricted Marine
- Shelf Lagoon
- Open Normal Marine

- Shelf Crest Shoal and Barrier Island (Gulf-Princ)
- Outer Shelf (Fusulinid W-P-O)
- Calcioporeacea-Tubiphytes Reef

- Basin Margin Apron-Debris Flows

Greg Wahlman
Wahlman Geological Services, LLC
September, 2010
FACIES 1

SKELETAL MUDSTONE - WACKESTONE
PHYLLOID ALGAL FRAGMENTS WHICH THRIVED IN SHALLOW WATER BANKS AND SHOALS
FACIES 2

SLIGHTLY DOLOMITIC SKELETAL & PELOIDIAL LIME PACKSTONE

PELOIDS

ECHINODERM FRAGMENTS

MOLLUSK FRAGMENTS

INTERPARTICLE POROSITY

INTRAPARTICLE POROSITY

FUSULINID
FACIES 3
ANHYDRITIC, PELOIDAL, SKELETAL
DOLOWACKESTONE

ANHYDRITE FILLED MOLDS
ANHYDRITE FILLED MOLDS
BITUMEN
BURROW
FACIES 4
FINE CRYSTALLINE DOLOMITE SHOWING GRAIN DISSOLUTION WITH SOME DOLOMITE INFILLING AND PORE OCCLUDING ANHYDRITE

PORE-FILLING DOLomite CEMENT

PORE-FILLING ANHYDRITE CEMENT

Abo Carbonate Platform Facies Model

Inner Shelf  Middle Shelf  Outer Shelf  Slope

Mudstones
Pebble mudstone packstones
Skeletal mudstone packstones
Mudrocks
Mussel reefs
Mussel gravelstones
Planktonic foraminifera
Bivalves
Clams
Dolomites
Porites
Laminated dolostones
Porous dolostones

PORE FILLING DOLomite CEMENT
FACIES 5

V/FINE - FINE CRYSTALLINE DOLOMITE WITH GOOD INTERCRYSTALLINE POROSITY
FACIES 6

FINELY CRYSTALLINE, CHERTY, PELOIDAL, SKELETAL DOLOPACKSTONE WITH CHERT AND DOLOMITE REPLACED SKELETAL FRAGMENTS
FACIES 7

VERY SLIGHTLY DOLOMITIC/ANHYDRITE
THE LOWER ABO RESERVOIR

THE RESERVOIR ROCKS OF THE LOWER ABO ARE COMPOSED ALMOST EXCLUSIVELY OF DOLOMITE WHERE THE BEST POROSITY AND PERMEABILITY ARE FOUND.

MOST CORE ANALYSIS OF THE LIMESTONE LITHOLOGIES INDICATE THAT THESE UNITS, ALTHOUGH ON OCCASION MAY HAVE FAIR – GOOD POROSITY, USUALLY HAVE POOR – V/POOR PERMEABILITY. PRESENTLY, THERE ARE ONLY 2 KNOWN LOWER ABO HORIZONTAL WELLS WHICH PRODUCE FROM OF A LIMESTONE RESERVOIR.

THE PRIMARY PORE TYPES FOUND IN THE LOWER ABO ARE: INTERCRYSTALLINE, MOLDIC, INTRAPARTICLE, INTERPARTICLE AND SOME SMALL VUGS.

THE BEST RESERVOIRS ARE FOUND IN FACIES 5 & 6 WHERE THE LOWER ABO HAS BEEN COMPLETELY DOLOMITIZED AND HAS GOOD INTERCRYSTALLINE POROSITY.
INTERCRYSTALLINE POROSITY DEVELOPED IN THE LOWER ABO DOLOMITE
INTRAPARTICLE & INTERPARTICLE POROSITY DEVELOPED IN THE LOWER ABO
TRAP TYPES

LOWER ABO TRAPS ARE PRINCIPALLY STRATIGRAPHIC IN NATURE CONSISTING OF:

PINCHOUTS OF INDIVIDUAL LENSES OF POROSITY & PERMEABILITY.

PINCHOUT OF THE ENTIRE LOWER ABO PAY SECTION INTO THE REGIONAL ANHYDRITE.

“ATTIC” POROSITY DEVELOPED AT THE UNCONFORMITY ON THE TOP OF THE LOWER ABO.
POROSITY PINCHOUT OF INDIVIDUAL PAY LENSES
POROSITY PINCHOUT INTO MASSIVE ANHYDRITE

CIMAREX ENERGY
CROW FLATS 16 STATE COM #2H
SEC. 16, T16S - R28E
660' FSL & 330' FWL
KB = 3590'

AMOCO PRODUCTION
PAVO MESA #1
SEC. 16, T16S - R28E
1680' FNL & 1800' FFI
KB = 3579'

COG OPERATING
REINDEER 21 FEDERAL #2H
SEC. 21, T16S - R28E
330' FNL & 330' FFL
KB = 3617'

COMP 7-2007
IP (L. ABO) 6786-10452'
P 277 BOPD & 268 MCFGPD & 373 BWPD
CUM. 106 MBO & 300 MMCFG LT (5-2011)
P 13 BOPD & 69 MCFGPD

ACTIVE ATOKA GAS WELL

COMP 6-2008
IP (L. ABO) 6627-8589'
F269 BOPD & 303 MCFGPD
CUM 79MBO + 353MMCFG (143 MBOE)
POROSITY PINCHOUT INTO UNCONFORMITY AT TOP OF LOWER ABO
THE DIAGENETIC FOOTPRINT

THE LOWER ABO HAS UNDERGONE MANY PHASES OF DIAGENESIS; SOME FOR THE BETTER AND SOME NOT. EITHER WAY IT HAS CREATED A COMPLEX, MIXED-BAG OF LITHOLOGIES AND DISCONTINUOUS LENSES OF PAY

DIAGENETIC SEQUENCE OF EVENTS

• DEPOSITION OF LOWER ABO SEDIMENTS
• EARLY COMPACCTION
• EARLY DOLOMITIZATION
• DISSOLUTION OF SKELETAL FRAGMENTS
• PRECIPITATION OF CALCITE, ANHYDRITE AND SILICA (CHERT) CEMENTS
• SECONDARY DOLOMITE RECRYSTALLIZATION
• OIL MIGRATION
LOWER ABO FACIES AND REFLUX DOLOMITIZATION

THE GOOD

FINE V/FINE CRYSTALLINE DOLOMITE WITH GOOD MOLDIC AND INTRAPARTICLE POROSITY AND FAIR INTERCRYSTALLINE POROSITY. SOME OF THE SKELETAL MOLDS ARE FILLED WITH ANHYDRITE CEMENT
THE BAD

EXTENSIVE CEMENTATION
BY ANYHDRITE AND SECONDARY
DOLOMITE WITH SOME PRESERVED
MOLDIC AND INTRAPARTICLE POROSITY

DOLOMITIC SKELETAL LIME PACKSTONE
WITH ABUNDANT PORE FILLING CALCITE,
DOLOMITE AND ANHYDRITE
THE UGLY

ABUNDANT PORE-FILLING CALCITE (RED) AND ANHYDRITE CEMENT

ALMOST COMPLETE CEMENTATION BY ANYHDRITE AND SECONDARY DOLOMITE
EXPLORING FOR THE LOWER ABO

IDENTIFY THE PAY INTERVAL AND LATERAL EXTENT OF THE PLAY.

DETERMINE PAY PARAMETERS (LITHOLOGY, POROSITY & PERMEABILITY)

CONSTRUCT A REGIONAL GRID OF CROSS SECTIONS. STRATIGRAPHIC SECTIONS WORK BEST. HANG SECTIONS ON THE REGIONAL SHALE MARKER BELOW THE PAY INTERVAL. LOOK FOR POTENTIAL TRENDS & ANOMALIES.

LOOK FOR OLD VERTICAL WELLS WITH MUDLOG SHOWS AND DST’S WITHIN THE LOWER ABO PAY. DST RECOVERIES ARE USUALLY VERY LOW CONSISTING OF O&GCM. THE FACT THEY RAN A DST IS ENCOURAGING AND A DIRECT INDICATOR OF A HYDROCARBON MUDLOG SHOW.

BUILD A INTERVAL ISOPACH MAP OVER THE ENTIRE PLAY AREA AND ADD A LITHOLOGY OVERLAY. TARGET AREAS IN ISOPACH THICKS THAT LIE WITHIN YOUR DOLOMITE LITHOLOGY OUTLINE.

INCORPORATE AVAILABLE 3-D SEISMIC. MODEL THE RESERVOIR, CONSTRUCT A STRUCTURE & PERTINENT STRATIGRAPHIC ATTRIBUTE MAPS. ALSO USE TO HELP IN STEERING THE LATERAL HOLE.
SIMPLE WORKS BEST- THE INTERVAL ISOPACH AND FACIES MAP

INTerval isopach thicks (potential pay)  Lower ABO limestone facies (not productive)
OWWO 3/06

IP (L/Abo) 8,990’ - 9,097’
P 89 BOPD + 96 BWPD, FTP 150#
PERF 8,990’-8,998’, 9,307-9,041’, 9,084-9,097’,
ACIDIZED W/7500 GALS. 15% HCL
Cum (L/Abo)
8 MBO + 15 MMCFG
March 2011 OWWO coningled L/Abo perf’s
with Lower Wolfcamp & Penn perf’s
AMPLITUDE VS MUDLOG SHOWS
3D: ARB LINE SHOWING AMPLITUDE RESPONSE IN THE LOWER ABO

ABC OPERATING, GUSHER# 1
IP LOWER ABO (30 DAY AVG.) 1000 BOEPD
CUM (4 ½ MONTHS) 119MBOE
LT. 7-2011 F778 BOEPD
IT TOOK A LOT OF HARD WORK & EFFORT TO CONVINCE MANAGEMENT TO TAKE A CHANCE ON THE LOWER ABO PLAY. IT WAS OUT OF THE NORM TO DRILL HORIZONTAL WELLS IN A TIGHT PLATFORM CARBONATE AND MAKE THEM WORK.

SO, THE NEXT TIME YOU’RE OUT THERE HUNTING FOR THE NEXT SHALE RESOURCE PLAY DON’T FORGET TO LOOK A LITTLE CLOSER AT YOUR SECTION, THERE MIGHT JUST BE ANOTHER LOWER ABO TYPE PLAY TO BE FOUND.

SPECIAL THANKS TO:

RUBY STRAHAN, JOHN POLASEK & KEITH McKAMEY, APACHE CORP.
RALPH WORTHINGTON & LEE CATALINO, CIMAREX & GREG WAHLMAN