# Surprises in Stratigraphy and Structure found during Hydrocarbon Exploration in the Rio Grande Rift, New Mexico.

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Abstract - Recent oil and gas exploration in the Espanola and Albuquerque Basins of the Rio Grande Rift has greatly expanded our knowledge of both the Tertiary and the pre Tertiary geologic sections. It has also given us a greater understanding of the structural styles in these frontier basins in the rift. Ongoing exploration, including drilling, reinterpretation and reprocessing of 2 D seismic, as well as new gravity and magnetic studies are helping to define both structural and stratigraphic targets.

Several surprises (both in structural style and in the rift stratigraphy) have been found in the drilling to date. Additional unexpected problems (and opportunities) will undoubtably be found as exploration proceeds.

Productive rifts around the globe constitute approximately 2.5% of the basinal areas - yet produce over 12% of the worlds oil and 4% of its gas (Klemme, 1980). With the first (sub commercial) high gravity oil production established in the southern part of the Espanola Basin the necessary parameters for hydrocarbon generation and entrapment, in parts of the rift, have been documented. Future discoveries of commercial oil and/or gas accumulations are considered probable, but this new frontier area is deceptively complex in some areas.

## INTRODUCTION

This article is an attempt to briefly update and summarize the results of tests into the Pre Tertiary section (particularly the Albuquerque Basin) in light of our present recognition that the Albuquerque Basin and other basin in the rift are part of a major rift system that has now been proven to have movable hydrocarbons. A history of oil and gas exploration in the Albuquerque Basin through 1980 was summarized in the Albuquerque Country II Guidebook (Black,1982). An update through 1999 was summarized in Albuquerque Geology (Black, 1999). Between 1999 and 2001 two additional Tertiary tests were drilled in this basin. Of all the wells drilled in this basin only ten have definitely been drilled into the Cretaceous section. The two latest test in the basin were drilled by Twinning Drilling Corp. Both of these wells were reportedly unsuccessful in reaching the Mesozoic. Attempts at a completion were made in the Tertiary section, but were apparently unsuccessful.

# ANALYSIS OF ALBUQUERQUE BASIN MESOZOIC TESTS

Why haven't the ten Mesozoic tests in the Albuquerque Basin found commercial oil and gas? The short answer is because these tests were drilled in the wrong place and at the wrong time. More specifically they were not drilled on closed structures in this rift system - and when gas productive- as some were - were not commercial at the time.

The great majority of oil and gas accumulations in rift basins are found on structural highs located in high blocks that are in, or immediately adjacent to, the rift proper. These high structural blocks are typically adjacent to deeper graben blocks, which have provided adequate maturity for the contained source rocks. The intervening tensional normal faults have acted as avenues for migration of hydrocarbons out of the low areas, up the faults, and into the reservoirs available on the highs. The locations of the tests in the Albuquerque Basin have not been located properly to test the locations that have highest probability for structural hydrocarbon traps in rift systems (namely on the highs immediately adjacent to source potential).

Shell Oil in the late 1960's and early 1970's began deep gas exploration in the Albuquerque Basin. Their initial efforts were not directed toward exploiting highs in the rift, but were aimed at drilling the deeper, hotter, low areas in the rift. Using the San Juan Basin as an model, Shell drilled the deep Cretaceous section which was stratigraphically similar to the adjacent San Juan Basin. The purpose was to try to tap the in-situ hydrocarbons that they believed was being generated and stratigraphically trapped in the deeper mature areas. The philosophy was to look for another San Juan Basin type central basin gas accumulation.

The majority of the first ten wells drilled into the Mesozoic section were drilled in the deeper parts of the basin and reflected this San Juan Basin analog philosophy. The important point is that the play was not initially made as a structural play, but rather it was made as a stratigraphic play (in a structural rift system).

Shell was in fact successfully in finding deep gas in the Cretaceous section in at least two of their initial wells. However, because of the extreme depths, difficulty in making completions, and the poor reservoir character found in the deeper wells, they were deemed non-commercial even though gas was being generated and was present in the Cretaceous rocks. Drill stem tests and sustained production tests (that produced as high as seven hundred thousand but more commonly a hundred thousand cubic feet of gas a day or less) were not commercial when the wells were costing several million dollars to drill and complete. Shell's theories on source rocks, maturation and oil and gas generation in the deep Albuquerque Basin were right, but they were unsuccessful making commercial wells with the technology available at that time.

While the structurally highest parts of relatively high blocks in the basin were not tested three wells were drilled in relatively high positions. The Shell SFP No. 1 was drilled, in part, because of expiring acreage and was primarily a stratigraphic test to find out if a Cretaceous section was even present in the north end of the basin. The well was drilled on a surface nose in the Santa Fe Group with no apparent northerly closure. Although primarily a stratigraphic test, it ended up low on a relatively high block which was probably also an old paleo-high.

The Shell Laguna Wilson No.1 was drilled on the extreme west flank of the basin on another surface structural nose (this well may technically be outside of the rift) and was spud in an immature shallow Cretaceous section. Several large fault blocks separate it from the deep basin proper, and provided barriers to oil migration into this immature area.

The first conscious attempt to get on a high block adjacent to the cooking pot was a well drilled by TransOcean Oil in 1978. This well was drilled on a pass-through farm out from Shell Oil to Black Oil who turned it to TransOcean Oil. Subsequent reprocessed seismic showed the well was located in a low saddle and was not drilled on a closed high.

The recent Burlington well is located on an intermediate fault block adjacent to the deeper basin. It is scheduled to be off set in 2002 0r early 2003 to test apparent gas sands in the Dakota section that were not tested in the original well on this structure.

## LESSONS LEARNED

Virtually all of the parameters necessary for oil and gas accumulations exist in the Albuquerque Basin and the Santa Fe Embayment of the Espanola Basin. They may also exist in other basins of the Rio Grande Rift as well (although traps with commercial accumulations have yet to be proven).

Most importantly abundant source rocks and maturity in the source rocks have been proven and the timing of the necessary events has been favorable. Excellent reservoir are present in many areas of the rift and migration routes and seals are present, particularly in the Cretaceous and Jurassic rocks.

While the Paleozoic and Mesozoic sections are similar in most respects to the San Juan Basin there are several important differences. For instance the Pennsylvanian section was deposited in a different basinal area than the Pennsylvanian section in the present San Juan Basin. However, there is abundant evidence that the section does contains good source rocks and shallow water reservoir rocks which also makes the Pennsylvanian prospective in the Albuquerque Basin area.

Likewise there are similarities and important differences in the Jurassic Todilto/Entrada package. This part of the section is not present in the southern part of the Albuquerque Basin due primarily to pre Dakota erosion of the Mesozoic section. This erosion progressively cuts deeper as you move to the south. None the less, there is excellent source rock potential in the Todilto Limestone and excellent reservoir sands in the Entrada where they are still present in the north and central parts of the basin.

The Cretaceous section at the north end of the basin is similar to the southeast part of the San Juan Basin and is easily correlatable to it. However the Cretaceous section in the central and southern parts of the Albuquerque Basin was generally deposited further landward than the producing parts of the San Juan Basin. This presents excellent opportunities to find the Hosta

and Dalton as well and the massive Gallup sandstones as potential reservoir in the Albuquerque Basin. At the same time the Point Lookout and higher marine sands pinchs out as you move south in the basin and a thicker non marine section is present in the Menefee and deeper non marine sections. Pre rift uplift and erosion, probably related to Laramide thrusting, has removed some of the upper Cretaceous section (usually down to the Meneffe) over many parts of the Albuquerque Basin.

There are numerous potential reservoir sands in the Tertiary section and these may be sealed with lacustrine shales or even salt beds. Recent wells drilled into the Tertiary section in the southern part of the basin have penetrated several thick beds of salt and these beds could be important as seals in the Tertiary section if oil and gas is migrating and leaking upwards into Tertiary reservoirs beneath these beds . The salt will also be important in the proper geophysical interpretations in this part of the basin because of its strong density and sonic contrasts with the sands and shales in the section and its effect on the geophysical records.

Even though the vast majority (probably more than 90%) of the oil and gas found in rifts are found on structural or stratigraphic closures on the high structural blocks, to date no structural closure has been drilled in this rift (with one possible exception). The possible exception was the 1997 Burlington Resources Westland Development No. 1Y well. This well had over 30 feet of gas effect on the FDC/CNL log in the Dakota, but was not tested (presumably due to the lack of mud log shows). Sun Valley Energy is planning an offset or reentry to test this zone in late 2002 or early 2003.

Structurally the rift in general, and the Albuquerque Basin in particular, is much more complex than the adjacent simple down warped San Juan Basin. Late Cretaceous and early Tertiary Laramide thrusting has effected the pre rift sediments in the Albuquerque Basin and implanted these effects across the rift. Middle to late Tertiary tensional tectonics associated with the later rifting has produced horsts, grabens and tilted fault blocks bounded by normal and listric faults. These fault blocks still contain the earlier Laramide compressional imprint. This history must be taken into account in any present interpretation of the structural grain.

## CONCLUSIONS

Oil and gas exploration in the Rio Grande Rift has been going on sporadically for at least 88 years. While no large commercial accumulation has yet been found, small amounts of high gravity oil has been produced in the rift in the Santa Fe Embayment of the Espanola Basin. Additionally tens to hundreds of thousands of cubic feet of gas has been tested from wells in the Espanola and Albuquerque Basins. Low gas prices and the lack of pipe lines has hindered the exploitation of gas in the area in the past, however new technology and better gas prices now make these areas attractive exploration targets.

Oil and gas shows in exploration wells and oil on the outcrop have been reported in several areas along the rift. All of the necessary parameters for commercial oil and gas accumulations have been documented in several of the rift basins. The structural style is becoming well known with

numerous recent articles, published gravity, and the release of seismic data (Black, B.A.,1984 and Russel and Snelson, 1994) revealed in recent articles. The writer believes it is now more a matter of when, rather than if, a commercial discovery will be found.

There is an earlier Laramide overprint superimposed on the Tertiary rift tectonics which if not understood and accounted for makes structural interpretation of the area very difficult. Variations and lateral changes in the Cretaceous and Tertiary stratigraphy also add to the complexity of the area but also afford new and interesting opportunities for stratigraphic traps.

Until closed structural traps are located and drilled the potential of the rift in general, and the Albuquerque and Espanola Basins in particular, will not be exploited to their full potential.

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