

Title: **“Improved Miscible Nitrogen Flood Performance Utilizing  
Advanced Reservoir Characterization and Horizontal Laterals  
in a Class I Reservoir – East Binger (Marchand) Unit”**

Type of Report: **Quarterly Technical Progress (Report No. 15121R05)**

Reporting Period Start: **April 1, 2001**

Reporting Period End: **June 30, 2001**

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Report Date: **August 10, 2001**

Cooperative Agreement No: **DE-FC26-00BC15121**

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## **Abstract**

The first horizontal well ever in the Marchand sandstone has been drilled. Although major difficulties arose with certain aspects of the drilling operation, a horizontal section of approximately 1300' was drilled. The section was left open hole as planned.

The shales just above and between the Marchand sands appear to be very water-sensitive, requiring careful drilling practices. These shales were encountered in the middle part of the curve (45°-60°), which can be the most difficult part of a directional well to clean. Difficulties with these shales and cleaning this section led to a parted drill string, requiring a sidetrack.

There were no major geologic "surprises", such as formation tops coming in much shallower or deeper than expected, or unexpected faults. Thin kaolinite beds were encountered in the horizontal section of the well. Previous descriptions of the mineralogy of this formation did not mention any kaolinite. The lateral extent of these beds is unknown.

Completion of the well is under way.

One additional injection profile was gathered during the quarter. Results are consistent with other recently profiles that show gas within the C Sand is overriding the oil and failing to sweep the deeper parts of the reservoir.

International Reservoir Technologies, Inc. has completed the construction of the pilot area reservoir simulation model and the updating of historical production and injection data. They have begun fine-tuning the history match to better match production data and recently acquired pressure and profile data.

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## **Quarterly Technical Progress Report – 1<sup>st</sup> Quarter 2001**

### **Introduction**

Additional progress toward characterizing the East Binger (Marchand) Unit was completed during the second quarter of 2001. The first horizontal well in the Marchand sandstone has been drilled; though problems were encountered, the drilling is completed and well completion operations are under way. Construction of a finely gridded reservoir simulation model of the planned pilot area is complete and history-matching efforts are under way. With production data from the new horizontal well, the simulation model can be tuned to actual field performance and development alternatives for the pilot area can be evaluated.

### **Executive Summary**

Major progress in the East Binger (Marchand) Unit project was made on two fronts:

The first horizontal well ever in the Marchand sandstone has been drilled. Although major difficulties arose with certain aspects of the drilling operation, a horizontal section of approximately 1300' was drilled. The section was left open hole as planned.

The shales just above and between the Marchand sands appear to be very water-sensitive, requiring careful drilling practices. These shales were encountered in the middle part of the curve (45°-60°), which can be the most difficult part of a directional well to clean. Difficulties with these shales and cleaning this section led to a parted drill string, requiring a sidetrack.

Formation tops were found at or close to prognosed depths, and, as expected, no faulting was encountered. Thin kaolinite beds were encountered in the horizontal section of the well. The lateral extent of these beds is unknown.

Completion of the well was under way at the time of this report.

One additional injection profile was gathered during the quarter. Results are consistent with other recent profiles that show gas within the C Sand is overriding the oil and failing to sweep the deeper parts of the reservoir.

The second area of major progress is with the pilot area reservoir simulation model. International Reservoir Technologies, Inc. ("IRT"). has completed the construction of the model and the updating of historical production and injection data and has begun fine-tuning the history match to production data and recently acquired pressure and profile data.

## Results and Discussion

The following is a detailed review of the work conducted in this reporting period.

### *Task 1.1.2 – Reservoir Data Collection*

#### Calibration of Horizontal Productivity

One of the major items planned within this task was the drilling of two horizontal wells for the purpose of calibrating horizontal performance in the reservoir simulation models to actual field performance. The first of these wells, EBU 37G-3H, was spud during the second quarter of 2001, but had not been completed at the end of the reporting period. Significant problems and cost overruns were encountered during the drilling operations. This has forced Binger Operations to re-evaluate the cost/benefit relationship of a second well. After consulting with IRT, it was decided to forego the second well for the time being. EBU 37G-3H, originally planned as an injection well, will now be completed as a producer. Estimation of horizontal injectivity for the simulation work will be based on horizontal productivity. Figure 1 shows the location of the horizontal open hole.

As mentioned above, significant problems were encountered during the drilling operations of EBU 37G-3H. Two sidetracks were required as a result of tubulars lost in the hole.

The original drilling plan for the well was as follows:

- A. Drill 12-1/4" surface hole to 1100'.
- B. Run 9-5/8" surface casing.
- C. Drill 8-3/4" hole with water base mud through the curve to a horizontal target within the Marchand C Sand.
- D. Run 7" casing.
- E. Drill 6-1/8" horizontal hole with foam mud.
- F. Complete open hole.

The first major problem occurred while preparing the hole for the 7" casing. After drilling to the casing point, a reaming/conditioning trip was conducted. The reaming assembly would not go back through the middle of the curve (about 60° inclination) due to what was believed to be a cuttings/cavings buildup. The bottomhole assembly was changed to a bit without nozzles for better hole cleaning. Progress was being made when the drill pipe twisted off near the bit. After a failed fishing attempt, the hole was plugged back and sidetracked.

The second major problem occurred while preparing the sidetracked hole for 7" casing. After making a bit trip near the casing point, there was again difficulty working back through the middle part of the curve. This was worked through, the well was drilled to

the casing point, and two short trips were made. While pulling the drilling assembly for the casing run, it got stuck with about 4600' of drill collars and pipe still in the hole. After determining it was stuck at a single point at about 3100', the upper part of the string was backed off and pulled out. The remaining part – consisting of about 500' of collars and 1000' of pipe – was washed over, releasing it to fall down the hole. Only the collars and 1-1/2 joints of drill pipe could be recovered. The drill pipe below the collars was severely corkscrewed. This forced a second plugback and sidetrack and led to a revision to the drilling plan for the curve and horizontal portion of the hole. 7" casing was run as deep as possible (to the top of the remaining fish), a window was milled, and the second sidetrack was drilled.

The revised plan was to drill the curve and horizontal portion in a manner similar to how a sidetrack of an existing wellbore was planned – namely, to cut a window out of 7" casing and drill the entire curve and horizontal section with a 6-1/8" bit, then run a 4-1/2" liner through the curve, leaving the horizontal section open hole. Another change was to the planned drilling fluid for the horizontal section – from foam to an oil-base mud. This also resulted in a change from drilling underbalanced to drilling overbalanced. Finally, since it would be completed as a producer instead of an injector, the target depth was moved lower in the Marchand C Sand.

It is believed that the hole problems resulted from very water-sensitive shales just above the Marchand A Sand and between the Marchand A, B, and C Sands. Figure 2 is an open hole log from well EBU 37-1. Note the change in the shale line of the gamma ray curve that occurs at about 9900'. The change to an oil base mud was made to prevent further problems with these shales. For added insurance, a mud weight of 9.5 ppg or higher was maintained throughout the curve and horizontal section. Future horizontal wells in the Marchand will likely require oil base mud through the curve section, though the mud weight could possibly be reduced such the well could still be drilled underbalanced.

One other drilling problem occurred at the end of the horizontal section. After drilling about 1300' of horizontal section, the bottom of the drilling assembly got stuck in the hole. The tool string was backed off above the stuck point and the bottom 185' of the drilling assembly was left at the end of the horizontal open hole. Figure 3 is a plot of the path of the wellbore within the C Sand; the bit actually reached an additional 60' beyond the last point measured. Toward the end of the drilled section, the wellbore was drifting up in the section, despite efforts to keep it level and then turn it back down.

Other than the severe sensitivity of the shales to water (discussed above), there was only one geologic "surprise" with this well – the well crossed through kaolinite bedding a number of times in the horizontal section. There does not appear to be any faulting through the area, and the sand tops were hit at or close to expected depths.

The presence of kaolinite in the sand was unexpected. Kaolinite is a clay which can exist either as a discreet bed of detrital material or as crystals formed within pore spaces. The onsite mud logger believes it is detrital material in this case. It was first encountered as



the wellbore dropped through 10,062' TVD, then again as it came back up through 10,062' TVD. (The path of the horizontal well is approximately down-dip, but formation dip is less than 1°.) There was spotty kaolinite in the samples as the well maintained a fairly level path, and it became more abundant as the well drifted above 10,060' TVD.

There was never more than about 50% kaolinite in the cuttings, so assuming it is detrital in nature, an individual bed can only be a few inches thick. The lateral extent of the kaolinite is unknown; however, the kaolinite encountered above 10,060' TVD near the end of the horizontal section was not seen when the wellbore first dropped through this depth. Further, there has not been any mention of kaolinite in previous core descriptions, x-ray diffraction or scanning electron microscopic analyses, or geologic reports.

Completion operations for the EBU 37G-3H were under way at the time of this report.

#### Reservoir Pressure and Flow Profile Data Gathering

Another aspect of Task 1.1.2 is data gathering, both for model-tuning purposes and for project evaluation. One additional injection profile was obtained during this period – in well 46G-1, located in the center of the field, just north of the previously planned producer lateral in 46-2 (now deferred). At the time of the profile measurement, the injection rate was approximately 750 mcf/d. A baseline profile was deemed necessary to properly determine the impact of the horizontal well on offset injection. The interpretation of the log is as follows:

<u>Interval</u>	<u>% of Injection</u>	<u>Comment</u>
A Sand (7')	20	150 mcf/d or ~ 21 mcf/d per foot
Top 7' of C Sand	30	~ 32 mcf/d per foot
Next 20' of C Sand	21	~ 8 mcf/d per foot
Bottom 43' of C Sand	29	~ 5 mcf/d per foot

This is consistent with a number of previous injection logs which showed a high percentage of injected gas going into the overlying A and B Sands and/or the upper part of the C Sand. As mentioned in previous technical reports, the situation appears even worse than predicted by the full field simulation model, and efforts will be made with the pilot model to better match these field observations.

#### *Task 1.1.5 – Build Pilot Area Model*

Construction of the pilot area model by IRT was completed during this reporting period. The gridding of this model was discussed in the previous report. Construction of the pilot model included converting reservoir description data from the full field model grid to the new pilot model grid (splitting some cells into multiple cells in some areas and combining cells in other areas), converting cell references associated with well locations, etc. Additionally, all historical production and injection rate definitions were updated through

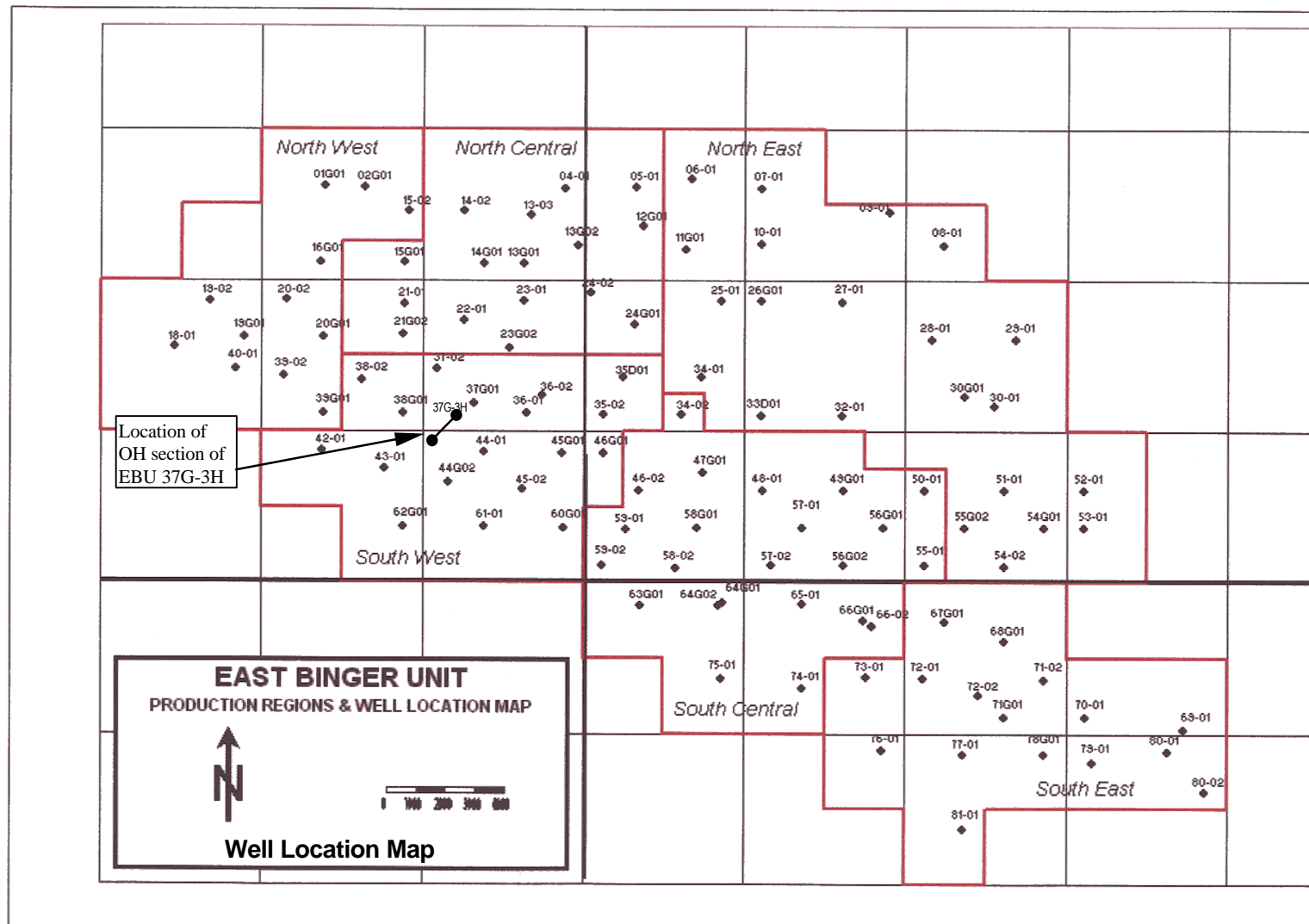
April 2001, and all recently gathered field pressure data was input into the historical database for the purpose of comparing model-predicted pressures with field pressures.

Efforts toward fine-tuning the history match with the new grid are now under way.

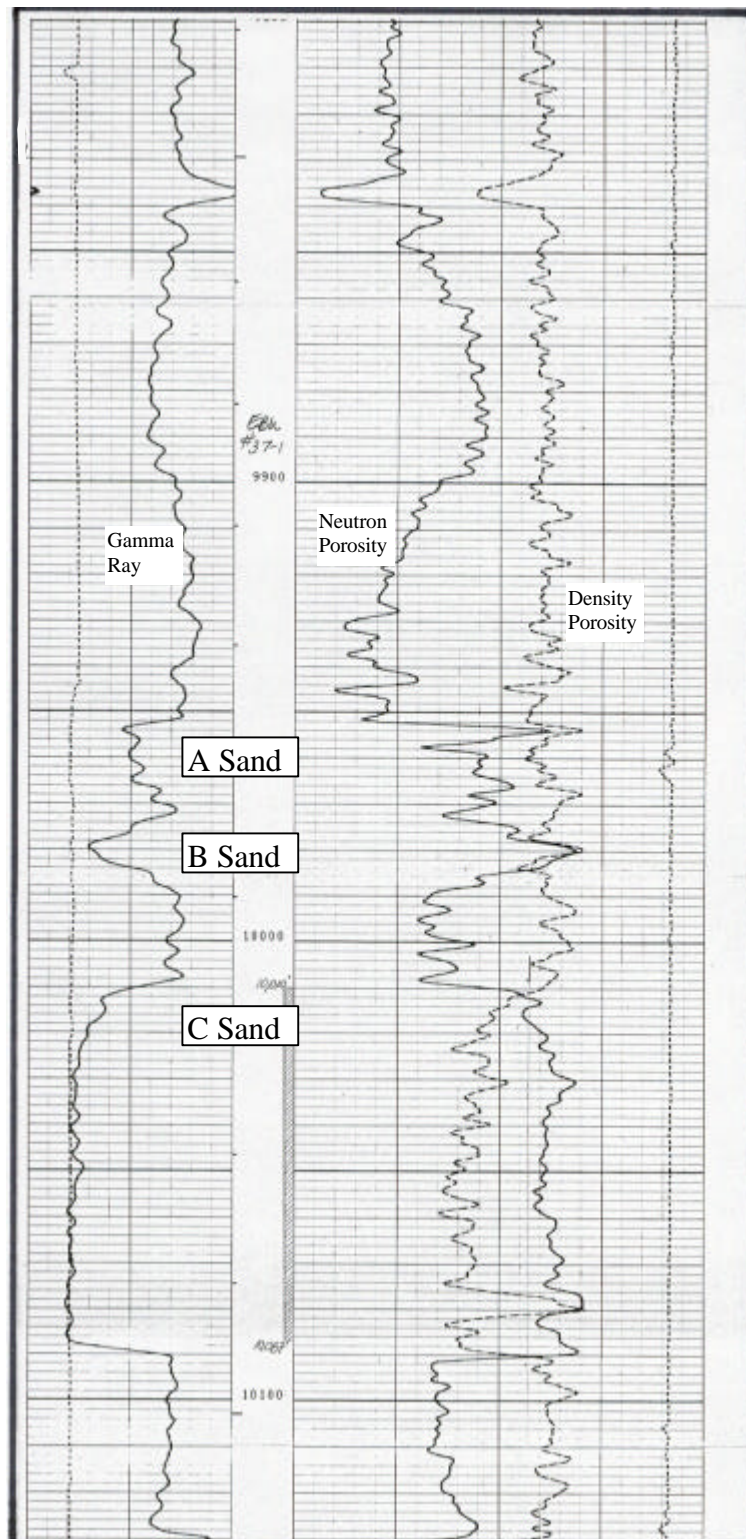
## **Conclusion**

The first horizontal well in the East Binger Unit has been drilled. Lessons learned from operational difficulties will be invaluable for the planning of future horizontal wells in the Unit.

The reservoir simulation model for the planned pilot area has been built and fine-tuning of the history match is under way. Future calibration of this model to actual field performance of the horizontal well will lead to evaluation of potential development alternatives.

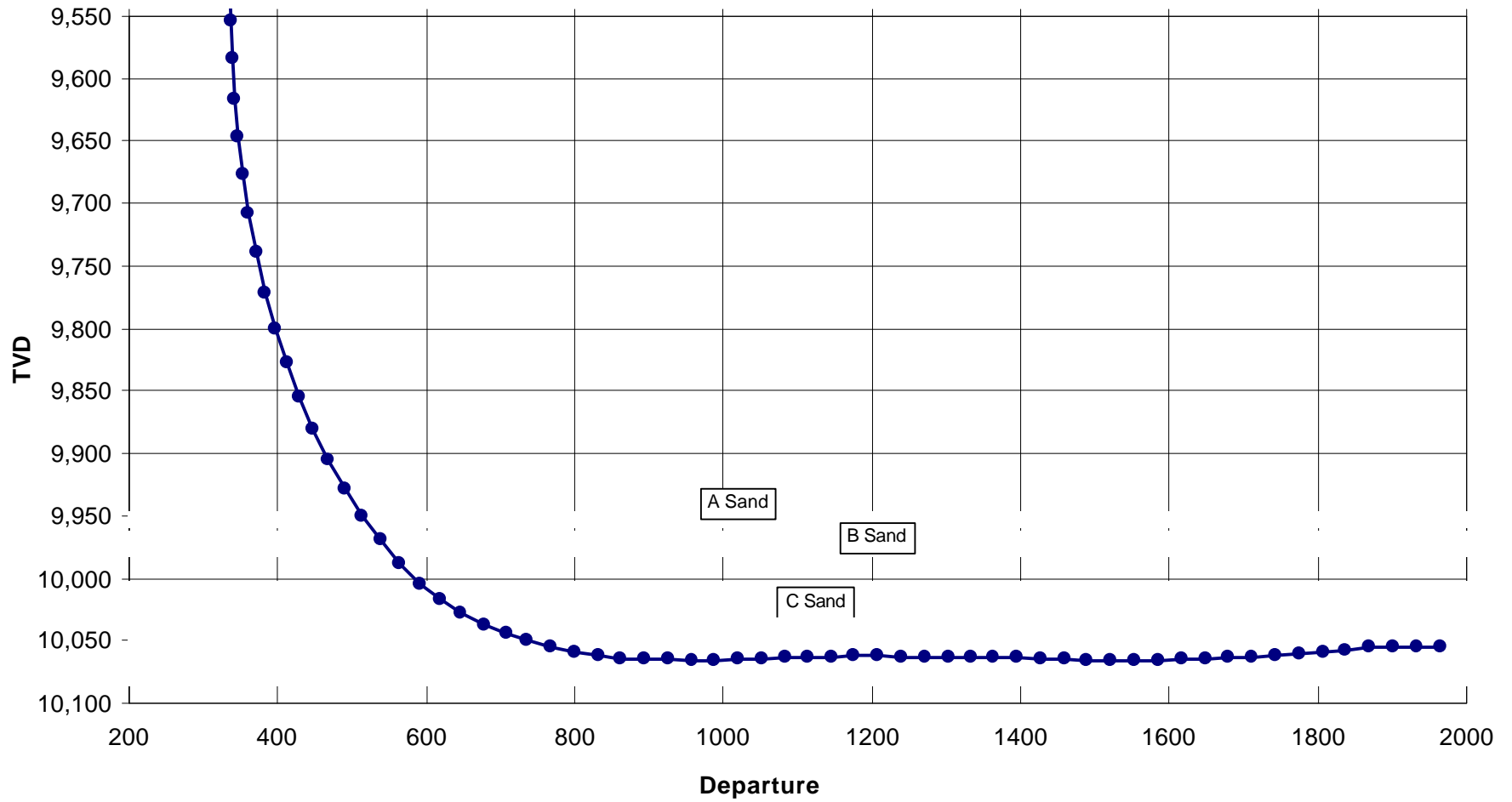


**Figure 1. East Binger Unit map showing well locations, including the new horizontal well EBU 37G-3H. The well's surface location is adjacent to EBU 37G01, which was plugged due to casing problems.**



**Figure 2. Open hole log from EBU 37G01 (Note - neutron porosity is based on a limestone matrix; density porosity is calculated using a grain density of 2.71 g/cc). Horizontal well EBU 37G-3H was drilled from the same surface location.**

### EBU 37G-3H Directional Data



**Figure 3. Path of EBU 37G-3H wellbore**