GAUSSIAN
WELLWORKS
RESERVOIR INTELLIGENCE

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FRACTURE DIAGNOSTICS

Gaussian Wellworks provides flexible fracture diagnostics services that translate planned completion data and field evidence into quantitative estimates of effective fracture half-length, stimulated area, fracture width, and stage performance.

The diagnostic pathway is selected according to the client objective, project maturity, and available data. Methods can be applied independently or compared when multiple datasets are available to improve confidence and reduce interpretation risk.

WHY FRACTURE DIAGNOSTICS MATTERS

DESIGNED VS PRODUCING GEOMETRY Actual producing fractures may differ from planned or simulated geometry.	**STAGE VARIABILITY** Whole-well averages can hide meaningful heel-to-toe differences.	**PARENT-CHILD RISK** Depletion and fracture interaction complicate infill timing and spacing.
FORECAST UNCERTAINTY Poorly constrained geometry weakens production and EUR forecasts.	**RESERVES CONFIDENCE** Geometry ranges provide a stronger basis for reserves support.	**CAPITAL ALLOCATION** Comparable diagnostics improve development and portfolio prioritization.

KNOW THE EFFECTIVE FRACTURE—NOT ONLY THE PLANNED COMPLETION.

HOW THE GAUSSIAN APPROACH DIFFERS

Conventional fracture diagnostics rely on isolated techniques (pressure analysis, decline curves, or analogs), each with inherent limitations.

Our method differentiators are:

- Physics-based foundation – grounded in reservoir flow and fracture mechanics
- Pre- and post-drill fracture diagnostics – estimation of fracture half-length
- Multi-method fracture modeling – four independent approaches for validation
- Data integration – combines frac data, flowback, and production seamlessly
- Scalability – applicable across large asset portfolios
- Uncertainty quantification – explicit confidence ranges, not just point estimates

DIAGNOSTIC METHODS

The four methods below are distinct data-to-decision workflows for estimating, constraining, or optimizing fracture half-length. Selection depends on project maturity (pre- and/or post-drilling), available reservoir and operational data, and the decision being supported. When more than one dataset is available, independent estimates can be compared to constrain uncertainty and interpretation risk.

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1. PRE-DRILL FRACTURE DESIGN & OPTIMIZATION Use before drilling or completion to screen fracture geometry and refine completion parameters. ▪ **Inputs:** pressure-dependent geomechanics and planned pumping design. ▪ **Outputs:** half-length ranges, sensitivity to pressure and geomechanics, and design-case comparisons. ▪ **Decisions:** stage spacing, cluster strategy, fluid, and proppant loading.	**2. POST-FRAC BASED ESTIMATION** Use operational frac-job records to reconstruct stage-level fracture growth and execution quality. ▪ **Inputs:** pressure, rate, volume, fluid, and proppant schedules. ▪ **Outputs:** stage half-length, width, propagation rate, operational outliers or interruptions, and stress-shadow or interference effects. ▪ **Decisions:** completion redesign inputs and production-based benchmarking.
3. FLOWBACK-BASED ESTIMATION Use reliable flowback and falloff records when production history is limited. ▪ **Inputs:** flowback volumes, elastic compliance, and completion parameters. ▪ **Outputs:** retained volume, leak-off balance, closure response, fracture capacity, and half-length range. ▪ **Decisions:** post-treatment fracture effectiveness and independent validation.	**4. EARLY-PRODUCTION GPT-BASED ESTIMATION** Use early production and pressure behavior GPT matching to infer effective producing geometry. ▪ **Inputs:** early rate and pressure history. ▪ **Outputs:** producing half-length, stimulated area, and P90/P50/P10 ranges. ▪ **Decisions:** forecast-ready inputs and planned-versus-producing comparison.

SIX-STEP MODELING WORKFLOW

Our fracture diagnostics workflow offers a flexible, data-driven process to estimate fracture geometry and convert field data into development decisions. It chooses the best diagnostic pathway based on project goals, data, and outcomes; when multiple datasets exist, it compares methods to boost confidence and lower interpretation risk.

01 **DEFINE THE OBJECTIVE** Identify the decision: design, completion evaluation, forecasting, or spacing optimization.	**02** **REVIEW AVAILABLE DATA** Assess completeness and quality of reservoir, frac, flowback, and production data.	**03** **SELECT THE METHOD** Choose the diagnostic path that fits project stage and required outcome.
04 **PERFORM THE ANALYSIS** Use selected method to estimate geometry, stimulated area, width, propagation, or stage performance.	**05** **VALIDATE THE RESULTS** Test assumptions, sensitivities, and confidence ranges; compare methods where possible.	**06** **DELIVER RECOMMENDATIONS** Translate findings into completion, forecast, reserves, and development guidance.

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TYPICAL APPLICATIONS

DEVELOPMENT & COMPLETION TEAMS	RESERVOIR, PLANNING & COMMERCIAL TEAMS
▪ Half-length feasibility, estimation, and optimization. ▪ Stage and cluster spacing optimization. ▪ Pumping, fluid, rate, and proppant calibration. ▪ Stage-level execution benchmarking. ▪ Well spacing, infill timing, and parent-child risk assessment.	▪ Production forecasts and EUR ranges. ▪ Reserves defensibility and asset valuation. ▪ Remediation and scenario screening. ▪ Portfolio benchmarking across completions. ▪ Development and capital-allocation decisions.

A FLEXIBLE WORKFLOW CONVERTS THE AVAILABLE EVIDENCE INTO A DECISION-READY FRACTURE INTERPRETATION.

CLIENT DELIVERABLES

Deliverables are tailored to the available data, project stage, and selected diagnostic method.

OPERATORS

- Effective fracture half-length and stimulated-area estimates.
- Stage-level fracture geometry and execution diagnostics.
- Inputs for completion design, spacing, infill timing and parent-child risk.
- Forecast-ready inputs for production, EUR and reserves analysis.

INVESTORS & LENDERS

- P90/P50/P10 ranges for effective fracture half-length.
- Risk-informed inputs for forecasts, reserves and asset valuation.
- Technical support for asset screening and capital allocation.
- Evidence supporting financing and portfolio decisions.

AUDITORS & REGULATORS

- Traceable data inputs, assumptions and calculations.
- Reproducible results with quantified uncertainty.
- Documented method selection and validation checks.
- Review-ready technical documentation.

CORE DECISION OUTPUTS

FRACTURE GEOMETRY Half-length, width and stimulated-area estimates.	**STAGE EFFECTIVENESS** Heel-to-toe variability, outliers and execution effects.	**COMPLETION DESIGN** Stage spacing, cluster strategy, fluid and proppant inputs.
FORECAST INPUTS Producing geometry ranges for production, EUR and reserves.	**INFILL RISK** Spacing, parent-child interaction and depletion considerations.	**PORTFOLIO VALUE** Comparable evidence for ranking wells, assets and capital.

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VALUE ACROSS THE ASSET LIFECYCLE

PLAN	DIAGNOSE	FORECAST	OPTIMIZE
Screen geometry and design options before execution.	Identify stage variability and completion effects after pumping.	Connect effective geometry to production and reserves.	Use results to guide the next well and portfolio priorities.

TRACEABLE INPUTS. QUANTIFIED UNCERTAINTY. ACTIONABLE COMPLETION AND DEVELOPMENT GUIDANCE.

CASE STUDY—STAGE-LEVEL FRACTURE DIAGNOSTICS FROM POST-FRAC JOB REPORTS FOR EAGLE FORD SHALE

Summary

A 22-stage Eagle Ford shale well was analyzed using operational data from post-frac job reports and historic production. The method converted routinely collected pressure, rate, volume, fluid, and proppant data into stage-by-stage estimates of effective fracture half-length, fracture width, and propagation rate.

Objective

The objective was to estimate actual fracture dimensions created in each completion stage, identify stage-to-stage variability along the lateral, validate the post-frac diagnostic result against production-based methods, and convert frac execution records into guidance for future completion optimization.

Provided solution

The analysis used a pressure-balance and volume-balance method applied to the post-frac report. Routine treatment data were used as the diagnostic starting point, including surface pressure, pumping rate, proppant density, and proppant concentration. These inputs are illustrated in **Figure 1**, which shows the treatment log for Stage 6.

Starting from wellhead pressure, pressure gains and losses were computed as fluid moved toward the active stage. Perforation losses, friction losses, and gravitational pressure gains were accounted for. The effective Sneddon pressure was then calculated as the pressure driving fracture growth. This pressure balance is shown in **Figure 2**, where the surface/fracturing pressure is converted into Sneddon pressure for representative Stages 6 and 7. The same process is implemented for all 22 stages.

Pumped fluid volumes were then mass-balanced to estimate fracture half-length and fracture width at each time step. Incremental half-length growth was used to calculate fracture propagation rate. The stage-level results were compared with independent production-history matches using CMG-IMEX and Gaussian Pressure Transient analysis.

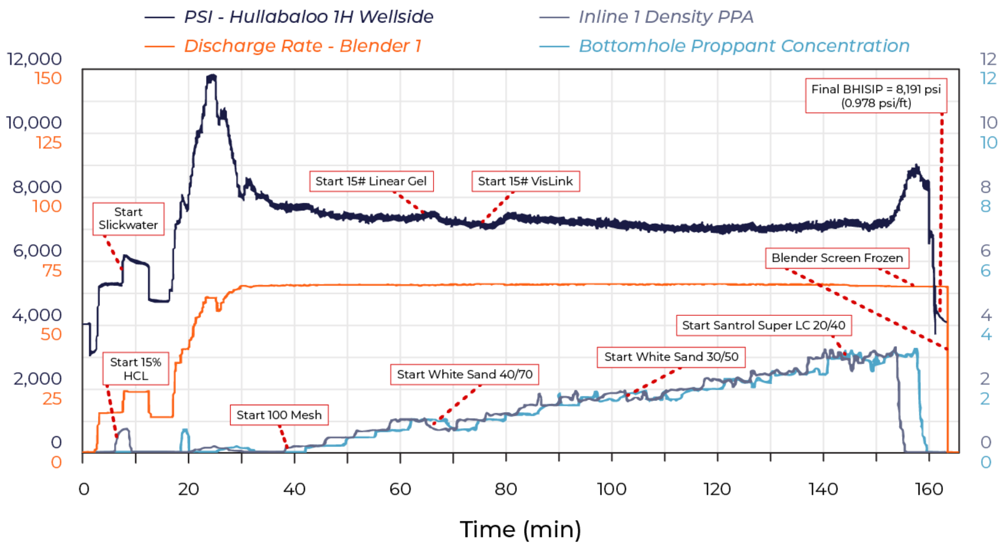

Figure 1 – Stage 6 frac-treatment record showing surface pressure, pumping rate, and proppant schedule used as diagnostic inputs.

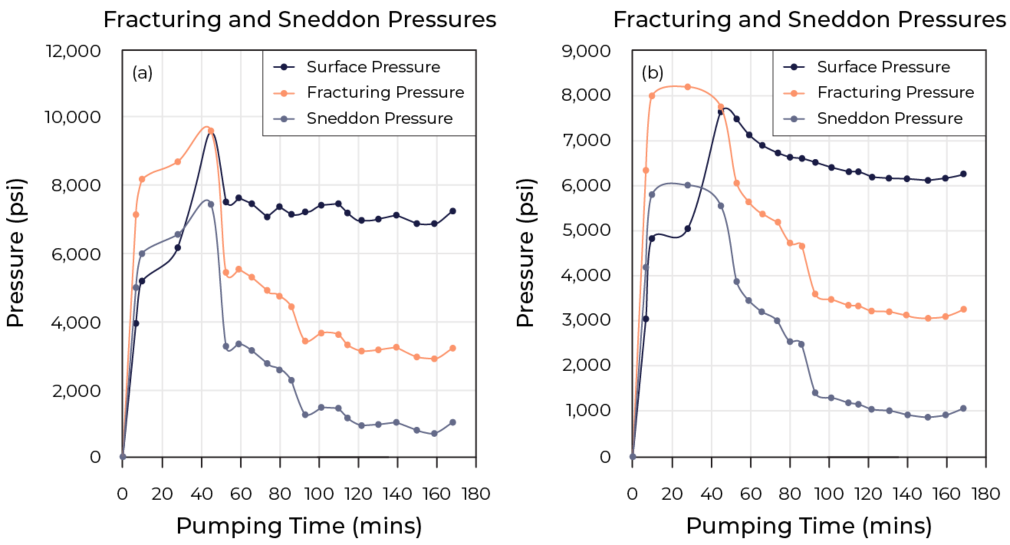

Figure 2 – Fracturing pressure and calculated Sneddon pressure for stages 6 (a) and 7 (b), showing the effective pressure driving fracture growth.

Results and Findings

The stepwise calculation produced fracture half-length growth profiles for individual stages. **Figure 3** shows how fracture half-length and incremental growth evolved during the pumping schedule for representative Stages 6 and 7.

Across the full 22-stage well, the analysis showed clear stage-to-stage variability. For the whole well, the arithmetic average fracture half-lengths varied from approximately 110 to 240 ft. The average stage-level fracture half-length was 157.3 ft, the average propagation rate was 0.92 ft/min, and the average fracture width was 4.82 mm. These full-well results are summarized in **Figure 4**.

Independent production-history matching provided a strong validation check. CMG-IMEX estimated an average fracture half-length of 159 ft, while GPT estimated 144 ft. The difference between the stage-level post-frac estimate and the GPT result was approximately 9.5%, which was interpreted as consistent with fracture closure after flowback and during the early production stage.

The case demonstrates that routine post-frac reports (**Figure 1)** can be converted into valuable diagnostic data (**Figure 2)** for fracture-growth calculations.

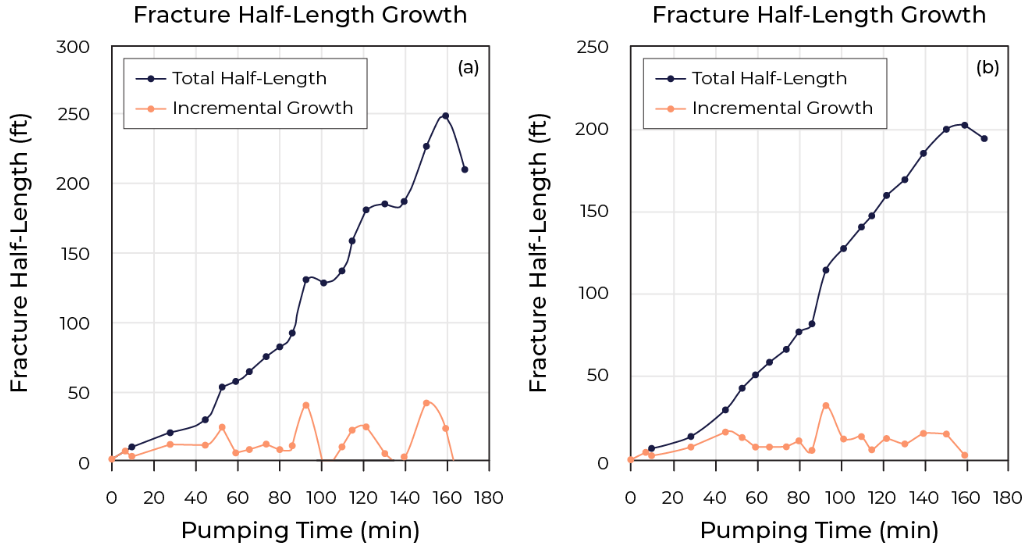

Figure 3 – Stepwise fracture half-length growth and incremental fracture extension for stage 6 (a) and 7 (b).

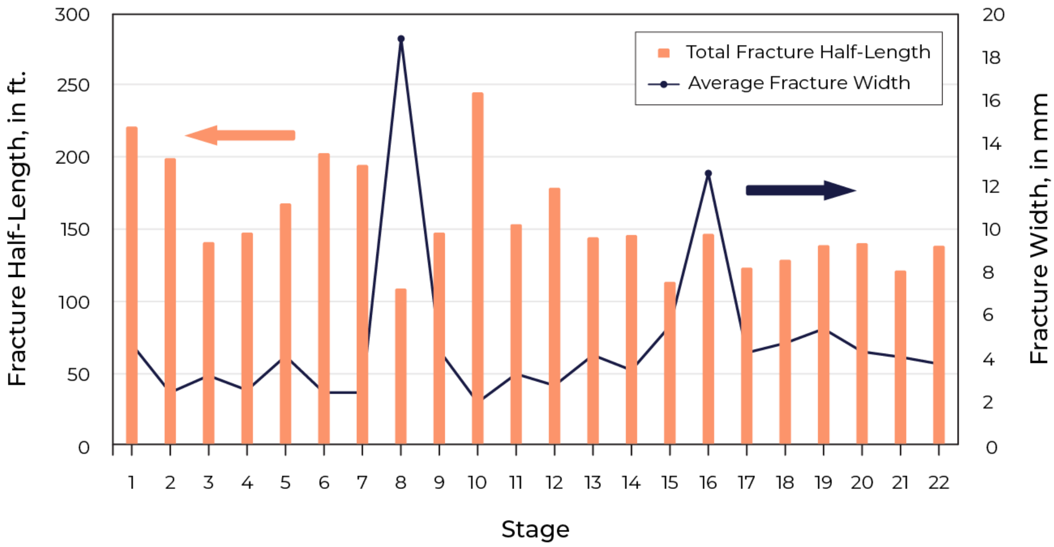

Figure 4 – Variation in fracture half-lengths (left-scale) and widths (right-scale) across the 22-stage Eagle Ford well.

The most important diagnostic result is the stage-to-stage variability shown in **Figure 4**, which would be hidden if the well were reduced to a single whole-well average. By showing which stages created longer or shorter fractures, the method provides a clearer basis for completion redesign and stage-level performance benchmarking.

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The comparison with production-history matching strengthened confidence in the interpretation and showed how frac execution data can be connected to production performance. The study demonstrates a practical bridge between completion operations, reservoir understanding, and next-well optimization.

READ THE FULL CASE STUDY

ADDITIONAL EVIDENCE

Explore selected peer-reviewed studies that highlight the reliability and technical validity of Gaussian technology in Fracture Diagnostics.

[1]. Al-Shaikh, A., and Weijermars, R., 2025. Fast Analysis Method of Diagnostic Fracture Injection Test Data: Examples from Four Different Shale Formations (Bakken, Three Forks, Wolfcamp, and Eagle Ford). SPE Hydraulic Fracturing Conference 2025 (23–25 September, Oman). DOI

[2]. Oshaish, A., and Weijermars, R., 2023. Fracture Propagation-Rate and Fracture Half-Length Estimated for an Individual Stage using Dynamic Balancing of Fluid Pressures: Eagle Ford Case Study. ARMA-IGS-2023-0176. DOI

[3]. Ibrahim, A., and Weijermars, R., 2023. Estimation of Fracture Half-Length with Fast Gaussian Pressure Transient and RTA Methods: Wolfcamp Shale Formation Case Study. Journal of Petroleum Exploration and Production Technology. DOI

[4]. Alvayed, D., Khalid, M.S.A., Dafaalla, M. Ali, A. Ibrahim, A., Weijermars, R., 2023. Probabilistic Estimation of Hydraulic Fracture Half-Lengths: Validating the Gaussian Pressure-Transient Method with the Traditional RTA-Method (Wolfcamp Case Study). Journal of Petroleum Exploration and Production Technology, 13,2475–2489. DOI

[5]. Wang, J., and Weijermars, R., 2023. Production-induced pressure-depletion and stress anisotropy changes near hydraulically fractured wells: Implications for intra-well fracture interference and fracture treatment efficacy. GeoEnergy Science and Engineering, 222, 211450. DOI

