

ATTACHMENT 3
U.S. Department of Energy
FEDERAL ASSISTANCE REPORTING CHECKLIST
AND INSTRUCTIONS

1. Identification Number: DE-FE0004566	2. Program/Project Title: "Prototyping and testing a new volumetric curvature tool for modeling reservoir compartments and leakage pathways in the Arbuckle saline aquifer: Reducing uncertainty in CO2 storage and permanence"																																				
3. Recipient: University of Kansas																																					
4. Reporting Requirements: A. MANAGEMENT REPORTING <input checked="" type="checkbox"/> Progress Report <input checked="" type="checkbox"/> Special Status Report B. SCIENTIFIC/TECHNICAL REPORTING * <small>(Reports/Products must be submitted with appropriate DOE F 241. The 241 forms are available at https://www.osti.gov/ejink)</small> <table style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">Report/Product</th> <th style="text-align: left; border-bottom: 1px solid black;">Form</th> </tr> </thead> <tbody> <tr> <td><input checked="" type="checkbox"/> Final Scientific/Technical Report</td> <td>DOE F 241.3</td> </tr> <tr> <td><input checked="" type="checkbox"/> Conference papers/proceedings/etc.*</td> <td>DOE F 241.3</td> </tr> <tr> <td><input type="checkbox"/> Software/Manual</td> <td>DOE F 241.4</td> </tr> <tr> <td><input checked="" type="checkbox"/> Other (see special instructions)</td> <td></td> </tr> <tr> <td style="padding-left: 20px;">Topical</td> <td>DOE F 241.3</td> </tr> </tbody> </table> <small>* Scientific/technical conferences only</small> C. FINANCIAL REPORTING <input checked="" type="checkbox"/> SF-425, Federal Financial Report D. CLOSEOUT REPORTING <input checked="" type="checkbox"/> Patent Certification <input checked="" type="checkbox"/> Property Certificate <input type="checkbox"/> Other E. OTHER REPORTING <input checked="" type="checkbox"/> Annual Indirect Cost Proposal <input checked="" type="checkbox"/> Annual Inventory Report of Federally Owned Property, if any <input type="checkbox"/> Other F. AMERICAN RECOVERY AND REINVESTMENT ACT REPORTING <input type="checkbox"/> Reporting and Registration Requirements	Report/Product	Form	<input checked="" type="checkbox"/> Final Scientific/Technical Report	DOE F 241.3	<input checked="" type="checkbox"/> Conference papers/proceedings/etc.*	DOE F 241.3	<input type="checkbox"/> Software/Manual	DOE F 241.4	<input checked="" type="checkbox"/> Other (see special instructions)		Topical	DOE F 241.3	<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Frequency</th> <th style="text-align: center;">No. of Copies</th> <th style="text-align: center;">Addresses</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Q A</td> <td style="text-align: center;">Electronic Version to NETL></td> <td style="text-align: center;"><u>FITS@NETL.DOE.GOV</u></td> </tr> <tr> <td style="text-align: center;">FG A</td> <td style="text-align: center;">Electronic Version to E-link></td> <td style="text-align: center;">http://www.osti.gov/ejink-2413 http://www.osti.gov/ejink-2413 http://www.osti.gov/estsc/241-4pre.isp</td> </tr> <tr> <td style="text-align: center;">A</td> <td></td> <td></td> </tr> <tr> <td style="text-align: center;">Q, FG</td> <td style="text-align: center;">Electronic Version To NETL></td> <td style="text-align: center;"><u>FITS@NETL.DOE.GOV</u></td> </tr> <tr> <td style="text-align: center;">FC FC</td> <td style="text-align: center;">Electronic Version To NETL></td> <td style="text-align: center;"><u>FITS@NETL.DOE.GOV</u></td> </tr> <tr> <td style="text-align: center;">A A</td> <td style="text-align: center;">Electronic Version To NETL></td> <td style="text-align: center;"><u>FITS@NETL.DOE.GOV</u></td> </tr> <tr> <td></td> <td></td> <td style="text-align: center;">http://www.federalreporting.gov</td> </tr> </tbody> </table>	Frequency	No. of Copies	Addresses	Q A	Electronic Version to NETL>	<u>FITS@NETL.DOE.GOV</u>	FG A	Electronic Version to E-link>	http://www.osti.gov/ejink-2413 http://www.osti.gov/ejink-2413 http://www.osti.gov/estsc/241-4pre.isp	A			Q, FG	Electronic Version To NETL>	<u>FITS@NETL.DOE.GOV</u>	FC FC	Electronic Version To NETL>	<u>FITS@NETL.DOE.GOV</u>	A A	Electronic Version To NETL>	<u>FITS@NETL.DOE.GOV</u>			http://www.federalreporting.gov
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FREQUENCY CODES AND DUE DATES: A - As required; see attached text for applicability. FG - Final; within ninety (90) calendar days after the project period ends. FC - Final - End of Effort. Q - Quarterly; within thirty (30) calendar days after end of the calendar quarter or portion thereof. S - Semiannually; within thirty (30) calendar days after end of project year and project half-year. YF - Yearly; 90 calendar days after the end of project year. YP - Yearly Property - due 15 days after period ending 9/30.																																					
5. SPECIAL INSTRUCTIONS: <ul style="list-style-type: none"> • The forms identified in the checklist are available at DOE Financial Assistance Forms Page. Alternate formats are acceptable provided the contents remain consistent with the form. • See Federal Assistance Reporting Instructions on the following page. 																																					

QUARTERLY PROGRESS REPORT

Award Number: DE-FE0004566

Recipient

**University of Kansas Center for Research and
The Kansas Geological Survey
1930 Constant Avenue
Lawrence, Kansas 66047**

Title

**“Prototyping and testing a new volumetric curvature tool for modeling
reservoir compartments and leakage pathways in the Arbuckle saline aquifer: reducing
uncertainty in CO₂ storage and permanence”**

**Project Director/Principal Investigator: Jason Rush
Joint Principal Investigator: Lynn Watney**

7th Quarter Progress Report

Date of Report: 8/9/2012

Authors: Jason Rush and W. Lynn Watney

Period Covered by this Report: April 1, 2012 through July 30, 2012

Executive Summary

The contract for the project, “*Prototyping and testing a new volumetric curvature tool for modeling reservoir compartments and leakage pathways in the Arbuckle saline aquifer: reducing uncertainty in CO₂ storage and permanence*,” was signed with U.S. DOE on October 1, 2010. The project is collaboration between the Kansas Geological Survey (KGS) and its industry partner MVP LLC (a partnership between Murfin Drilling Company and Vess Oil Corporation). The project study area is located in Ellis County, Kansas.

Major results from this quarter include: (1) simulation and history matching of the pre-spud geocellular model; (2) completion of the petrophysical evaluation for the McCord-A 20H logs; (3) inclusion of the seismic inversion volume into the porosity modeling workflow; and (4) delivery of thin sections corresponding to the L. Hadley-4 core analyses, which will be used to constrain rock fabric-petrophysical relationships (i.e., facies model).

A numerical simulation model has been created for the Bemis Shutts Arbuckle formation to evaluate flux between fracture blocks and the applicability of directional wells in this style of reservoir. The simulation model focused on the fault block including or adjacent to the McCord-A 20H well. The model has been validated as a predictive tool by history matching individual well production history. The Leases in the study area have been on production from 1937, but the principal validation is based on well tests and historical water cut performance over the period September 1990 through December 2011. The history match is not a unique solution. Several suitable matches were derived under different values for the uncertainty parameters. The next phase of these models will be to analyze the effect of uncertain on the flux between fault blocks.

Structural interpretation of the McCord-A 20H image log is ongoing. Structural heterogeneities identifiable in the image log consist of fault or paleokarst breccias, to shale-filled faults, solution-enlarged vugs, and faults/fractures having a disparate apertures and orientations. Work on the revised fault model is ongoing. We are investigating whether Petrel’s seismic-based *automatic fault extraction* can identify faults/fractures consistent with the volumetric curvature interpretation. Different seismic pre-processing routines have been carried-out ranging from variance, vertical smoothing, chaos, and ant-tracking. Such processed volumes are then used by *automatic fault extraction* to quickly identify potential faults.

Next quarter objectives are: (1) to acquire fluid samples from boreholes offsetting the McCord-A 20H; (2) complete seismic attribute conditioning volumes; (3) finalize facies model; (4) complete image log interpretation; (5); continue simulation-based sensitivity studies; and (6) import remote sensing interpretations (ArcGIS shape file format). Research results to date will be presented in August at the DOE’s Carbon Storage R&D Project Review Meeting and again in October during the DOE’s Carbon Storage Peer Review.

DISCUSSION

Approach:

Pre-spud Simulation—Simulation studies are being undertaken by Gene Williams. As discussed in earlier reports, a pre-spud, static geocellular model was created in Petrel. Specific reservoir structure and data were exported from the static model for use in the dynamic numerical simulation models. For these studies, numerical simulation modeling is carried out utilizing the Computer Modeling Group simulation tools “IMEX”, a black oil simulation tool.

The static model data was exported in RESCUE format. The RESCUE file was imported into the CMG software program BUILDER. The total grid as imported is illustrated in Figure 1.

The static model covered a larger volume of the reservoir than necessary for analysis of the fault blocks relevant to the McCord-A 20 H lateral wells. Using BUILDER, a sub-grid was extracted from the static model data for use in dynamic modeling. This sub-grid and the relevant fault block ID is presented in Figure 2. The McCord-A 20H well is located in Fault Block 11.

The specific parameters imported from the static model were:

- Rescue grid: corner point geometry
 - 166×169×60 – total cells:1,683,240 (active cells: 793,080)
 - Each cell is 25m by 25m (82 ft by 82 ft) areally and 4-ft thick
 - Several no-throw faults are present throughout the model
- Dynamic model sub-grid (only modeling fault blocks of interest)
 - 70×57×60 – total cells: 239,400 (active cells:74,640)
 - Each cell is 25m by 25m (82 ft by 82 ft) areally and 4 ft thick
 - Several no-throw faults are present throughout the model
- Cell porosity – Figure 3 illustrates the porosity distribution in the sub-grid model and in fault block 11
- Cell permeability – Figure 4 illustrates the permeability distribution in the sub-grid model and in fault block 11
- Null (inactive) cells
- Initial water saturation
- Well trajectories

Other relevant simulation grid values assigned to the dynamic model are:

- A pseudo steady state (Fetkovich) aquifer function is connected to the bottom of the model
 - Aquifer parameters (height, area, porosity, permeability, etc) are history matching variables
- Rock compressibility 5.0E-6 psi-1 at 1500 psi

The reservoir fluid properties were determined from correlations and the oil PVT report for the Peavy No B-1 well which is located in the Bemis-Shutts Field. PVT values for gas oil ratio, formation volume factor and viscosity are illustrated in Figures 5 and 6. For simulation modeling the oil at initial conditions, in the reservoir, was assumed to be under-saturated with a bubble point pressure of 1000 psi.

SCAL was not available for the Bemis Shutts reservoir but typical values for similar reservoirs were taken from the available literature. For the reference case a residual oil saturation of 35%, a connate water saturation of 27%, and a K_{rw} at residual oil of 0.25 were assumed (Figure 7). Note that these endpoints are history matching variables and the values assumed were selected to ensure that they would serve as limiting values.

The water saturation for the reservoir model was taken from static model. However at time 0, the simulation model is initialized assuming capillary equilibrium. For this, a capillary pressure curve is estimated from the saturation versus height above free water level as illustrated in Figure 8 (the capillary pressure function is the black line with the yellow markers).

This capillary pressure function was applied to an uncertain original oil water contact (OWC) near 1550 ft SS. For capillary equilibrium, IMEX calculates first an initial cell pressure based on height above the contact and density differences between the oil and water. With this pressure the software then calculates a capillary pressure shift from the capillary pressure curve to match the input water saturation. This process ensures that the model is initially in equilibrium.

The initialized model and water saturation are illustrated in Figure 9. The initial in place volumes calculated are presented in Table 1. Well locations relative to the selected sub-grid are shown in the various images of the simulation grid. The relevant wells are listed in Table 2. The perforation history of each well was review to determine when and which layers in the model will be open to flow for each well.

Oil production data, by lease was available on an annual basis from 1937 to 1970 and monthly from 1970 to 2011 as illustrated in Figure 10. Also, the number of wells available for production in each lease was available over this period. However, allocated production by well was not available. For purposes of these models, the indicated lease production was assumed to be divided equally by the number of wells shown as available for production.

For history matching, data was available monthly and from test separator for a period from 1994 to 2011. It is this monthly data, especially the water cut information, that is used to validate the simulation model. Production test data was available for:

- Figure 11: McCord A-11
- Figure 12: McCord A-17
- Figure 13: Colahan B-28
- Figure 14: Hall B-15

For the producing period, well control uses estimated oil rate by well.

Petrophysical evaluation— The total porosity of the Arbuckle was estimated using a multi-mineral model of dolomite, quartz, calcite, and shale applied to photoelectric factor, gamma-ray, density and neutron porosity curves (Figure 15). This porosity was then partitioned between “primary” and “secondary” porosity by comparing sonic porosity (calibrated to the multi-mineral matrix transit time) to the total volumetric porosity. Many empirical studies have suggested that the sonic porosity is primarily sensitive to interparticle porosity (“primary”) and that the difference with total porosity reflects vugs (“secondary porosity”), although the explanatory physical model is mildly controversial.

An alternative method to partition the pore space was proposed by Watfa and Nurmi (1987) using some simple modifications to the Archie equation that incorporate fracture porosity and vug porosity. They reported that application of these equations were matched well by core measurements from a variety of Middle Eastern carbonate reservoirs and were an improvement on the simple Archie equation with cementation exponent, m of 2 that is generally applicable for carbonates dominated by interparticle porosity. If planar fractures have an m value of unity and the matrix has intergranular and intercrystalline porosity with $m=2$, then the apparent m of a fractured carbonate can be solved by considering the fractures and matrix as resistances in parallel. Then:

$$\Phi^m = \Phi_f + \Phi_{mx}^2$$

where Φ is the total porosity made up of Φ_f , the fracture porosity and Φ_{mx} , the “matrix porosity” (intergranular plus intercrystalline porosities). If the vugs are not connected, then electrical current bypasses these unconnected vugs and, therefore, they are non-conductive voids (Figure 16). For this model, the equation is:

$$\Phi^m = (\Phi - \Phi_{nc})^2$$

where Φ_{nc} is the vug porosity. There is insufficient information to solve for both fractures and vugs. However, if the apparent m of the carbonate is clearly higher than 2, then unconnected or poorly connected “vugs” (either molds or vugs) are suggested. In this case, the vug equation can be used to solve for vuggy porosity. (This assumes that the elevated m values are not caused by hydrocarbon saturations.) If the apparent m value is markedly less than 2, then fracture porosity may be suspected.

REFERENCE:

- Watfa, M., and Nurmi, R., 1987, Calculation of saturation, secondary porosity and producibility in complex Middle East carbonate reservoirs, paper CC, in 28th annual logging symposium transactions: Society of Professional Well Log Analysts, 24 p.

Seismic Inversion and Geocellular Modeling—Results from PSTM inversion was discussed in the 6th Quarterly Report. Because a PSTM volume can not be used as a probability cube for property modeling within Petrel, a genetic inversion of the PSDM amplitude volume was performed within Petrel. The genetic inversion algorithm can predict—using a neural network—interwell seismic attributes that are correlated with training data from acoustic petrophysical logs such as sonic, neutron, and density (Figures 17). The PSDM seismic volume was re-sampled to create an Arbuckle-only volume, so that the resulting genetic inversion would not be biased to data above the Arbuckle. This new 3-D seismic porosity attribute was then converted to a grid within the 3-D geocellular model (Figure 18). A workflow was set-up whereby the porosity distribution is conditioned to the facies model and collocated, co-Kriged to the PSDM seismic porosity model using a 75% correlation coefficient. The porosity is then smoothed to reduce the nugget effect. A preliminary porosity model—which is not yet been conditioned to a facies model—is shown in Figure 19. Development of the facies model is ongoing.

Results and discussion:

Pre-spud Simulation—History matching was carried out using the CMG automatic history matching software program CMOST. Uncertain history matching parameters include:

- Aquifer Parameters
 - Angle, radius, thickness
- Depth to Oil Water Contact
- Reference Pressure (at the oil water contact)
- Relative Permeability shape and end-points
 - Gravity Stable or Corey
 - Critical water saturation
 - Residual oil saturation
- Transmissibility (i.e. Connectivity or Tortuosity)
 - Variable by fault block
 - I-Direction versus J-Direction anisotropy
- Pore volume modifiers by fault block

The objective functions for the history matching were the water cut match for the 4 wells. The history matching process involved numerous simulation runs and used both CMOST DECE and Latin Hypercube with proxy approximation objective methods. During the process, response surface modeling using the software program JMP was applied to evaluate the significance of the uncertainty parameters and to accelerate the history matching process.

The results of the history match showing an oil production and water cut case for the combined wells is illustrated in Figure 20. The dark green line represents cumulative oil production, the lighter green line represents oil rate in STB/day. The black line shows the water cut—which is very high throughout the productive life of these wells. Individual well matches are provided in Figures 21–24. The historical water cut is represented by the blue circles, and the calculated water cut is represented by the red line.

Petrophysical evaluation—There is an excellent visual match between the sonic secondary porosity and the non-connected vuggy porosity calculated by the Watfa-Nurmi equation, which is a mutually supportive confirmation that both approaches are sensitive measures of larger pores, even though they are based on different physical properties (review Figure 16). The close match in values also suggests that the majority of the vugs are non-connected, at least in the electrical sense, rather than there are both connected and non-connected vugs. These results will be incorporated into the final geocellular model.

Seismic Inversion and Geocellular Modeling— Because bore-hole data represent only a fraction of a percent of the volume of oil & gas reservoirs, seismic attributes are frequently used by industry to predict inter-well, petrophysical trends. Geocellular porosity models that only model petrophysical properties measured from wire-line logs appear can appear almost random if not conditioned to facies and stratigraphic models and/or seismically derived probability volumes. Results from the PSDM genetic inversion for 3-D porosity trends is encouraging and cross-correlation to “blind wells” is 78%. Despite the current lack of a facies model, conditioning provided by the 3-D PSDM seismic porosity attribute during the porosity modeling routine results in a spatial distribution of porosity that is stratigraphically realistic (review Figure 20).

Conclusions:

Results from the simulation, petrophysical evaluation, and PSDM genetic inversion are promising and will aid the evaluation of seismic volumetric curvature for structural characterization and seal risk assessment. We should complete the integrative image interpretation (e.g., with petrophysical evaluation and seismic attributes) next quarter. The interpretation will also be integrated with observations made from the L. Hadley-4 core description, routine core analyses, and thin section descriptions. Observations from core, image logs, and the petrophysical evaluation will permit us to build a robust facies model not only includes depositional facies, but also paleokarst-related facies. With the delivery of Petrel 2012, we can now move forward with importing remote sensing interpretation results, which are in ArcGIS shape file format.

Cost Status

Please refer to Attachment 1

Schedule/Milestone Status

Please refer to Attachment 2

BP1 Milestone Status: BP1–BP2 milestone status is as follows:

- Milestone 1.1 (completed): obtain field data including 3-D seismic, gravity magnetic, satellite imagery, production records, and well logs
- Milestone 1.2 (completed): seismic processing and interpretation, VC-analysis, surface mapping, generate pre-spud geocellular model
- Milestone 1.3 (completed): history match well performance using pre-spud geocellular model
- Milestone 1.4 (completed): locate, permit, drill, and log horizontal borehole (i.e., McCord-A 20H)
- Milestone 2.1 (in progress): complete formation evaluation: log analysis, XRD, core analysis, and water geochemistry
- Milestone 2.2 (completed): VC and seismic interpretation remain unchanged. Inversion completed.
- Milestone 2.3 (in progress): will constrain fault model to image interpretation and simulation results.

Changes in Approach or Aims

There are no changes to the post-Continuation SOPO for BP2. However, we are investigating using Petrel seismic processing tools and conditioning techniques for improving and streamlining structural, facies, and petrophysical modeling workflows as well as top and lateral seal assessment.

Actual or Anticipated Problems

There are no updates regarding *actual or anticipated problems* since the last quarterly report.

Absence or Key Personnel Changes

There are no updates regarding *absence or key personnel changes* since the last report.

Some promising news is that the Energy Research Section at the KGS has hired a replacement simulation engineer, Eugene Holubnyak. He has prior characterization experience working on DOE carbon sequestration studies.

Technology Transfer

The project website (<http://www.kgs.ku.edu/PRS/Bemis/index.html>) has been constructed and is available for public access. The project web site will display all results and interpretations obtained from this study and will be maintained by the KGS. Technology transfer activities are anticipated to begin during the final half of the last year, when all data collection has been completed, and analysis, interpretation, and modeling are in progress to demonstrate and validate the feasibility of using volumetric curvature analysis to characterize paleokarst reservoir compartmentalization to better model of CO₂ storage and permanence in saline aquifers such as the Arbuckle in Kansas.

Research results to date will be presented in August at the DOE's Carbon Storage R&D Project Review Meeting and again in October during the DOE's Carbon Storage Peer Review.

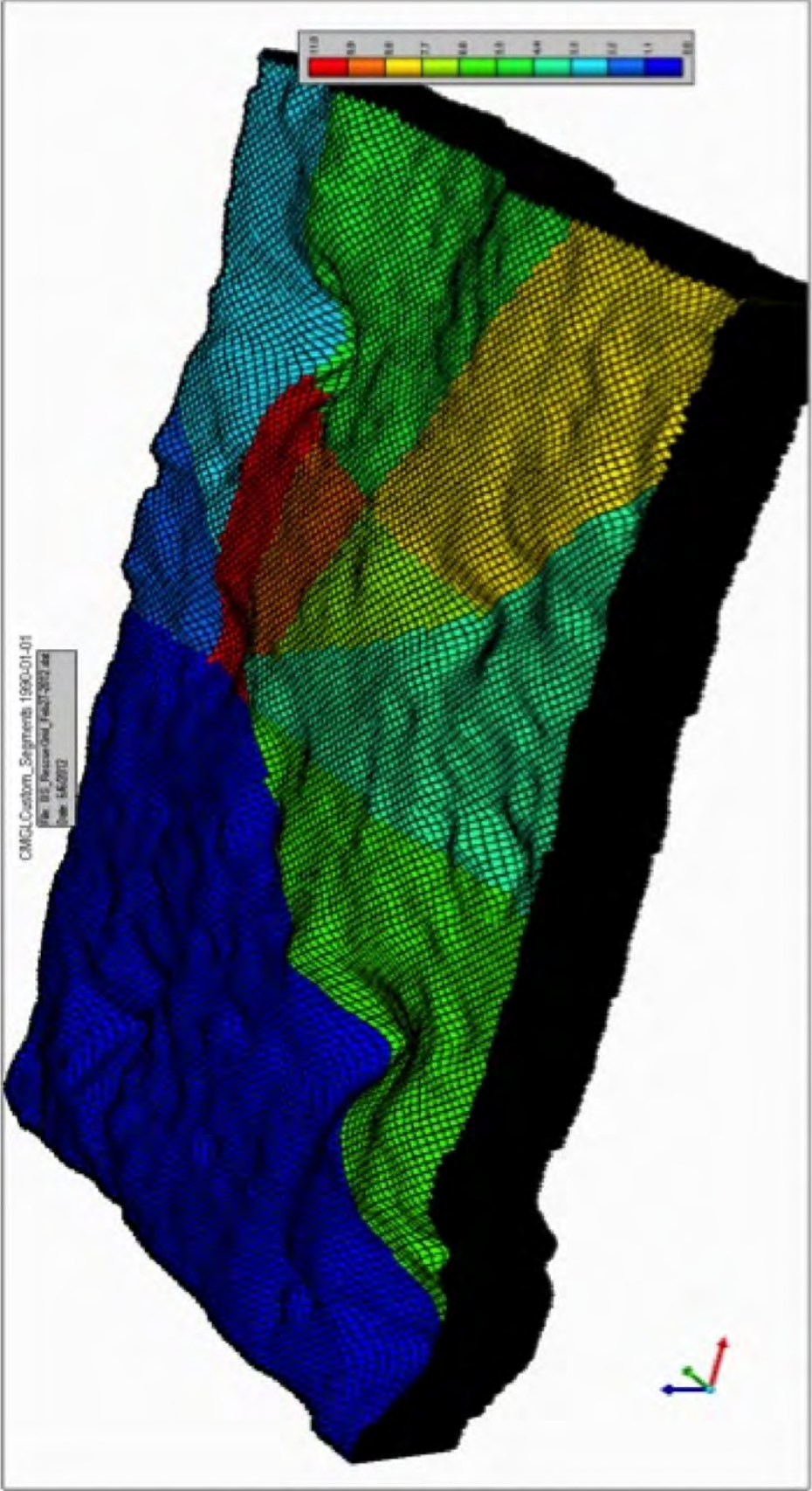


Figure 1. Initial Rescue model grid exported from Petrel. The color code in this figure corresponds to the segment (fault block) ID.

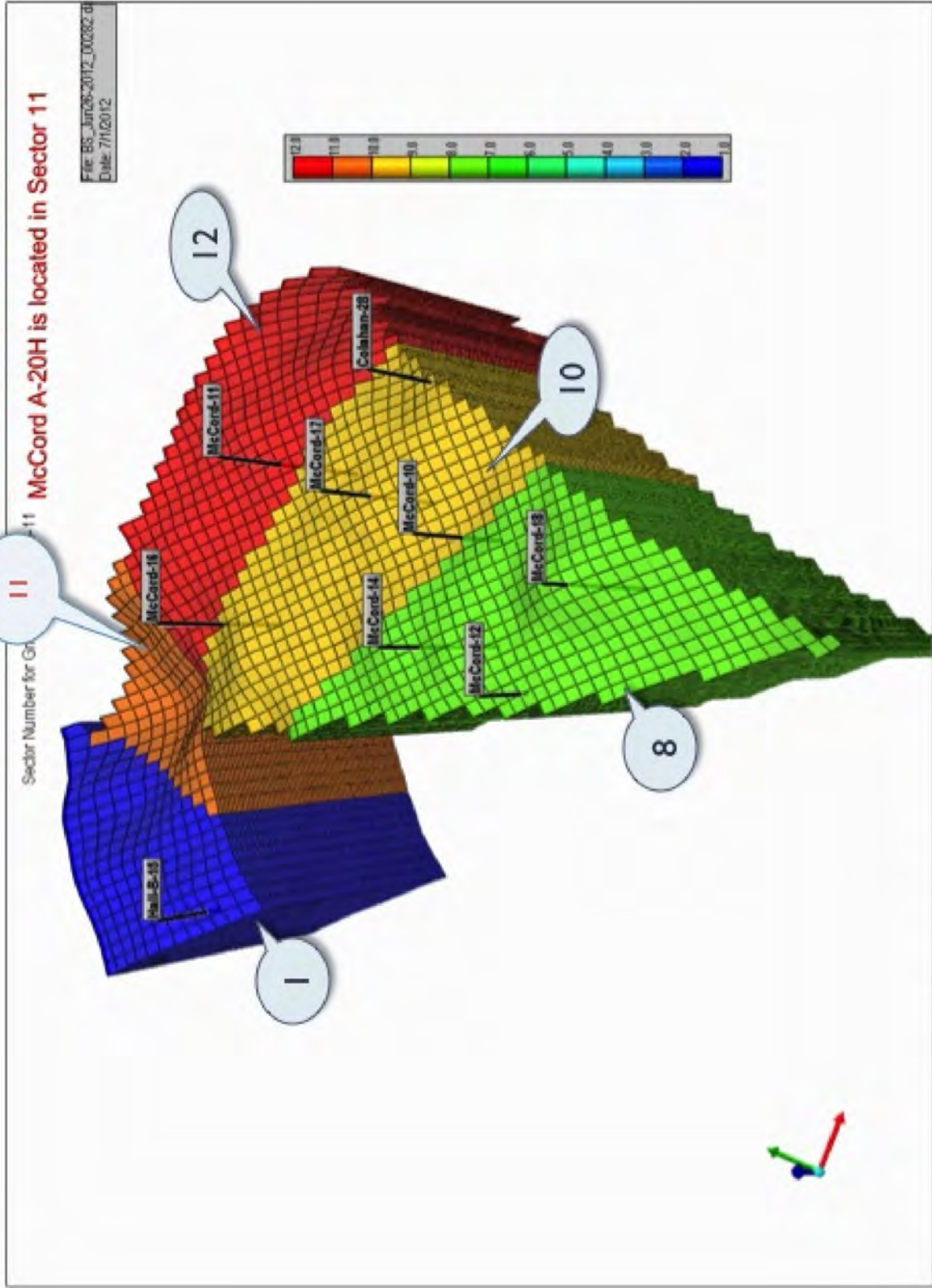


Figure 2. Segments in sub-grid dynamic model.

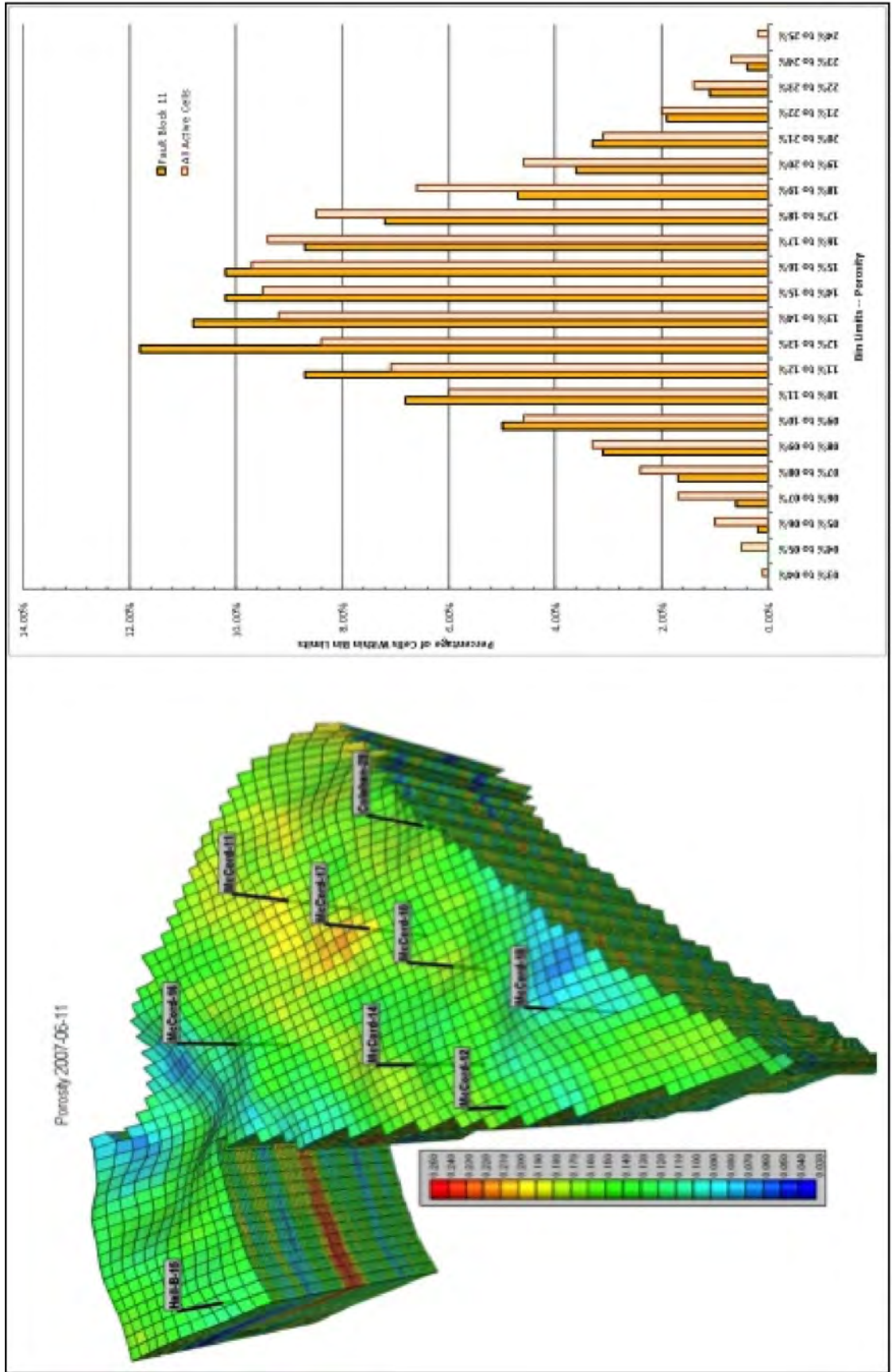


Figure 3. Porosity contrast between fault block 11 and others.

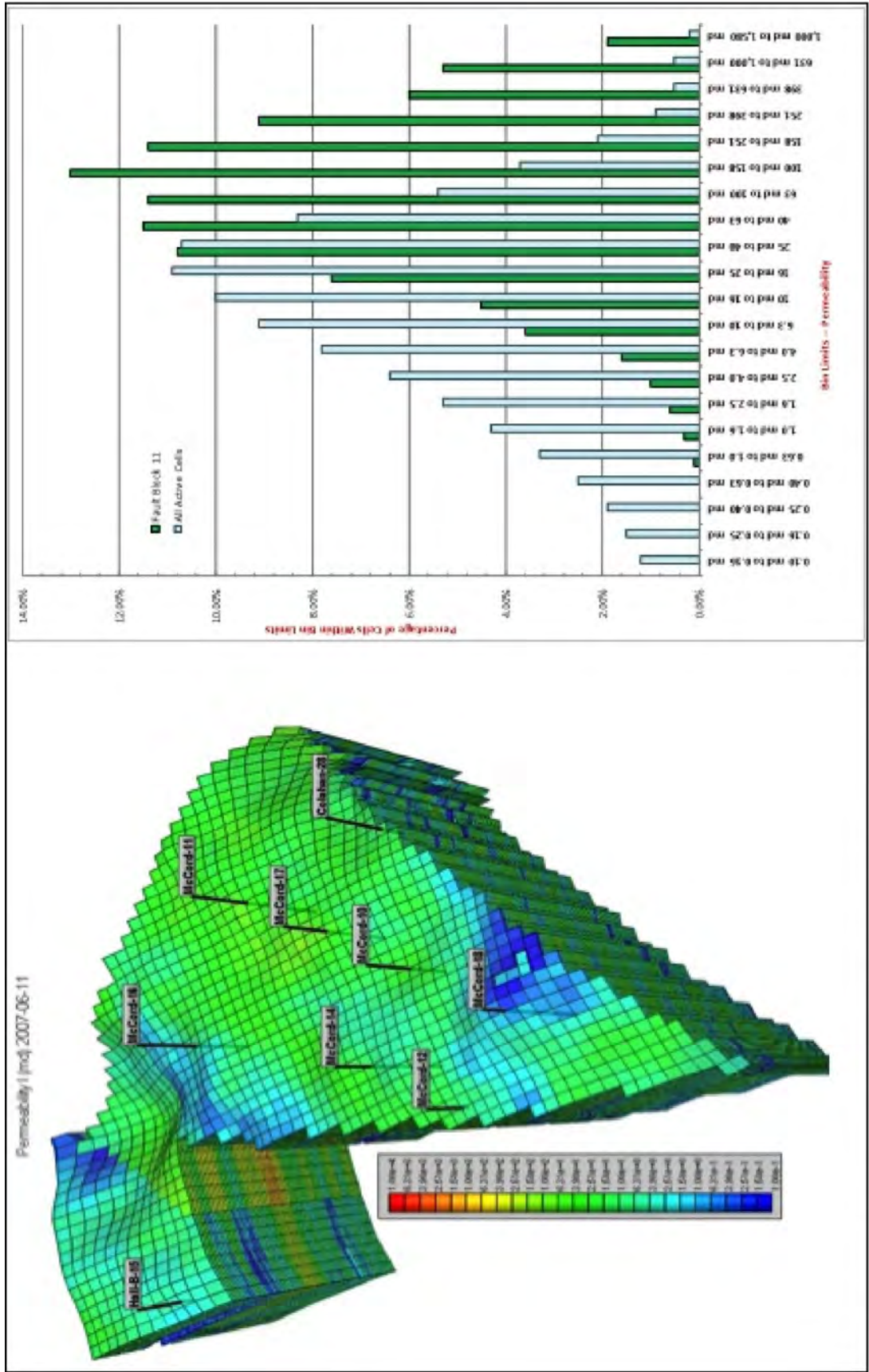


Figure 4. Permeability contrast between fault block 11 and others.

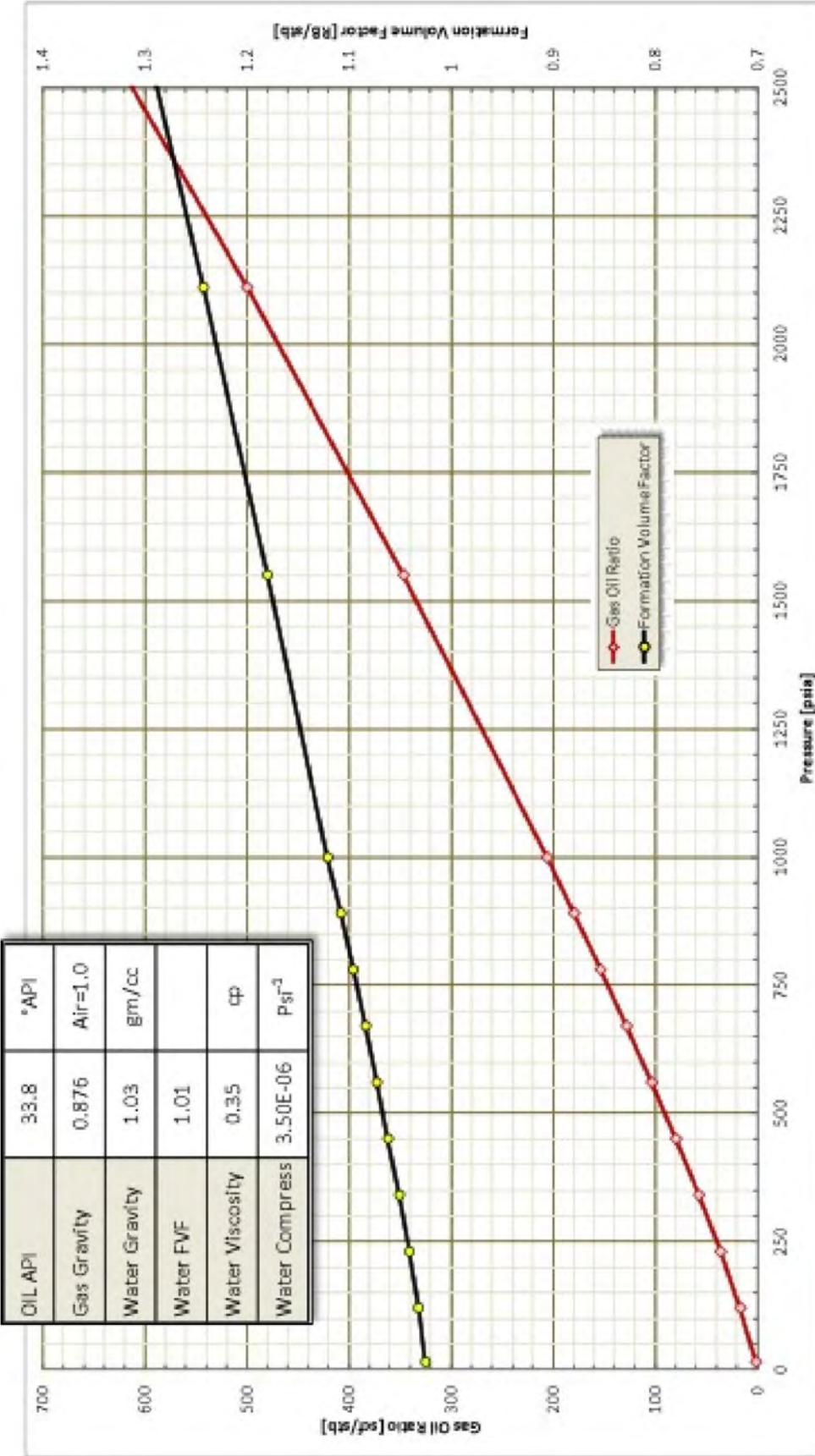


Figure 5. PVT relationship between gas oil ratio and formation volume factor.

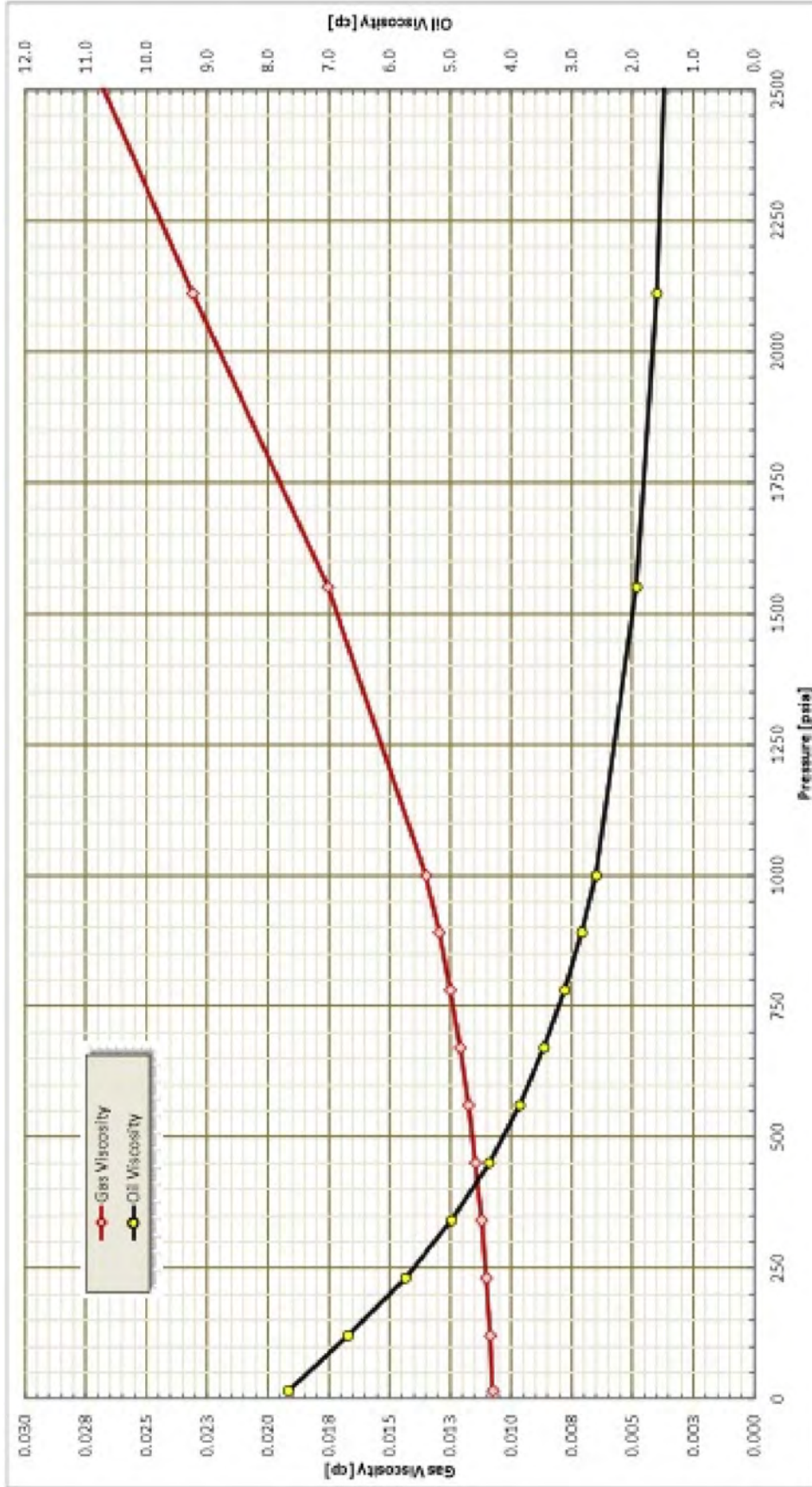


Figure 6. PVT --fluid viscosity.

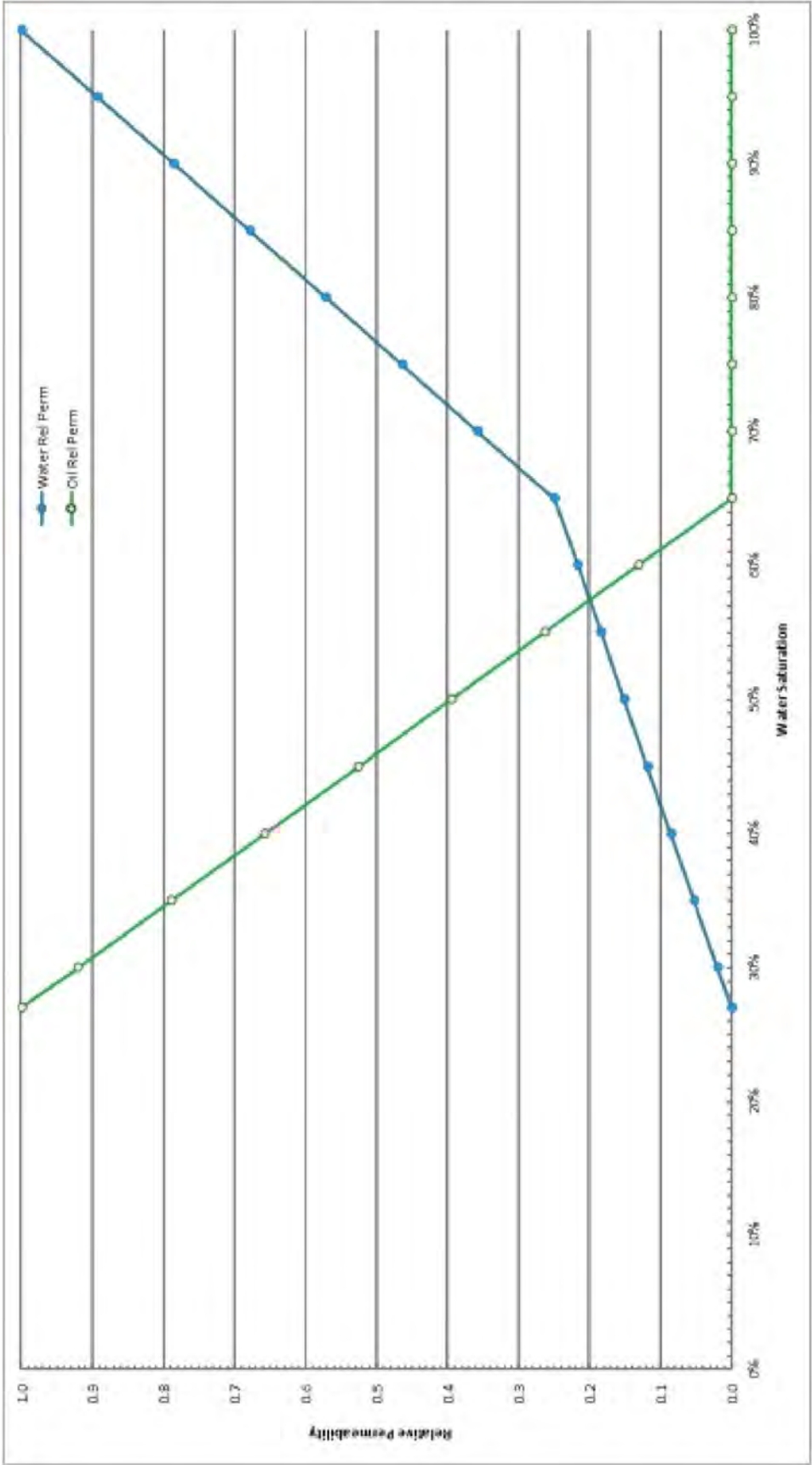


Figure 7. Gravity stable (VE) relative permeability .

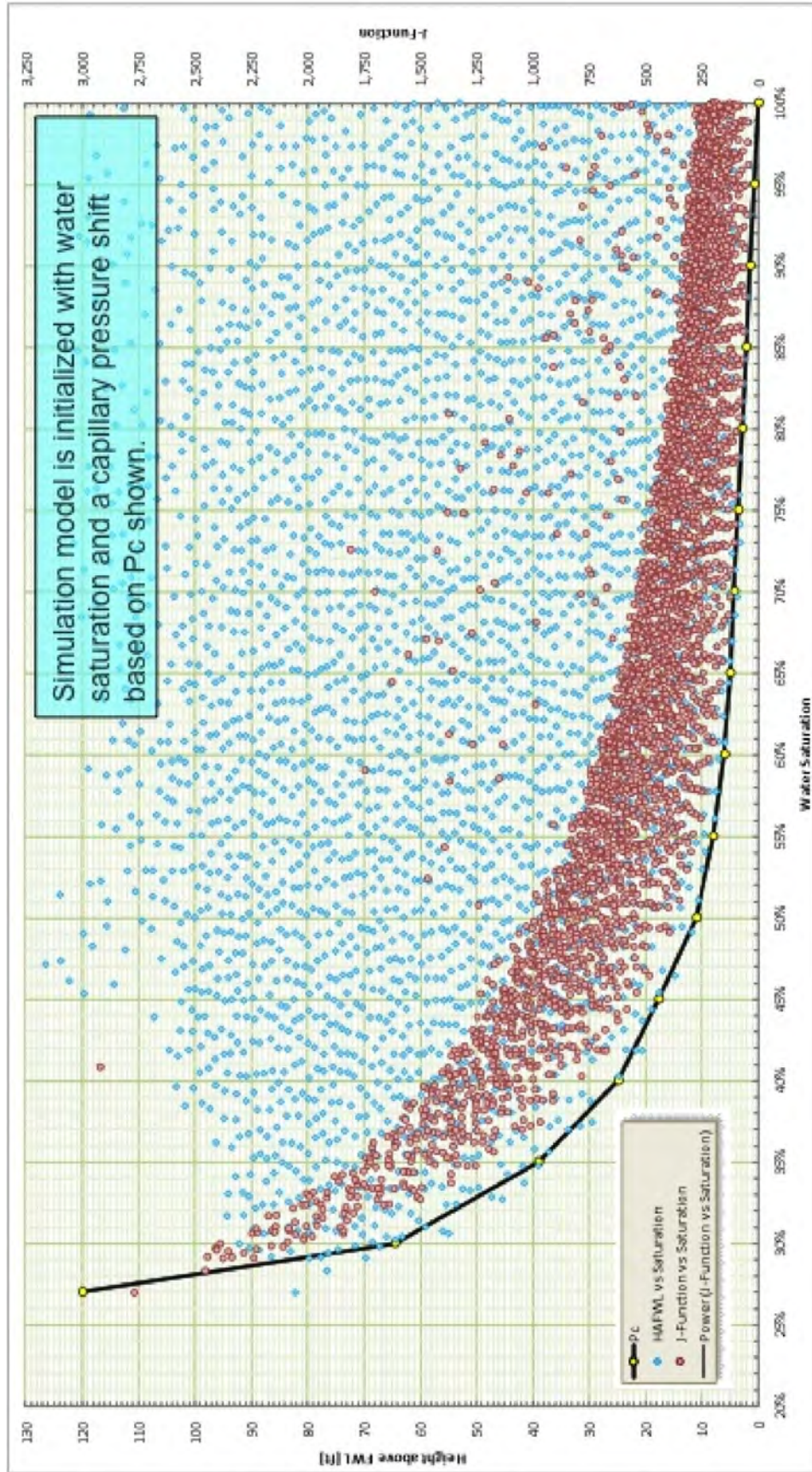


Figure 8. Capillary pressure used for initialization.

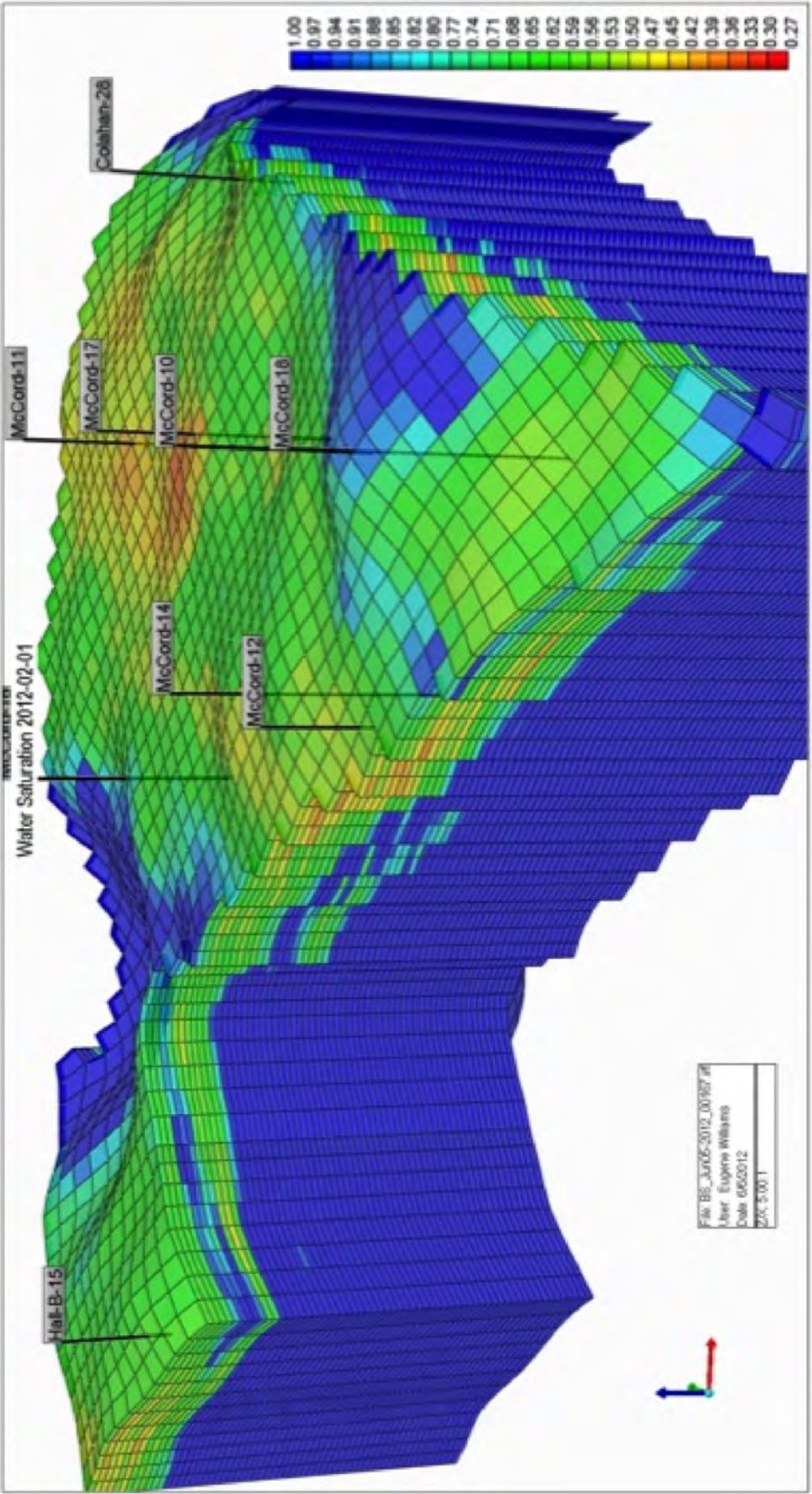


Figure 9. Initial water saturation model. Steady state (Fetkovich) analytic aquifer is connected to bottom layer.

		Entire Field	FB-1	FB-8	FB-10	FB-11	FB-12
Total Pore Volume.	M rbbl	51,009	7,876	13,924	11,816	4,652	12,687
HC Pore Volume	M rbbl	5,637	612	1,887	1,731	123	1,282
Fluids in Place							
Stock Tank Oil	M STB	5,054	549	1,692	1,552	110	1,149
Mobile STO	M STB	933	70	390	323	7	143
Total Gas	MM SCF	1,042	113	349	320	23	237
Free Gas	MM SCF						
Water	M STB	44,974	7,200	11,931	9,996	4,490	11,305
Reservoir Oil	M rbbl	5,637	612	1,887	1,731	123	1,282
Reservoir Gas	M rbbl						
Reservoir Water	M rbbl	45,373	7,264	12,037	10,085	4,530	11,405
Water Influx	M STB						
Average Pressure							
Total Pore Volume	psia	1320	1320	1313	1316.8	1335.8	1324.2
HC Pore Volume	psia	1281	1278	1277	1281.4	1287.9	1285.1
Pore Vol. at Datum	psia	1295	1295	1295	1294.8	1294.8	1294.8
Average Saturation %							
Oil		11.051	7.7763	13.552	14.65	2.6335	10.101
Gas							
Water		88.949	92.224	86.448	85.35	97.367	89.899

Table 1. Initialization volumes in-place.

<u>API Num</u>	<u>Lease and Well Number</u>
▶ 15-051-03462	Hall B 15
▶ 15-051-24960	Colahan B 28
▶ 15-051-05560	McCordA 10
▶ 15-051-05561	McCordA 11
▶ 15-051-05562	McCordA 12
▶ 15-051-05563	McCordA 14
▶ 15-051-05415	McCordA 16
▶ 15-051-22106	McCordA 17
▶ 15-051-22208	McCordA 18

Table 2. Wells of interest.

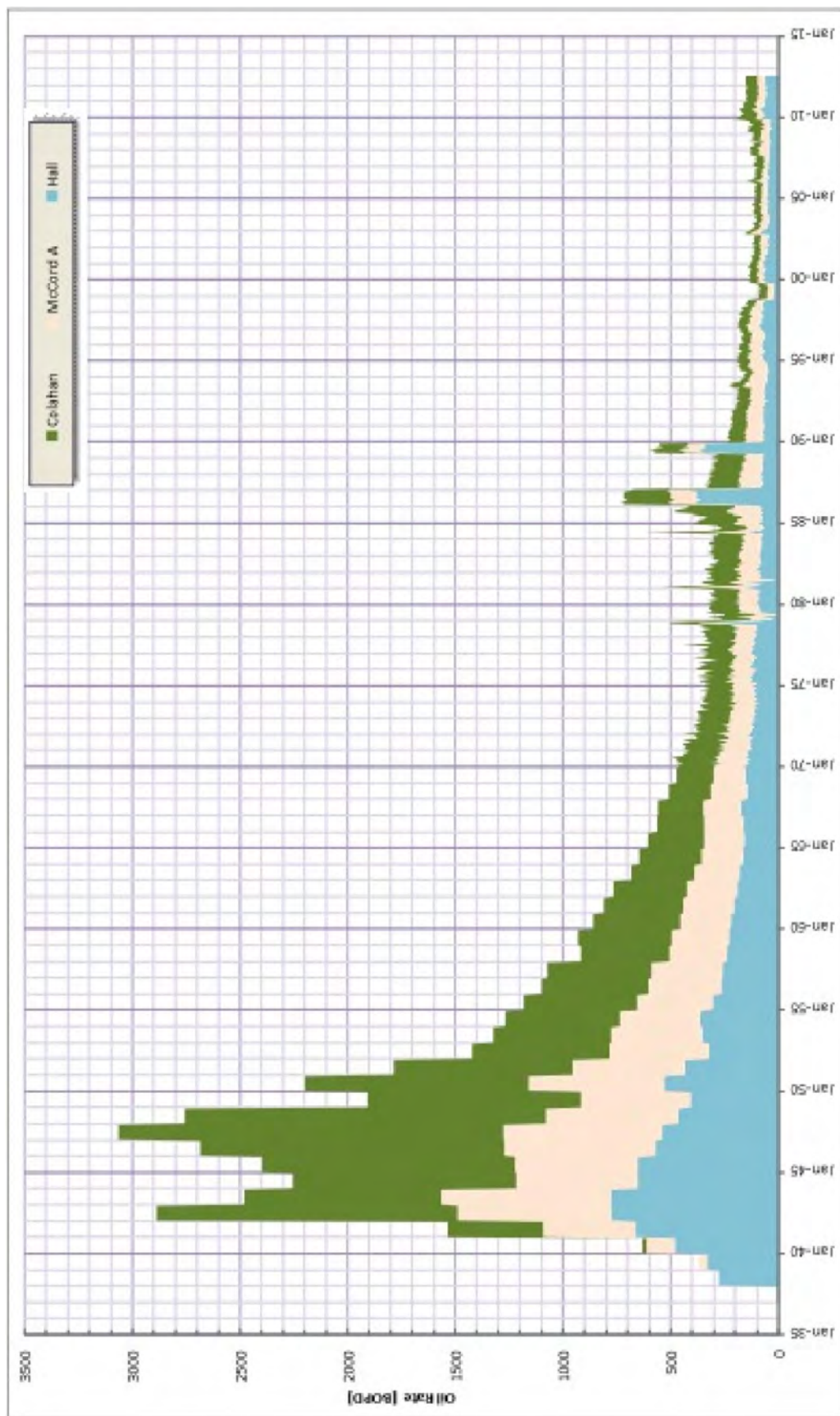


Figure 10. Production from KGS database for leases of interest.

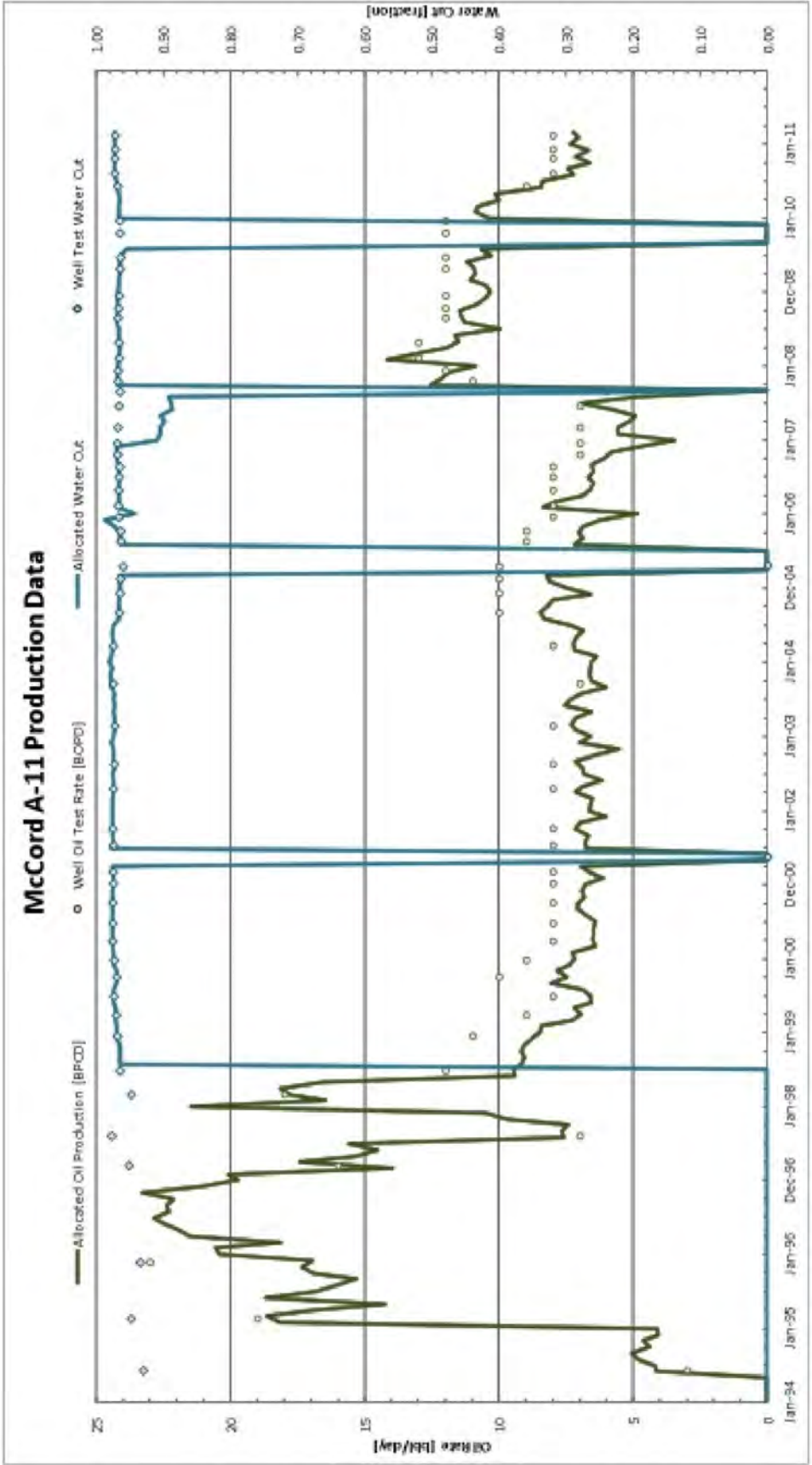


Figure 11. McCord-A 11 production data.

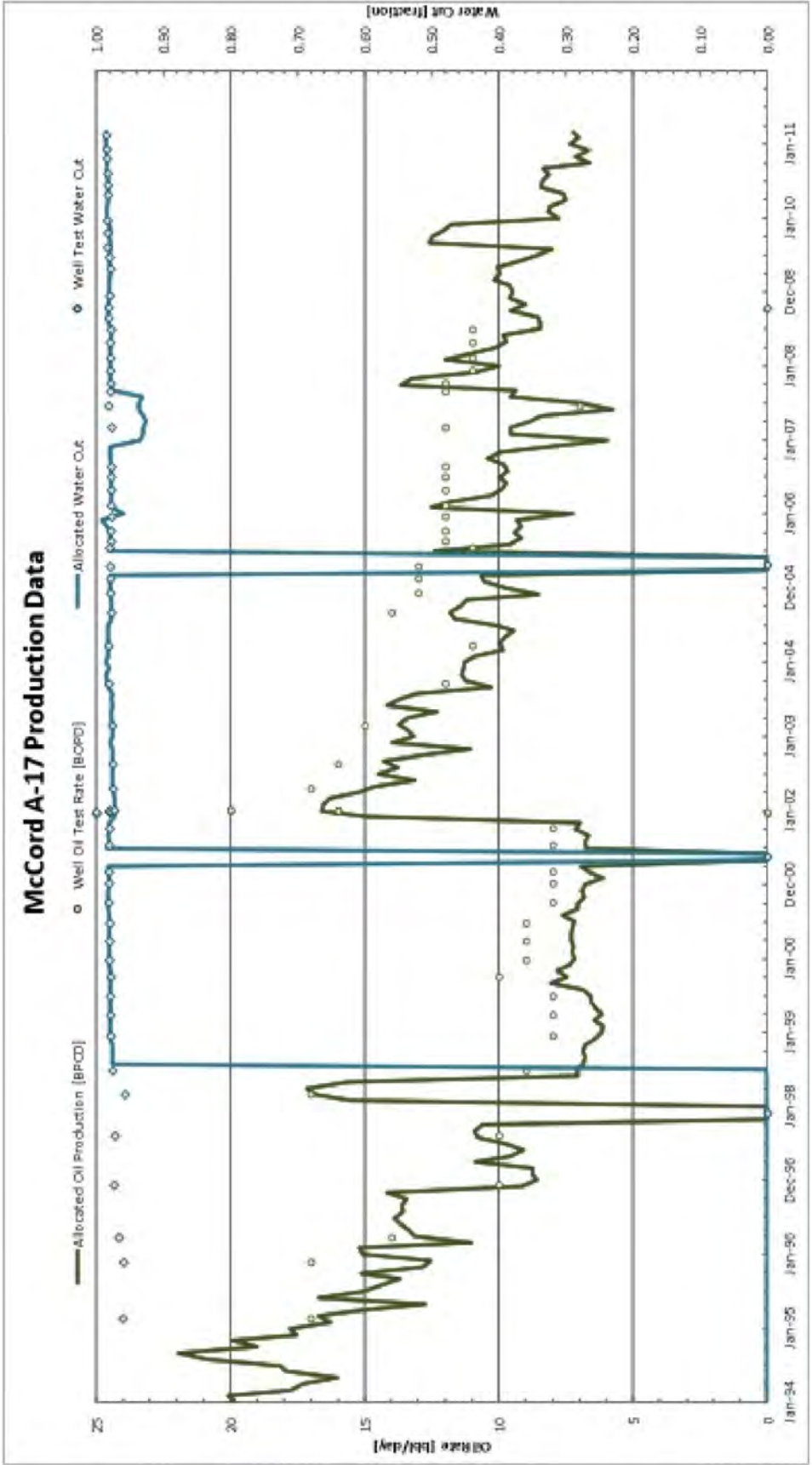


Figure 12. McCord-A 17 production data.

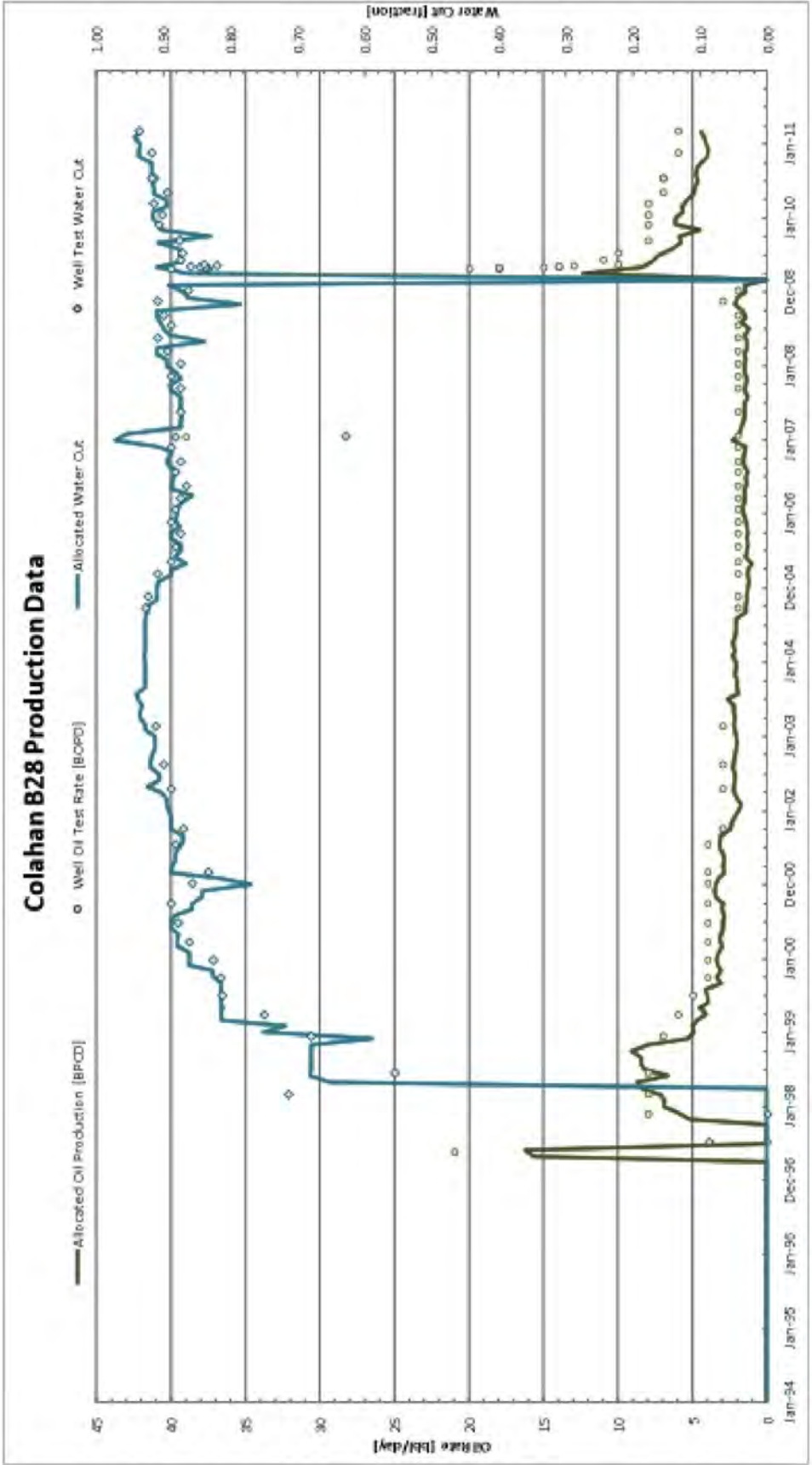


Figure 13. Colahan-B 28 production data.

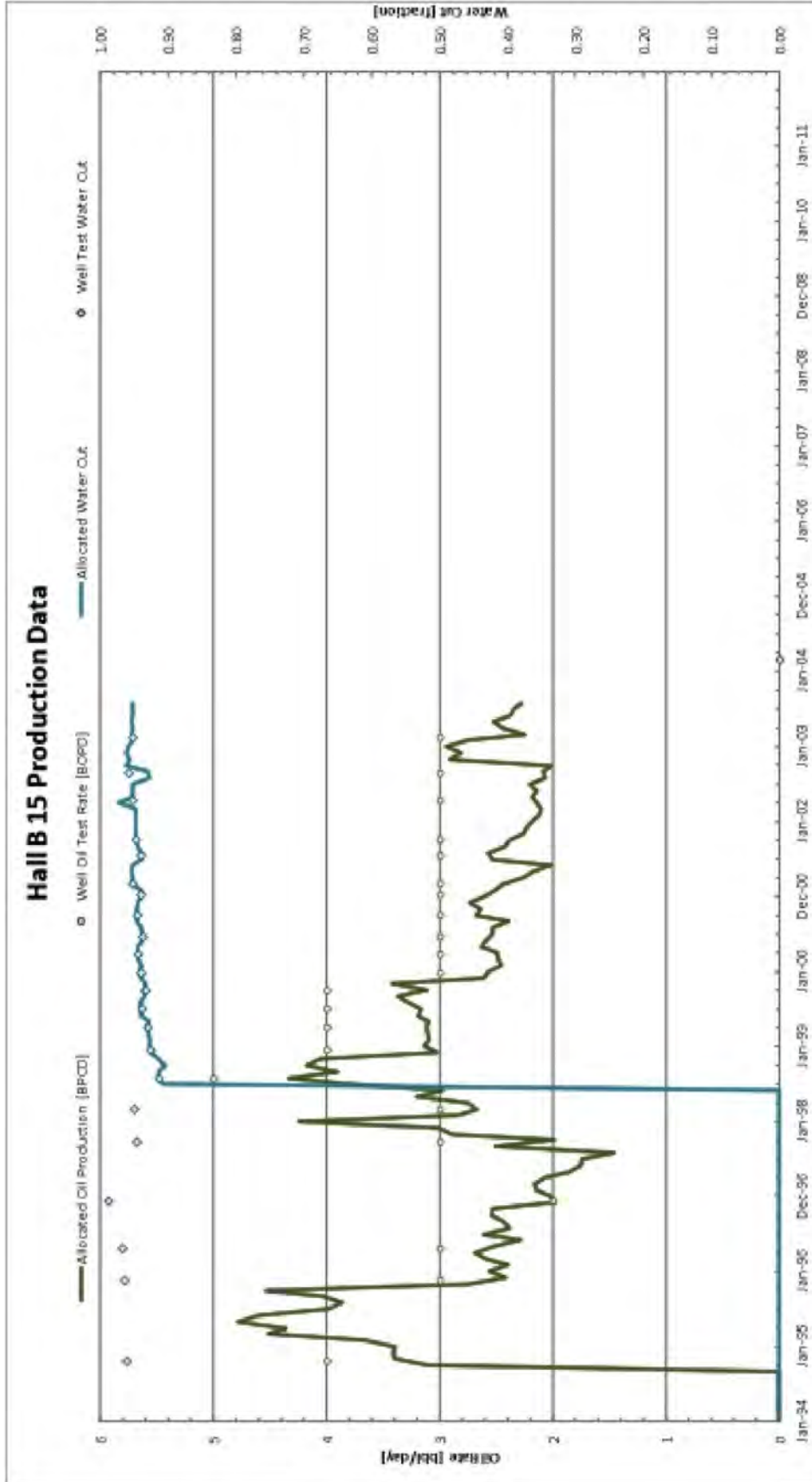


Figure 14. Hall-B 15 production data.

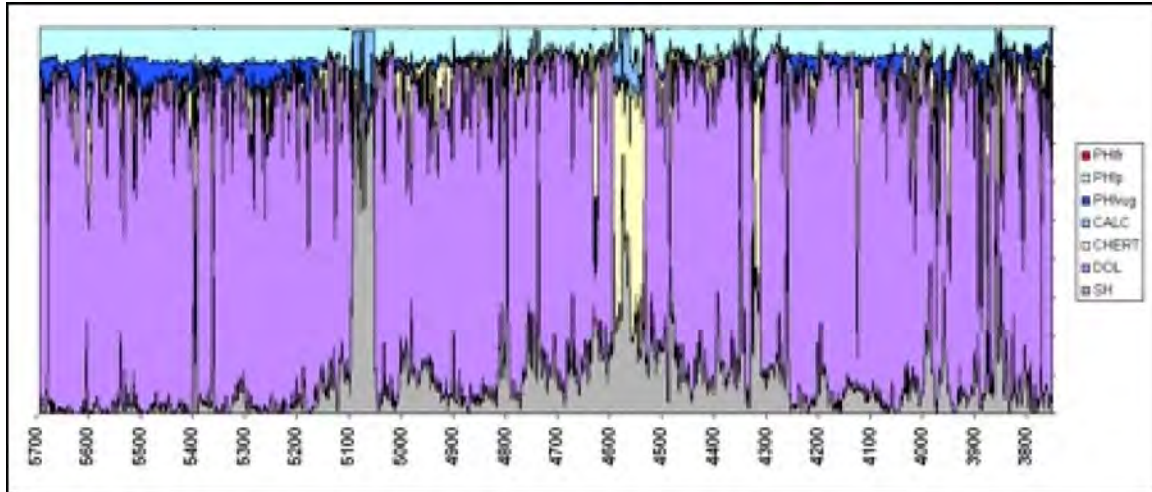


Figure 15. Mineralogy and porosity log from the McCord-A 20H.

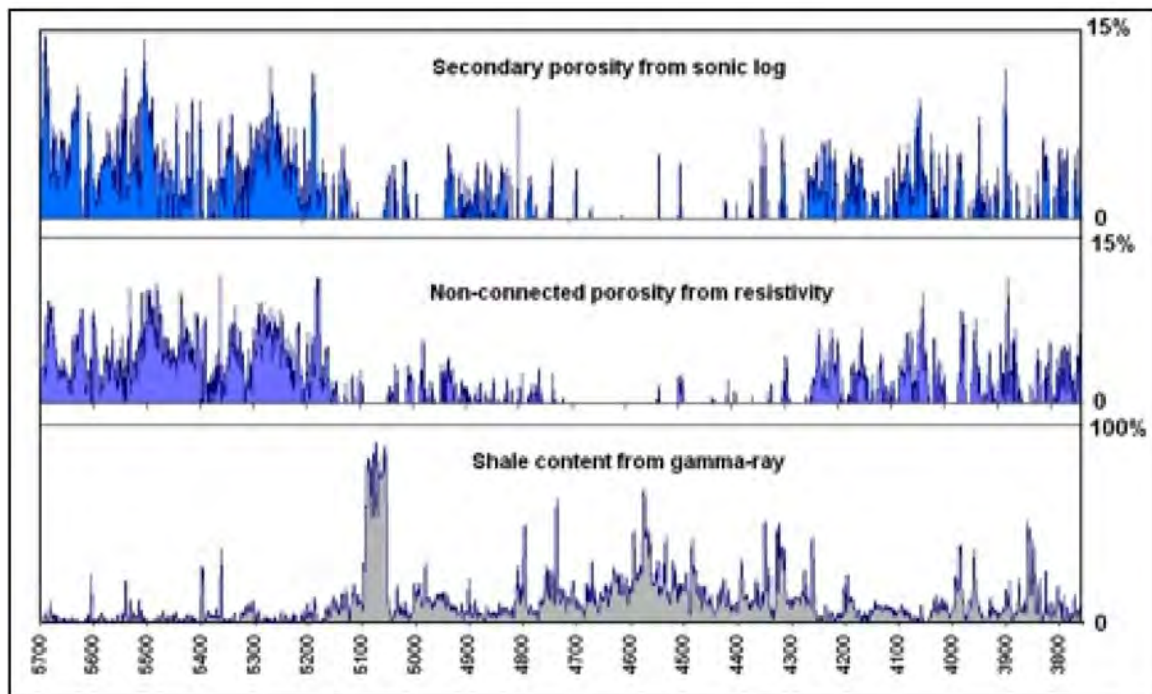


Figure 16. Logs showing secondary, or vug porosity, in relation to electrically non-connected porosity. Diagram indicates that most vugs are isolated and will not contribute to permeability (i.e., non-touching vugs).

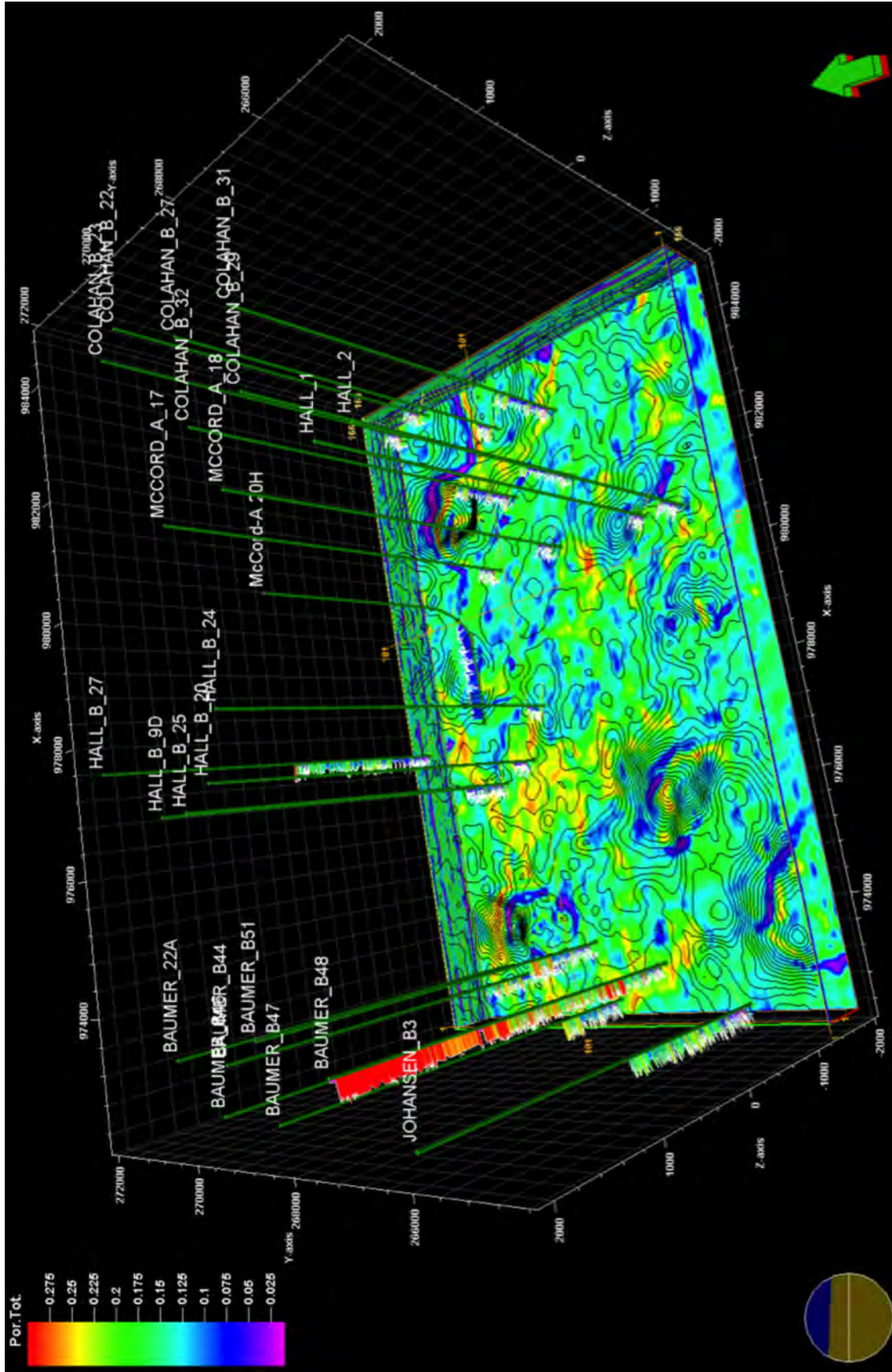


Figure 17. Petrel 3D window showing PSDM porosity attribute derived from genetic inversion and cross-correlation with porosity logs (XPHI). The Arbuckle-restricted, pre-processed volume was generated by resampling the entire PSDM volume in an attempt to limit biasing from overlying section during cross-correlation.

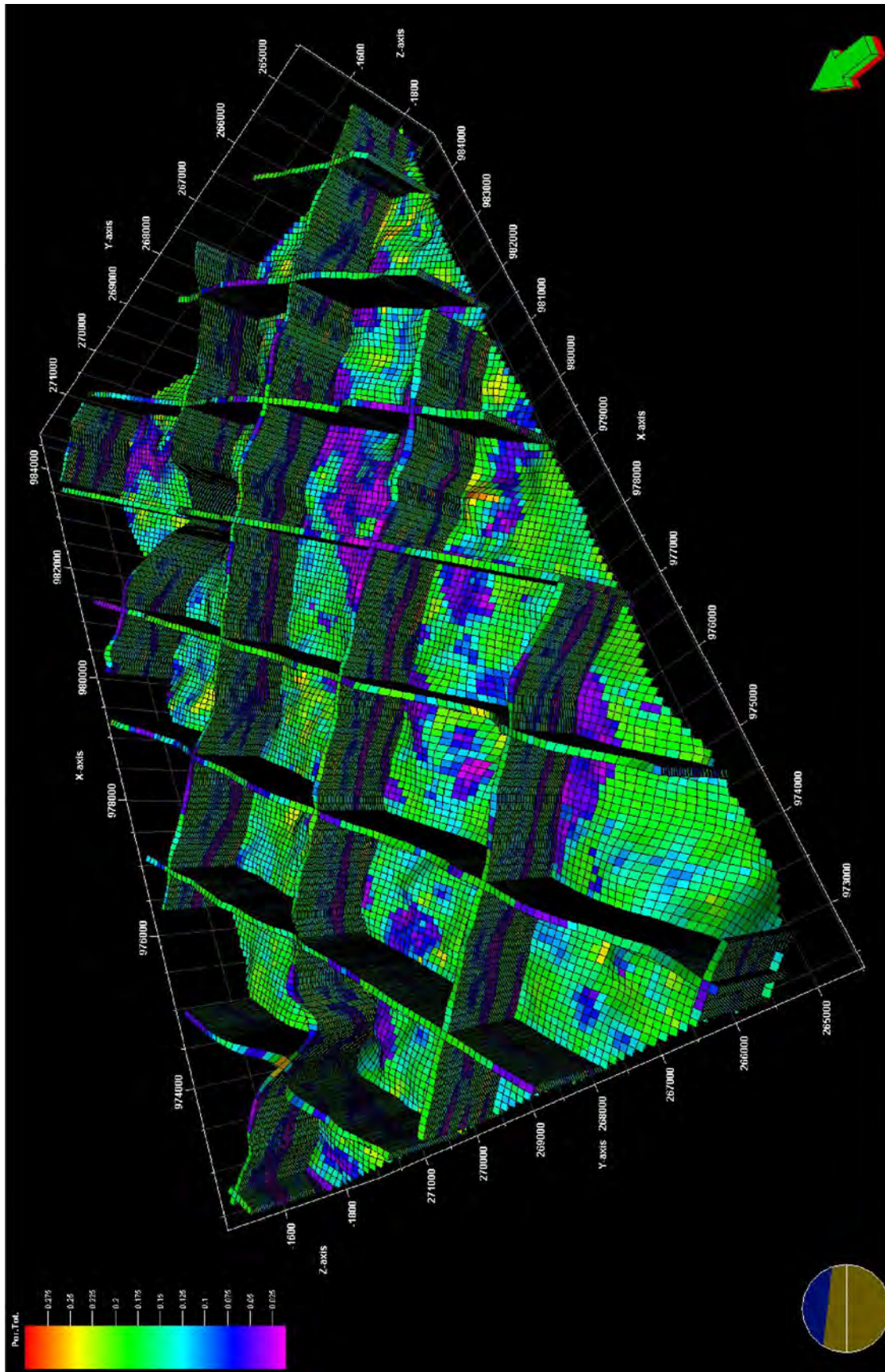


Figure 18. Petrel 3-D window showing PSDM seismic porosity attribute (via genetic inversion) converted to a 3-D grid within the geocellular model.

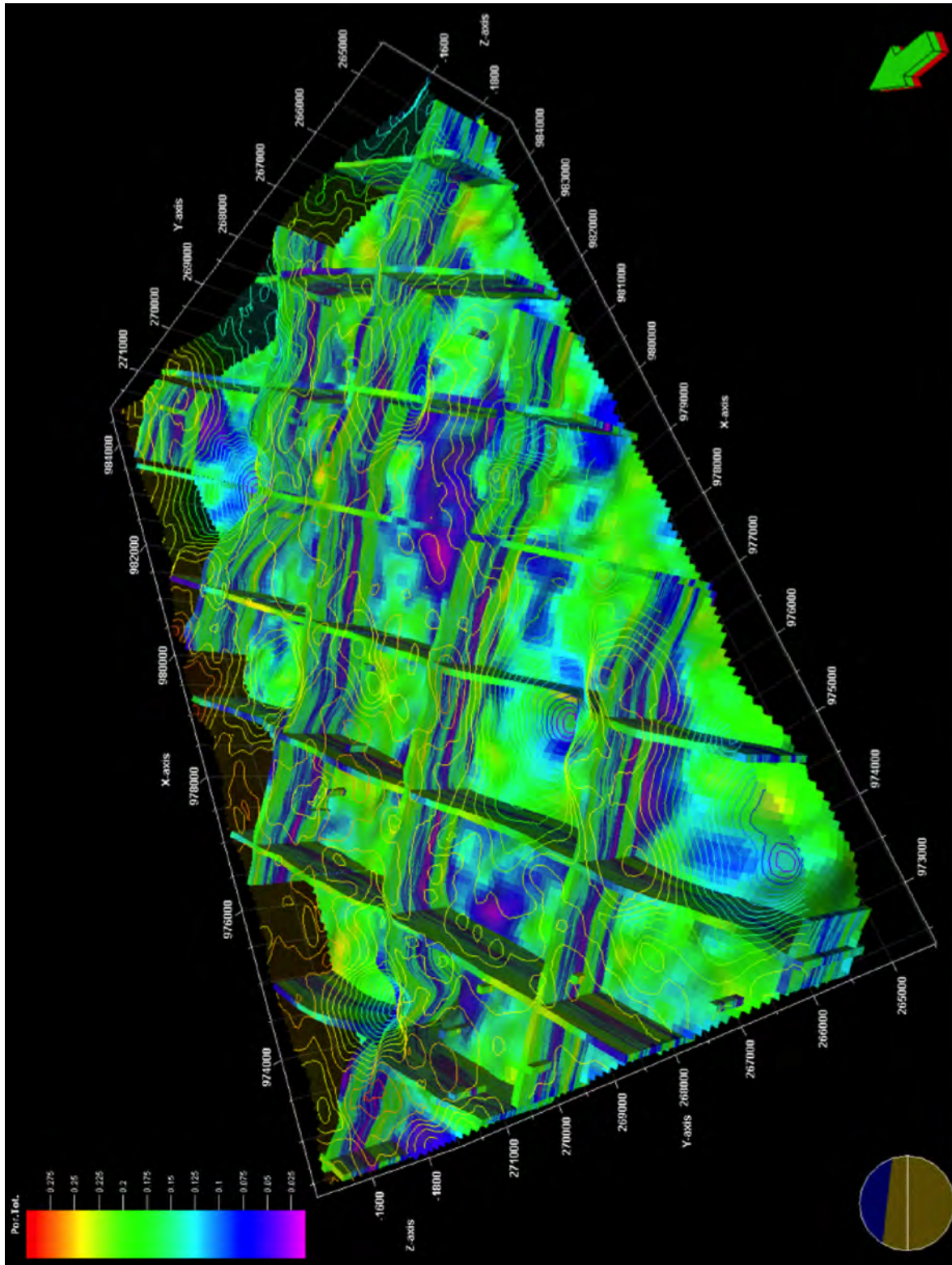


Figure 19. Petrel 3-D window showing preliminary porosity model that was conditioned to the PSDM seismic inversion.

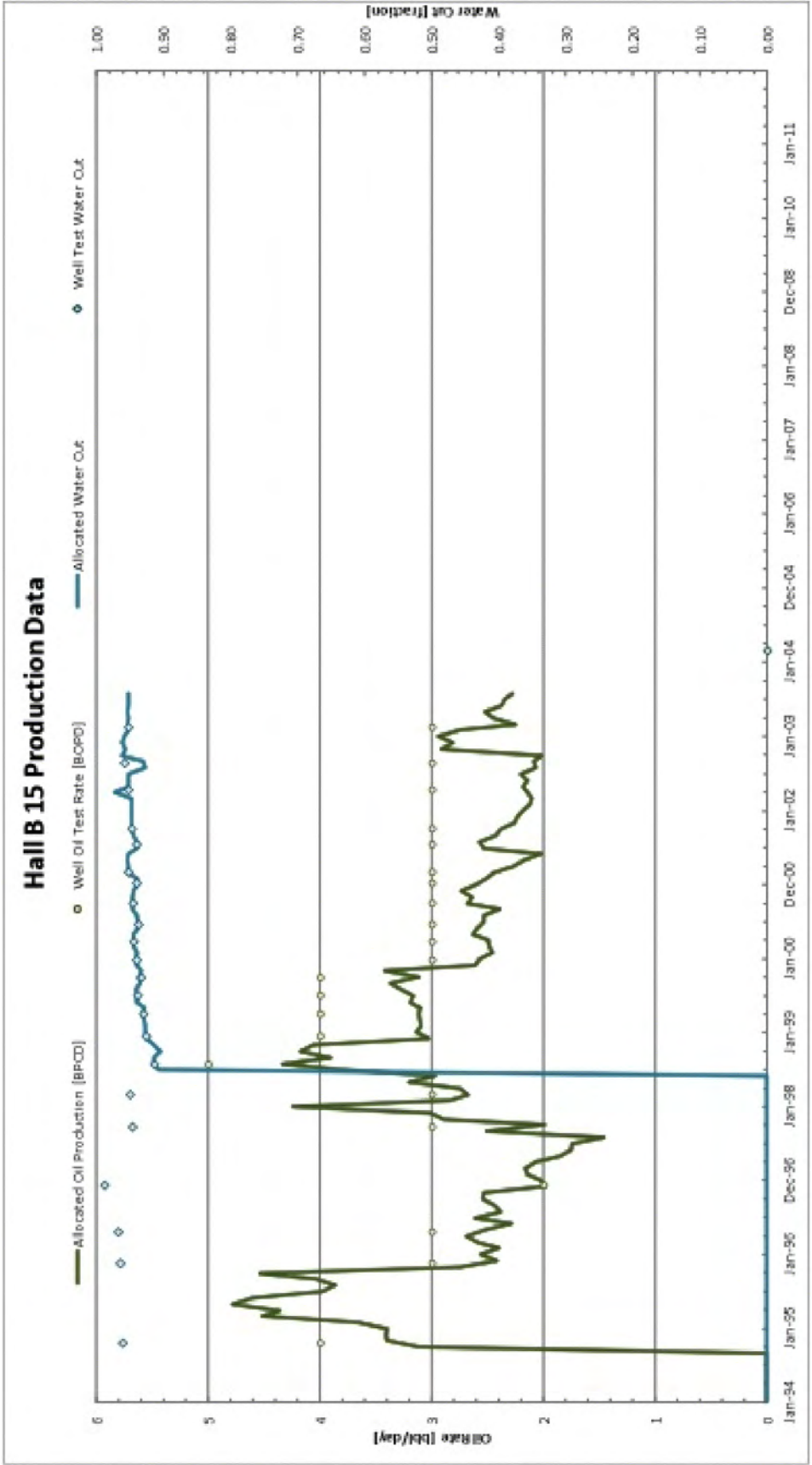


Figure 20. Full model calculated production.

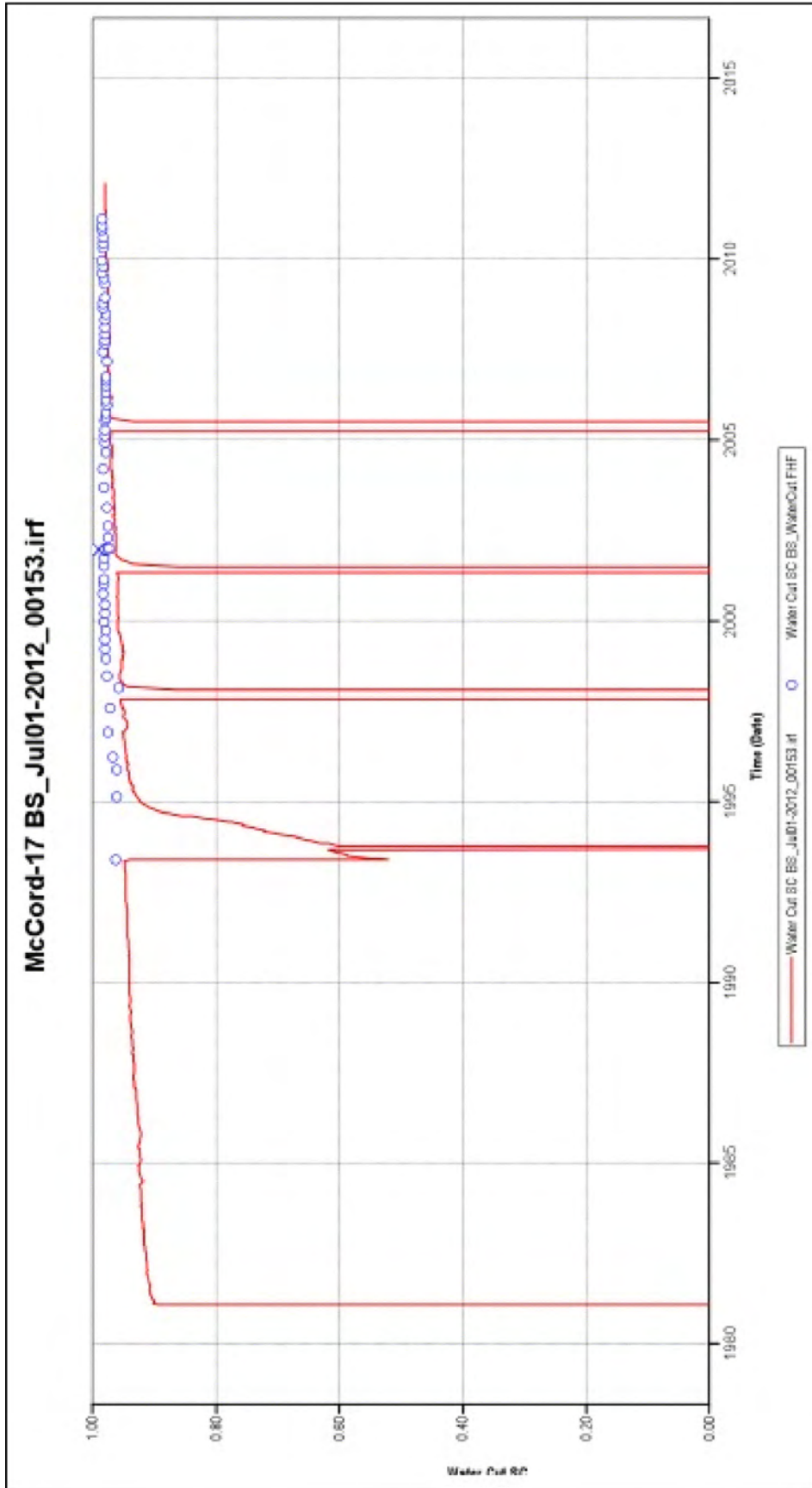


Figure 21. McCord-A 17 history match.

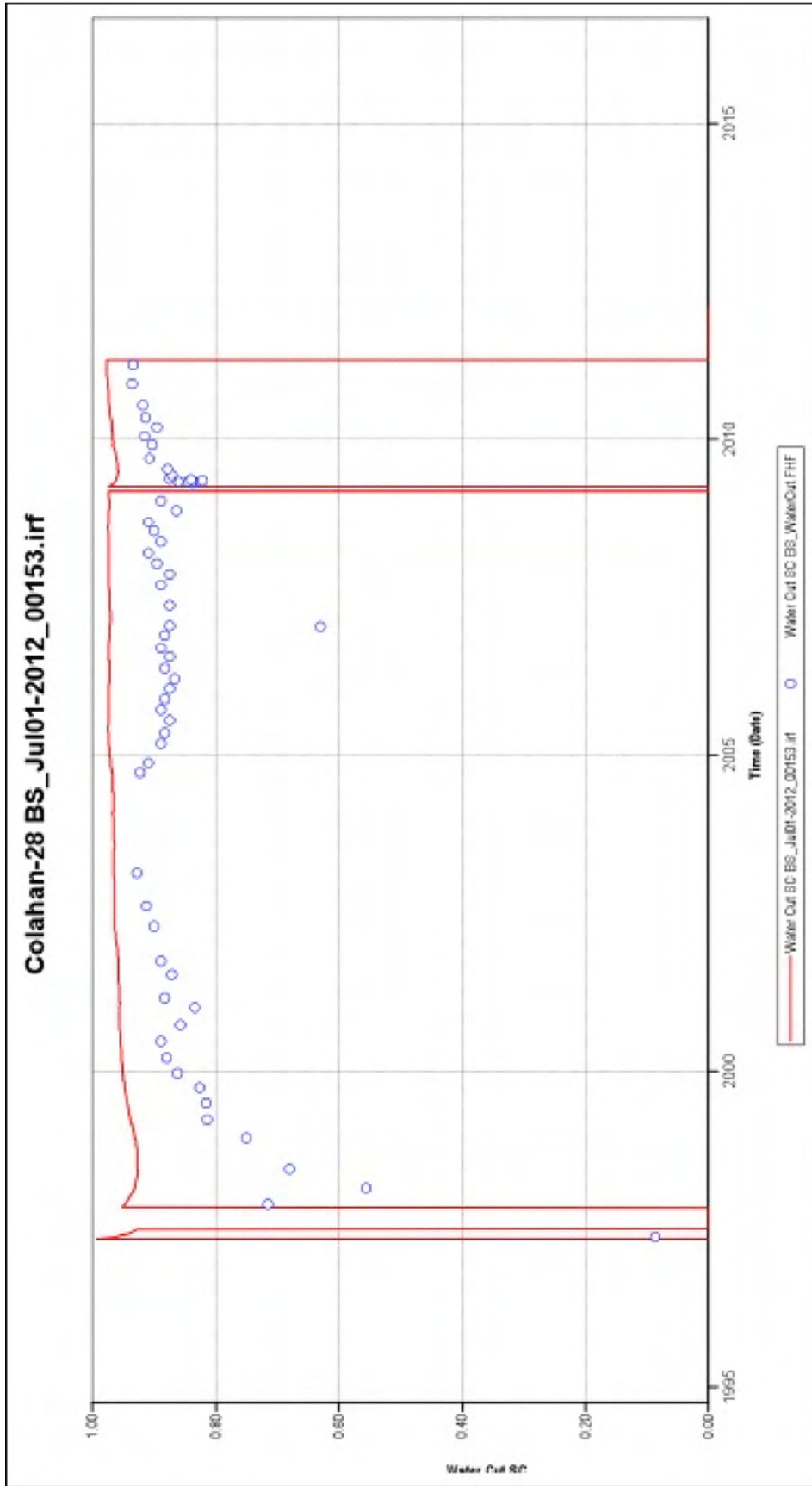


Figure 22. Colahan-28 history match.

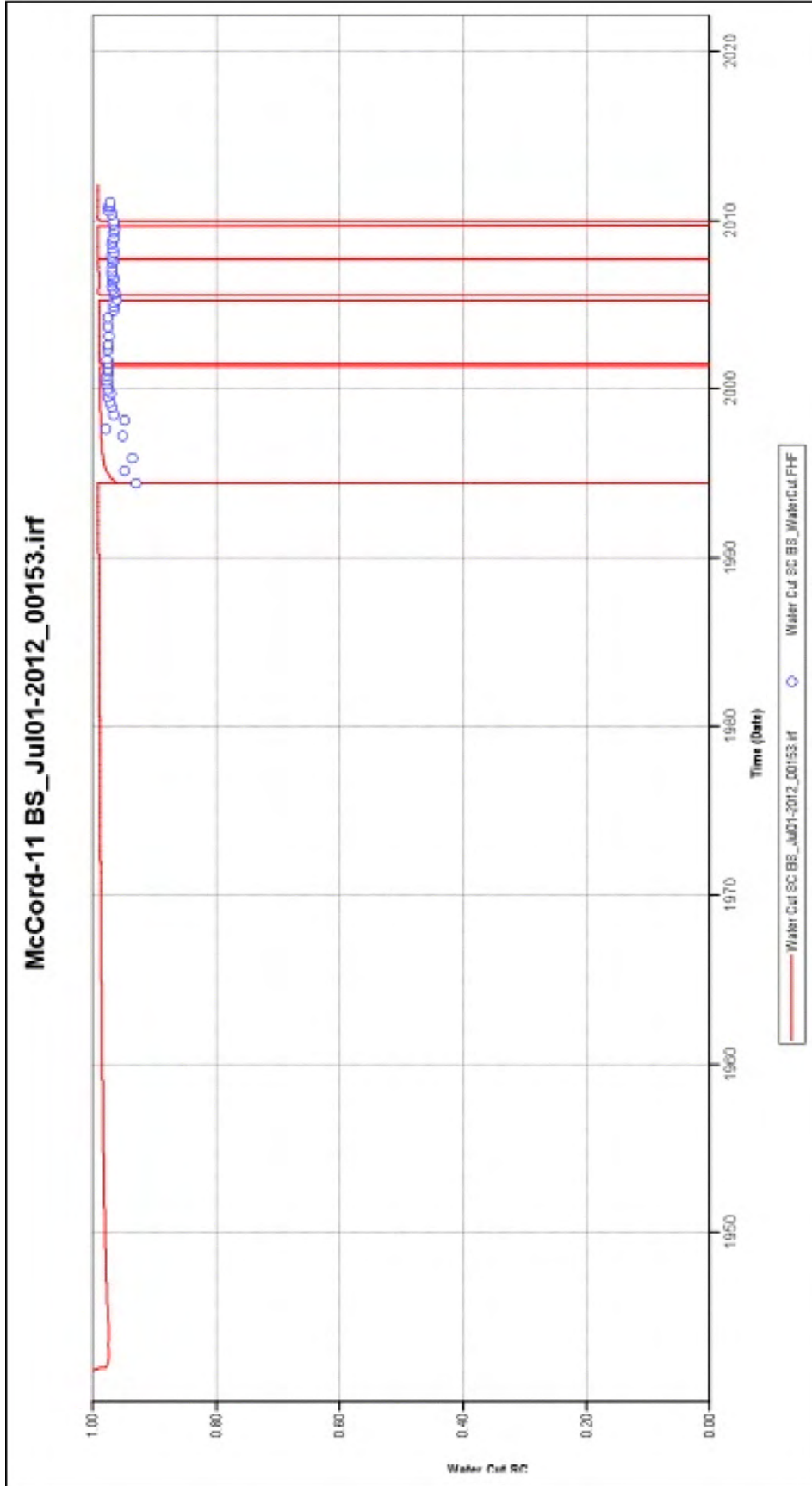


Figure 23. McCord-A 11 history match.

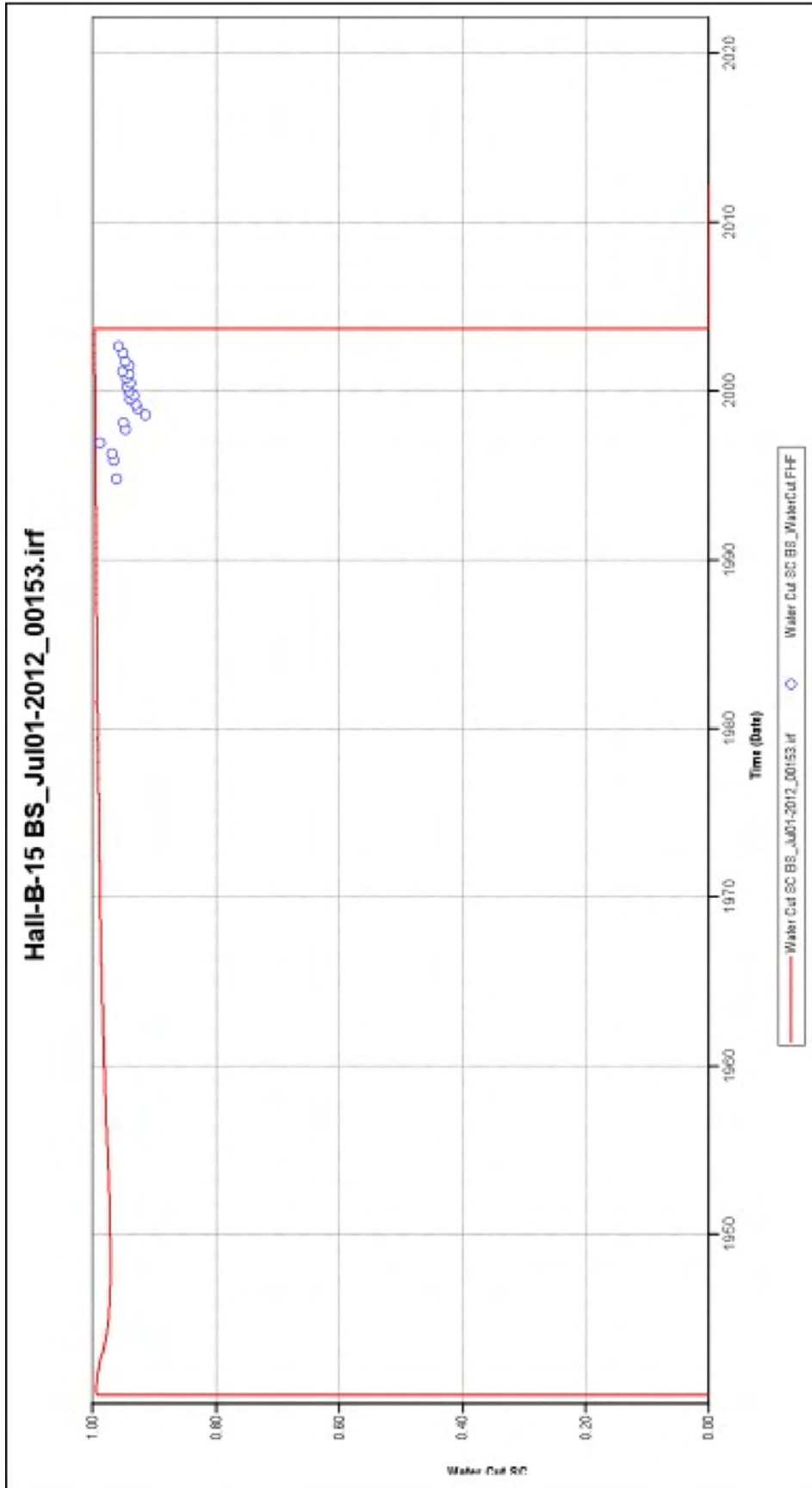


Figure 24. Hall-B 15 history match.

Attachment 1: Cost Status

COST PLAN STATUS - NOTE ALL BP's UPDATED WITH REVISED SF-424A SUBMITTED FOR BP2 CONTINUATION APPLICATION EFF 1/1/12

Baseline Budget Quarter Baseline Cost Plan (from SF-424A)	Year 1 Starts: 10/1/10		Ends: 9/30/11		NCE to 12/31/11		10/1/11 - 9/30/11		7/1/11 - 6/30/11		10/1/11 - 12/31/11		Year 2 Starts: 1/1/12		Ends: 12/31/12		Year 3 Starts: 1/1/13		Ends: 12/31/13			
	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	10/1/10 - 9/30/10	
Federal Share	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$332,668.00	\$46,318.50	\$46,318.50	\$46,318.50	\$46,318.50	\$19,647.75	\$19,647.75	\$19,647.75	\$19,647.75	
Non-Federal Share	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$62,826.75	\$11,366.75	\$11,366.75	\$11,366.75	\$11,366.75	\$6,231.75	\$6,231.75	\$6,231.75	\$6,231.75	
Total Planned (Federal and Non-Federal)	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$415,494.75	\$59,825.25	\$59,825.25	\$59,825.25	\$59,825.25	\$24,879.50	\$24,879.50	\$24,879.50	\$24,879.50	
Cumulative Baseline Cost	\$415,495.75	\$830,990.50	\$1,246,485.25	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,661,980.00	\$1,721,606.25	\$1,781,230.50	\$1,840,855.75	\$1,900,481.00	\$1,955,380.50	\$1,955,380.50	\$1,955,380.50	\$1,955,380.50	
Actual Incurred Costs																						
Federal Share	\$16,716.32	\$83,703.01	\$33,922.86	\$36,618.00	\$5,452.27	\$700,073.33	\$298,938.01	\$298,938.01	\$298,938.01	\$298,938.01	\$298,938.01	\$298,938.01	\$298,938.01	\$700,073.33	\$700,073.33	\$700,073.33	\$700,073.33	\$700,073.33	\$700,073.33	\$700,073.33	\$700,073.33	
Non-Federal Share	\$3,044.15	\$10,391.64	\$8,721.74	\$5,023.09	\$2,809.95	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99	\$678.99
Total Incurred Costs-Quarterly (Federal and Non-Federal)	\$19,760.47	\$94,194.65	\$42,644.60	\$41,641.09	\$8,262.22	\$700,751.92	\$306,616.96	\$306,616.96	\$306,616.96	\$306,616.96	\$306,616.96	\$306,616.96	\$306,616.96	\$700,751.92	\$700,751.92	\$700,751.92	\$700,751.92	\$700,751.92	\$700,751.92	\$700,751.92	\$700,751.92	\$700,751.92
Cumulative Incurred Costs	\$19,760.47	\$113,945.12	\$157,589.72	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$169,848.43	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58	\$1,207,401.58
Variance																						
Federal Share	\$315,952.68	\$246,674.69	\$298,745.12	\$296,632.00	-\$5,452.27	-\$651,754.83	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51	-\$251,619.51
Non-Federal Share	\$79,782.60	\$72,435.11	\$75,106.01	\$77,803.00	\$2,809.95	\$10,828.16	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75	\$11,306.75
Total Variance-Quarterly (Federal and Non-Federal)	\$395,735.28	\$319,109.80	\$373,851.13	\$374,435.00	-\$2,642.32	-\$640,926.67	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76	-\$240,312.76
Cumulative Variance	\$395,735.28	\$717,045.38	\$1,090,896.51	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57	\$1,465,330.57

Attachment 2: Schedule/Milestone Status

Milestone	Task/ Subtask	Project Milestone Description	Project Duration - Start: Jan. 1, 2010 - End: Dec 31, 2013												Planned Start Date	Planned End Date	Actual Start Date	Actual End Date	Comments (notes, explanation of deviation from plan)
			Project Year 1			Project Year 2			Project Year 3										
			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12					
1.1	2.1	Obtain 3D seismic, grav/mag, remote sensing, logs													10/1/10	1/1/11	10/1/10	1/31/01	Delay in data confidentiality negotiations and tracing missing logs
1.2	2.2-3.9	Complete initial pre-spud geomodel													10/1/10	3/31/11	2/10/11	9/30/11	PSDM & VC volumes delivered. VC interpretation in progress. BP1 extension granted.
1.3	4.1-4.3	History match and forecast.													3/1/11	6/1/3/11	9/30/11	6/15/12	Simulation of pre-spud model is completed.
1.4	5.1-6.8	Drill, Log, and Test Bore-hole #1 (McCord A 20H)													5/1/11	7/31/11	8/12/11	11/24/11	Bore-hole and horizontal lateral successfully drilled and logged.
2.1	7.1-7.5	Complete Formation Evaluation													7/31/11	12/31/11	11/24/11	12/31/12	Final formation evaluation and seismic attribute interpretations will be correlated
2.2	8.1-8.4	Evaluate pre-spud VC interpretation & revise seismic interp.													4/1/12	7/30/12	11/24/11	6/25/12	Finished PSDM interpretations and attributes. Continue to tweak parameters.
2.3	9.1-9.5	Complete fault & facies models													7/1/12	12/31/12	3/1/12		Will integrate fault model with image interp.