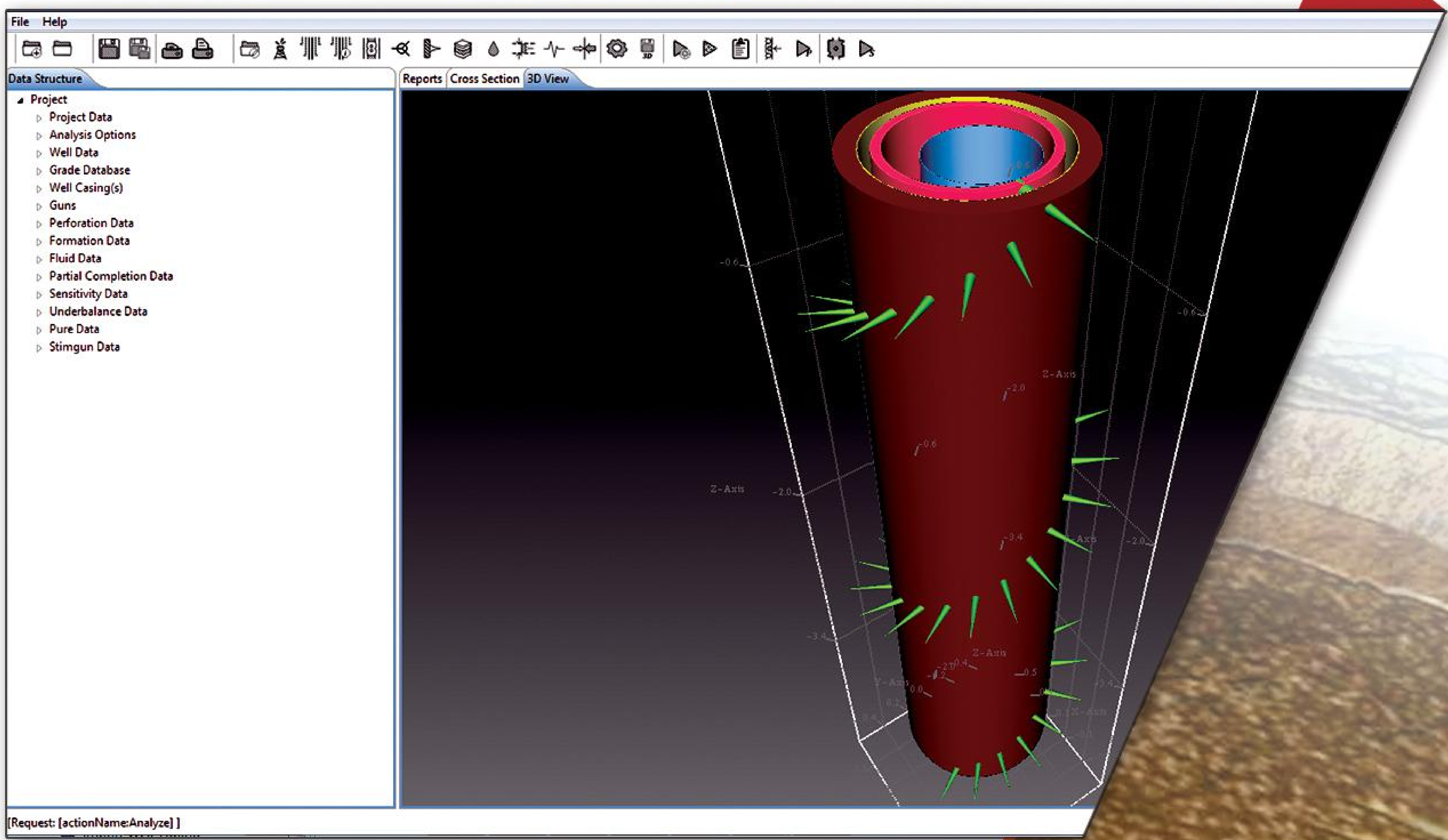
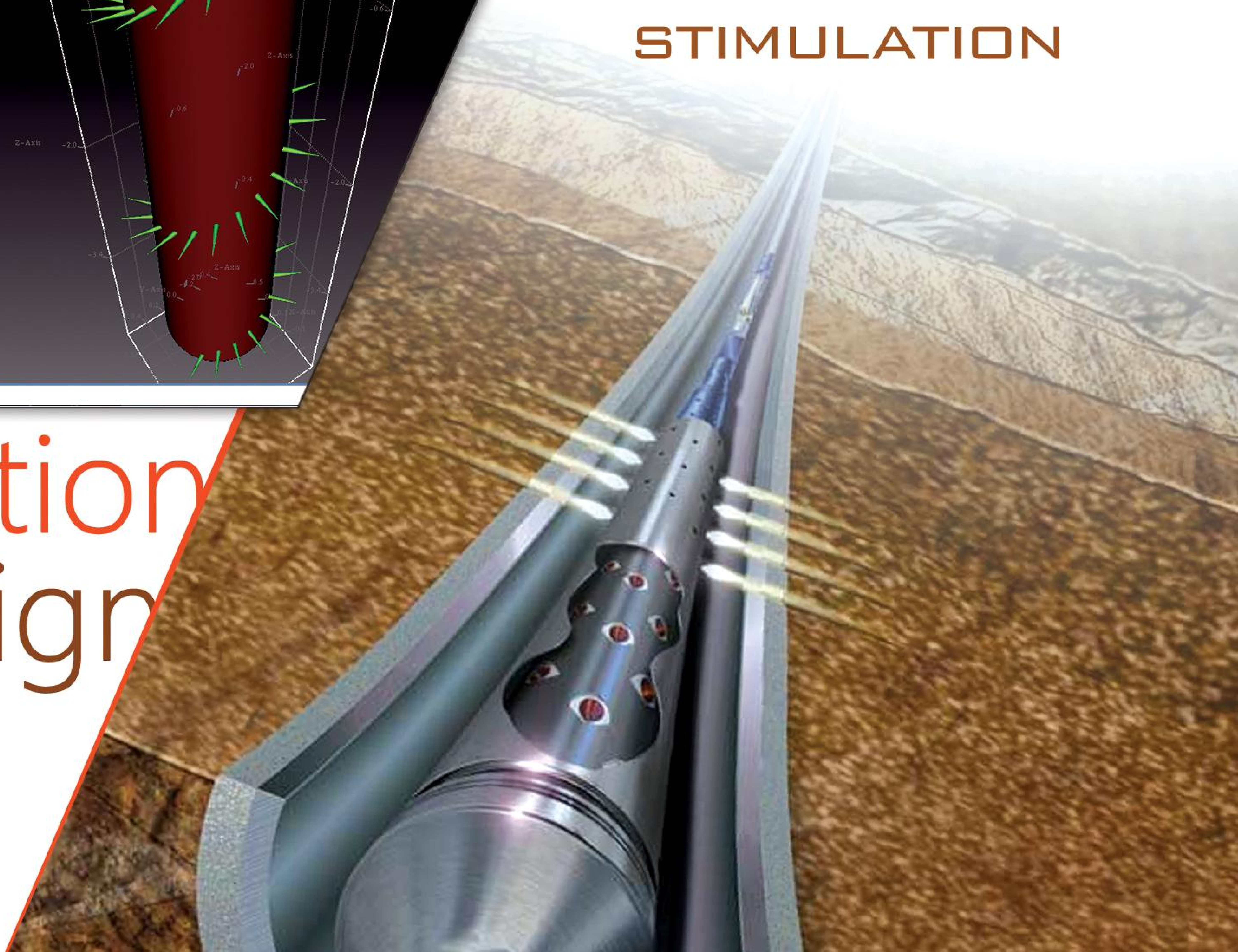
Full Completion toolbox, Smart



Stimulation design

RETINA
STIMULATION



ESTD

Engineering Support & Technology Development

Company Brief

Founded in 2012, Engineering Support & Technology Development (ESTD) is an engineering consultation and software development company focused on upstream oil and gas section.It has developed several engineering software products including :

RETINA™ SIMULATION, RETINA™ STATION and RETINA™ STIMULATION.

The main specialty of ESTD, is engineering software development which requires advanced mathematical modeling expertise and numerical analysis capabilities.

In addition to software development, and due to having access to special tools and highly educated engineers, ESTD offers several distinct and professional services. These services range from well stimulation design to non-conventional full field studies.

RETINA SIMULATION

RETINA STATION

RETINA STIMULATION

RETINA SIMULATION

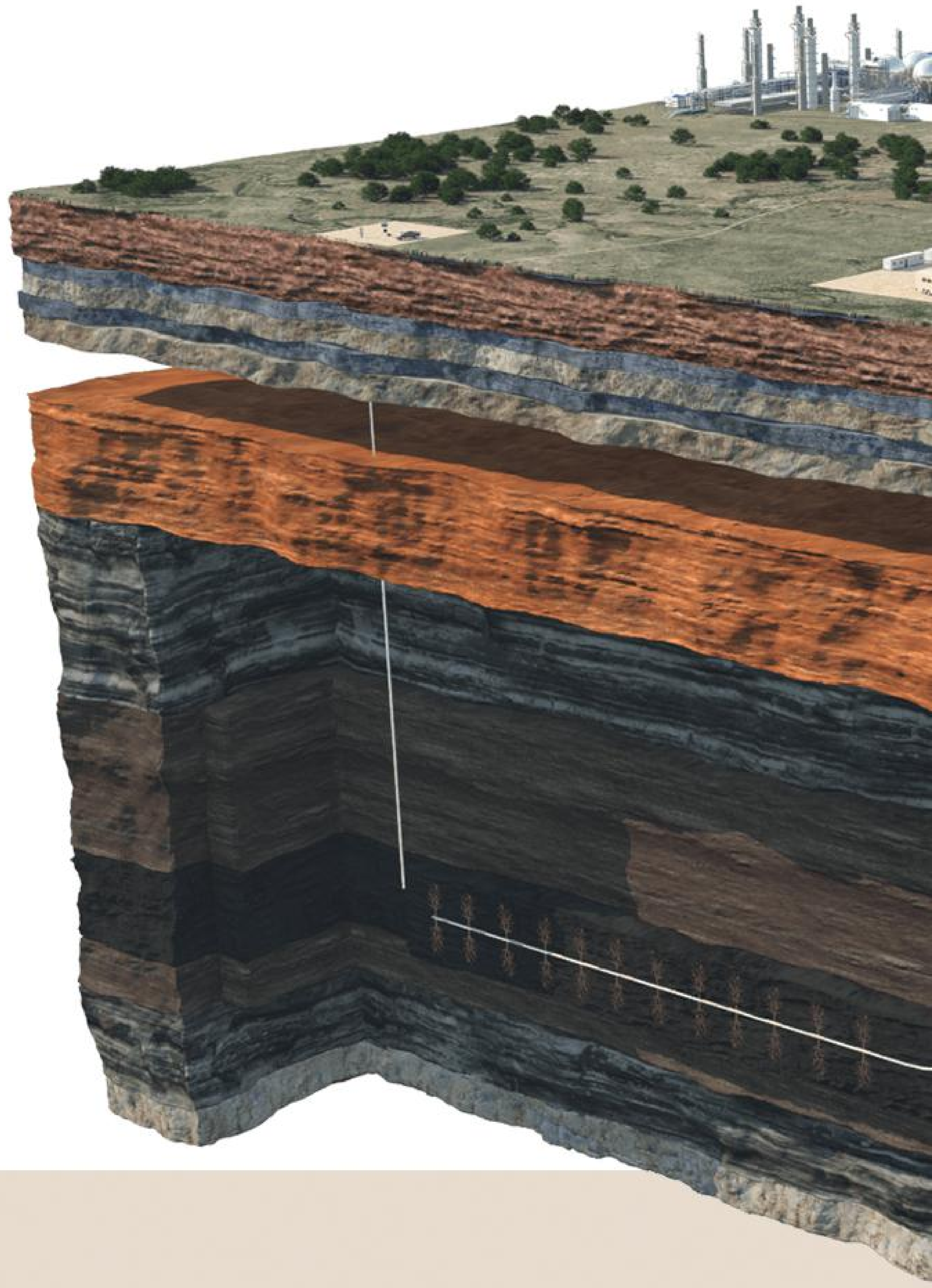
RETINA Simulation™ is a Black-Oil and Compositional reservoir simulation software fully developed in ESTD during the past 4 years. RETINA has been tested and certified by 4 of National Iranian Oil Company subsidiaries in cases of accuracy and stability compared to ECLIPSE 100™:
KARANJ-Asmari from National Iranian South Oil Company (NISOC), DOROUD-Asmari from Iranian Offshore Oil Company (IOOC), East PAYDAR-Asmari from Iranian Central Oil Fields Company (ICOFC) and North AZADEGAN-Sarvak from Petroleum Engineering and Development Company (PEDEC). RETINA results have less than 5% difference compared to ECLIPSE 100 in all cases. Main features of RETINA Simulation™ are:

- Powerful and stable linear solver and preconditioner: CPR AMG based ILU0
- All of the non-EOR physical models of ECLIPSE 100
- Fully integrated pre and post processor capable of loading ECLIPSE 100 and 300 DATA files completely and automatically
- Equipped with real time result visualization (plot and 3D) and live update of the model

RETINA STATION

RETINA Station™ is the main platform for data management and workflow integration of the RETINA software suite. It is used to manage all the petroleum engineering data as well as to create RETINA Simulation™ cases. RETINA Station™ is developed specially for E&P companies to meet their needs in management and analysis of their data. The main features of RETINA Station™ are:

- Importing and visualizing all Well data such as path, completion, logs, core data, observed data and well test
- Filtering, correcting and creating well logs
- Importing, organizing, modifying, visualizing and exporting all the common formats of Grid data
- Importing and visualizing all dynamic reservoir data such as PVT, SCAL and VFP tables
- Property calculation, static volumetric calculation, well log filtering and calculation and generating different cross-plots
- Comprehensive and integrated platform for all seismic to simulation tools

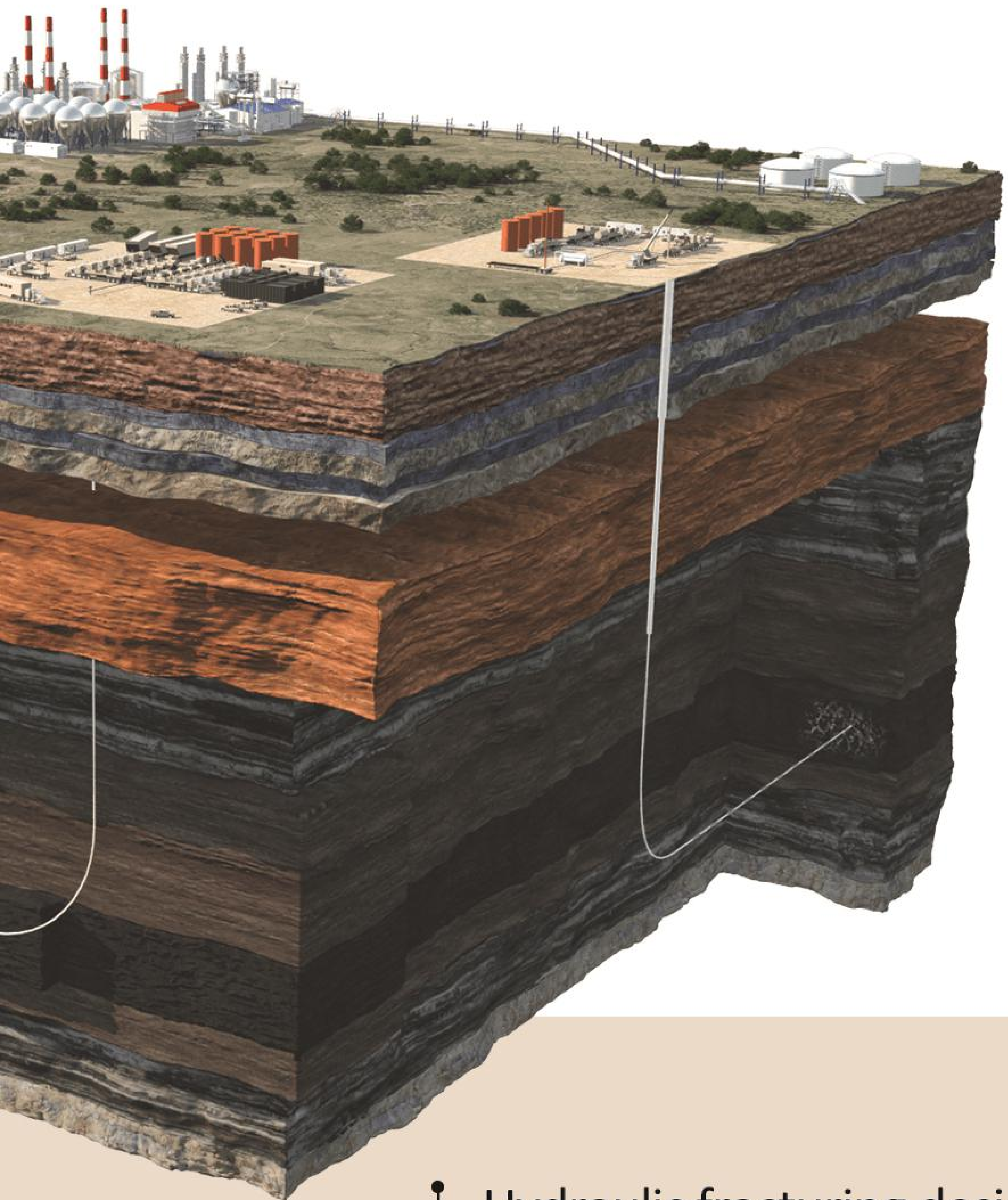


Main Services

Being composed of highly educated and talented engineers and access to their deep knowledge of physical models and numerical analysis, makes ESTD's team one of the best, most flexible and fastest consultation teams in the market. ESTD provides several specialized engineering services some of which are unique in terms of tools and workflows.

RETINA STIMULATION

RETINA Stimulation™ is a modeling tool used for designing stimulation methods and predicting perforation efficiency. It is used in real field cases to design the dynamic underbalanced perforation and propellant gas fracturing operations in the Persian Gulf region. Hydraulic Fracture design and modeling is also added to the software recently. The main features of RETINA Stimulation™ are:



- Conventional perforation prediction module
- Dynamic underbalance perforation module
- Propellant gas fracturing module
- Hydraulic fracturing module

Hydraulic fracturing design and optimization using RETINA Stimulation™
Perforation design and optimization using RETINA Stimulation™
Carbonate fractured reservoir full field study using RETINA Simulation™
Non-conventional reservoir full field study using RETINA Simulation™

Overview

RETINA Stimulation™ is a modeling tool used for designing stimulation methods and predicting perforation efficiency. It generates multiple reports and sensitivity plots for penetration, perforation, and stimulation methods such as dynamic underbalance perforation, propellant gas fracturing, and hydraulic fracturing for numerous perforating systems in easy-to-read formats including 2D cross-section and 3D visualization of the perforations, for the comprehensive understanding of the system. The formation penetration of charges, are predicted by experimental models, which are developed based on laboratory tests for each individual charge. Productivity and perforation skin are derived from semi-analytical correlations, developed through extensive 3D finite element simulations and laboratory experiments. The non-Darcy effect on gas and oil flow through porous media, perforation tunnels and tubular facilities are also taken into account.

RETINA
STIMULATION

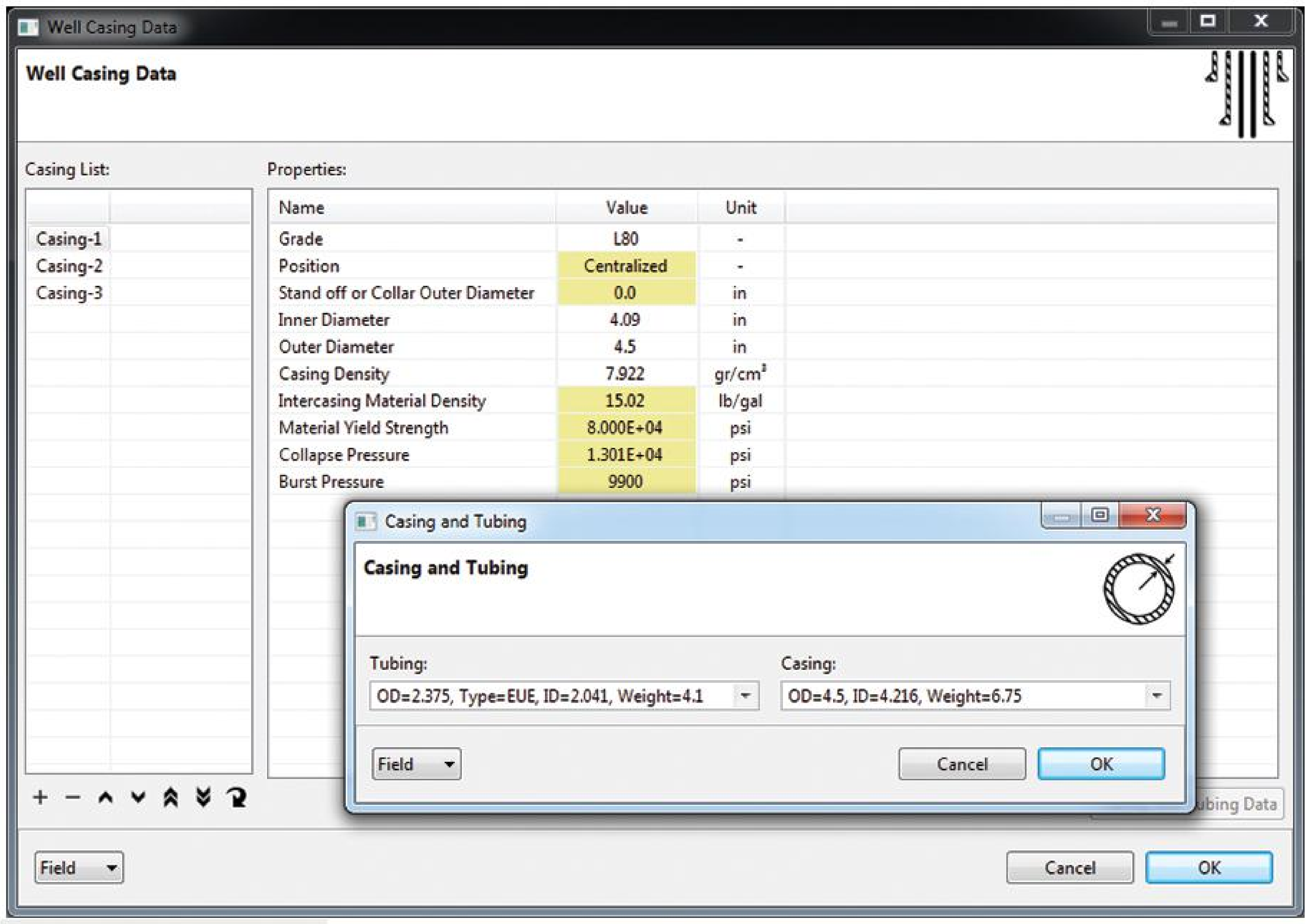
Key features

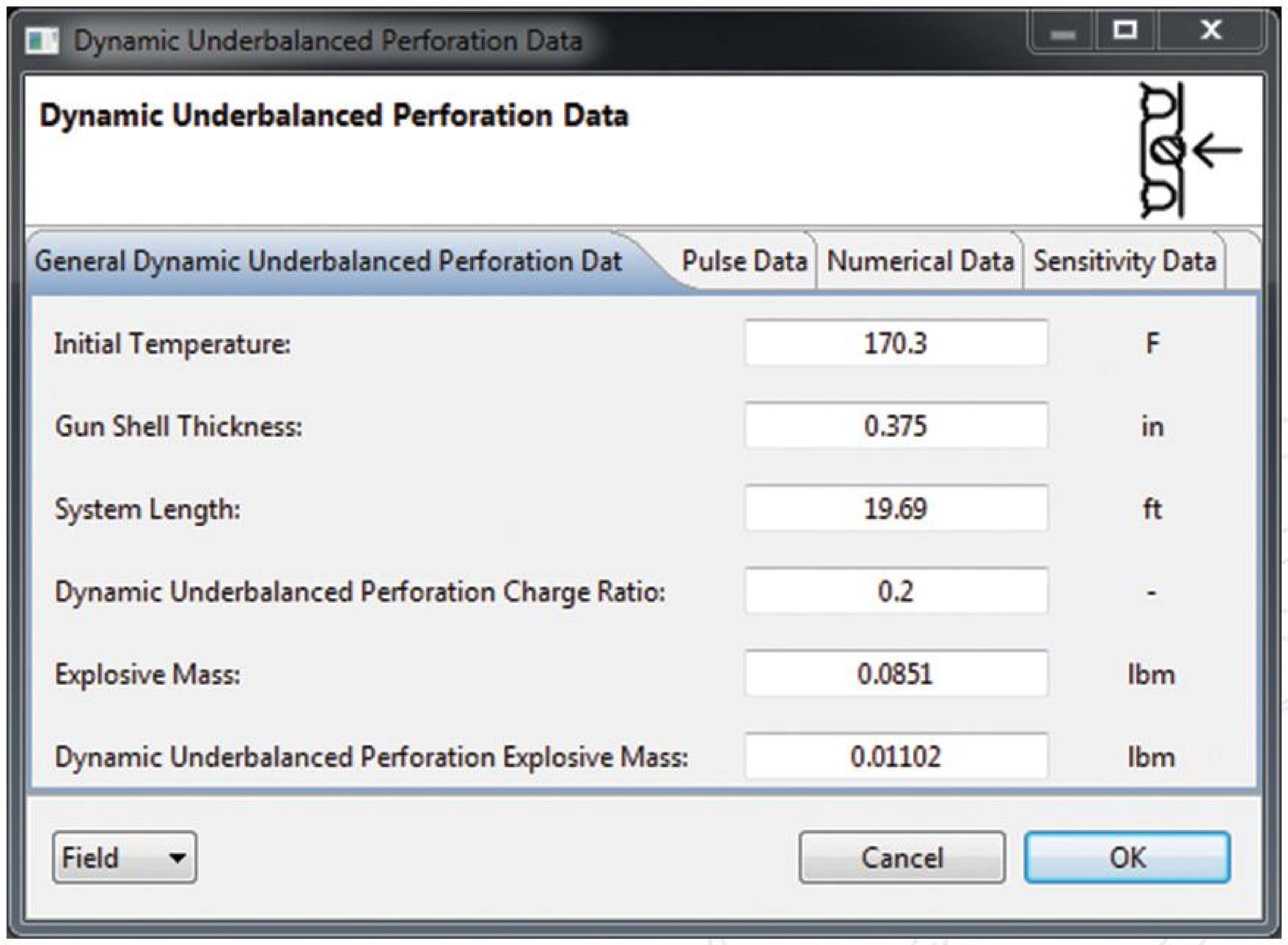
Engineering Support & Technology Development (ESTD)

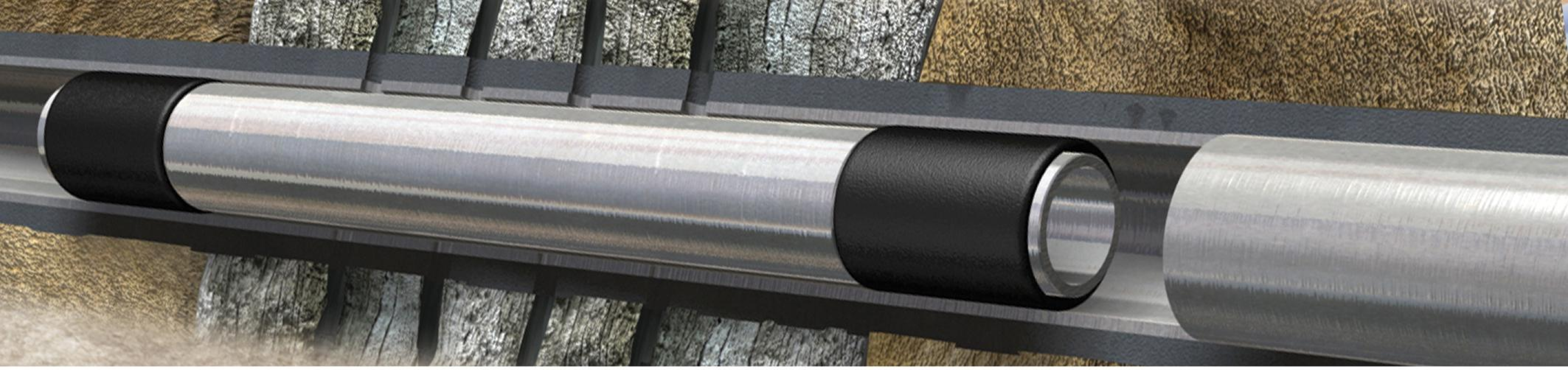
Key features

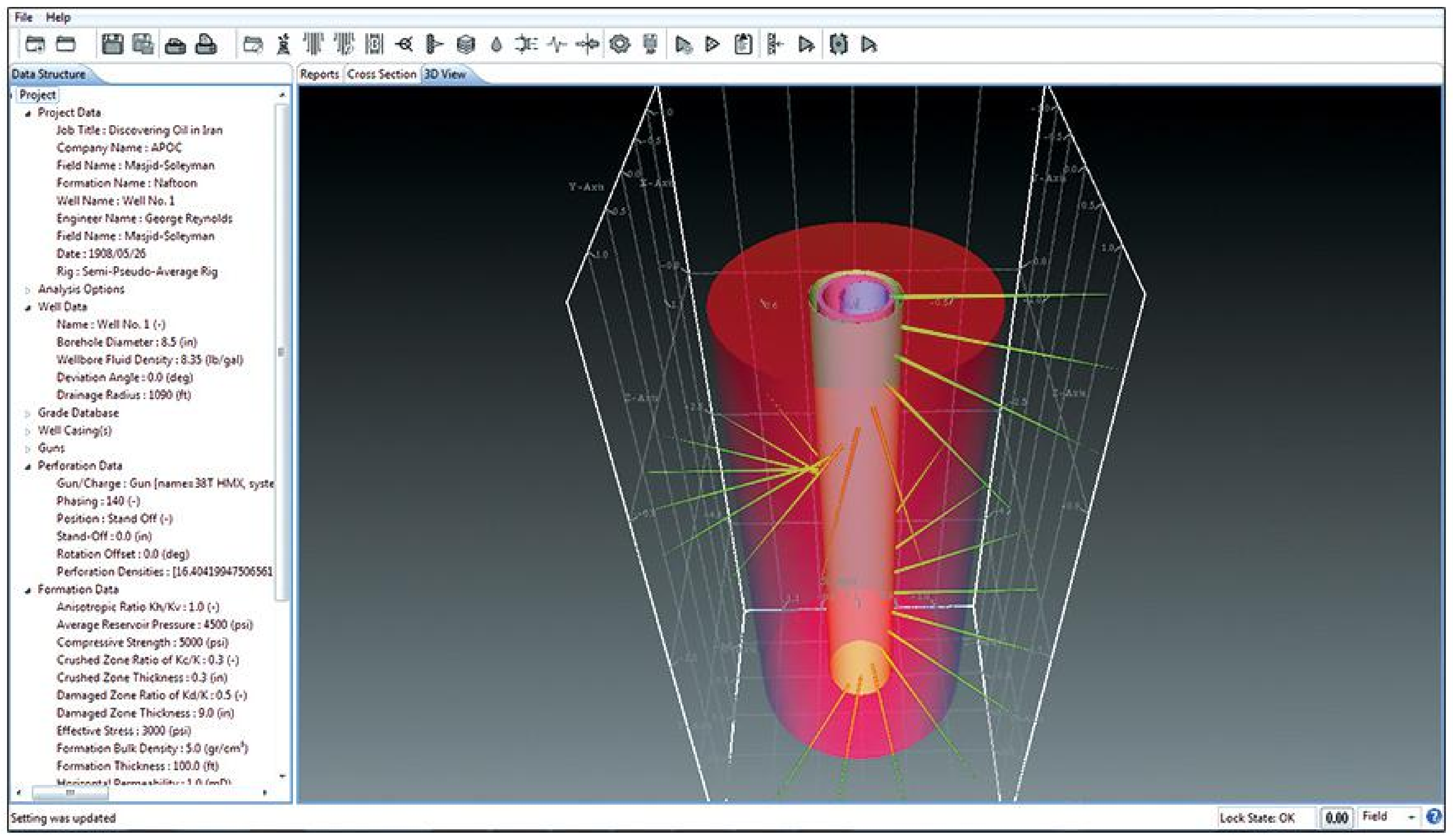
Pre-processing

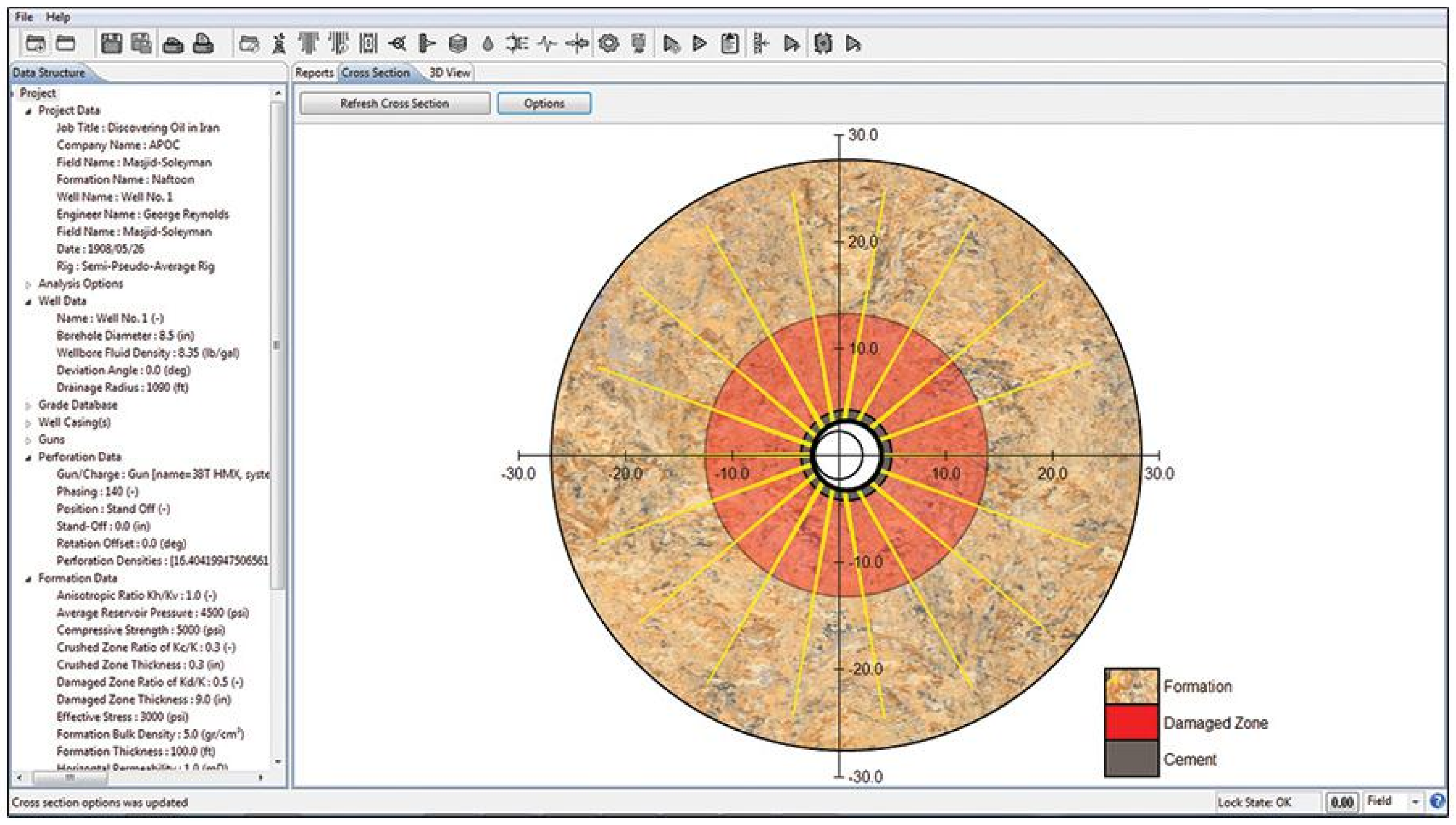
1. Completely user friendly and easy to use pre-processor
2. Darcy and Non-Darcy flow types
3. API 1st or 2nd sections penetration data
4. Control over unit system and the floating point viewing precision in each dialog
5. Gun/Casing and multiple Casing/Liner arrangements
6. Ability to define new casings and guns











7 Defining well deviation, partial completion, formation properties, formation heterogeneity, various gun types, damage zone, perforation crushed zone etc.

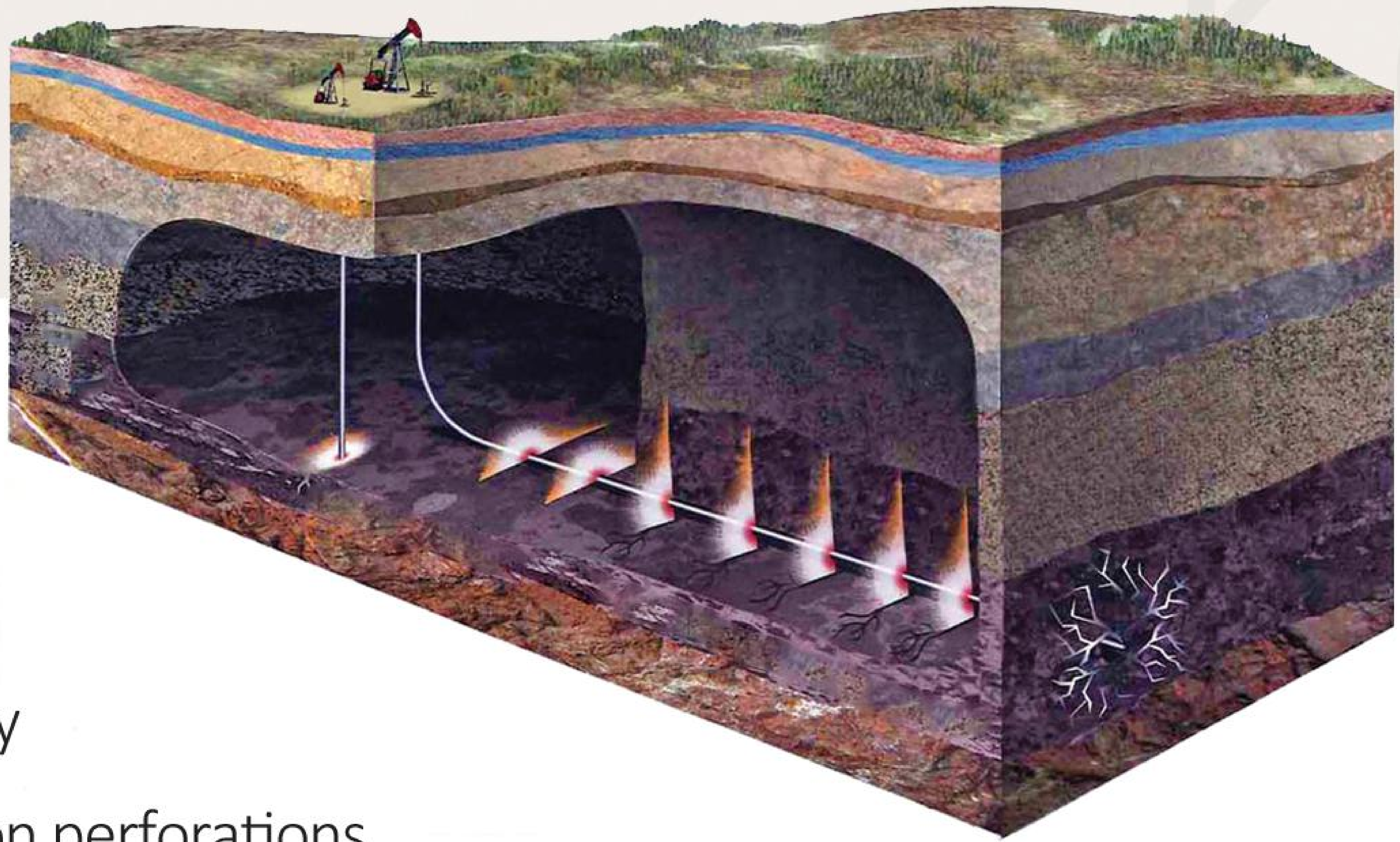
8 Initial well status of overbalance, underbalance or balance

9 New stimulation method of dynamic underbalanced perforation

10 New stimulation method of propellant gas fracturing

11 Stimulation method of hydraulic fracturing

12 Validating model before simulation



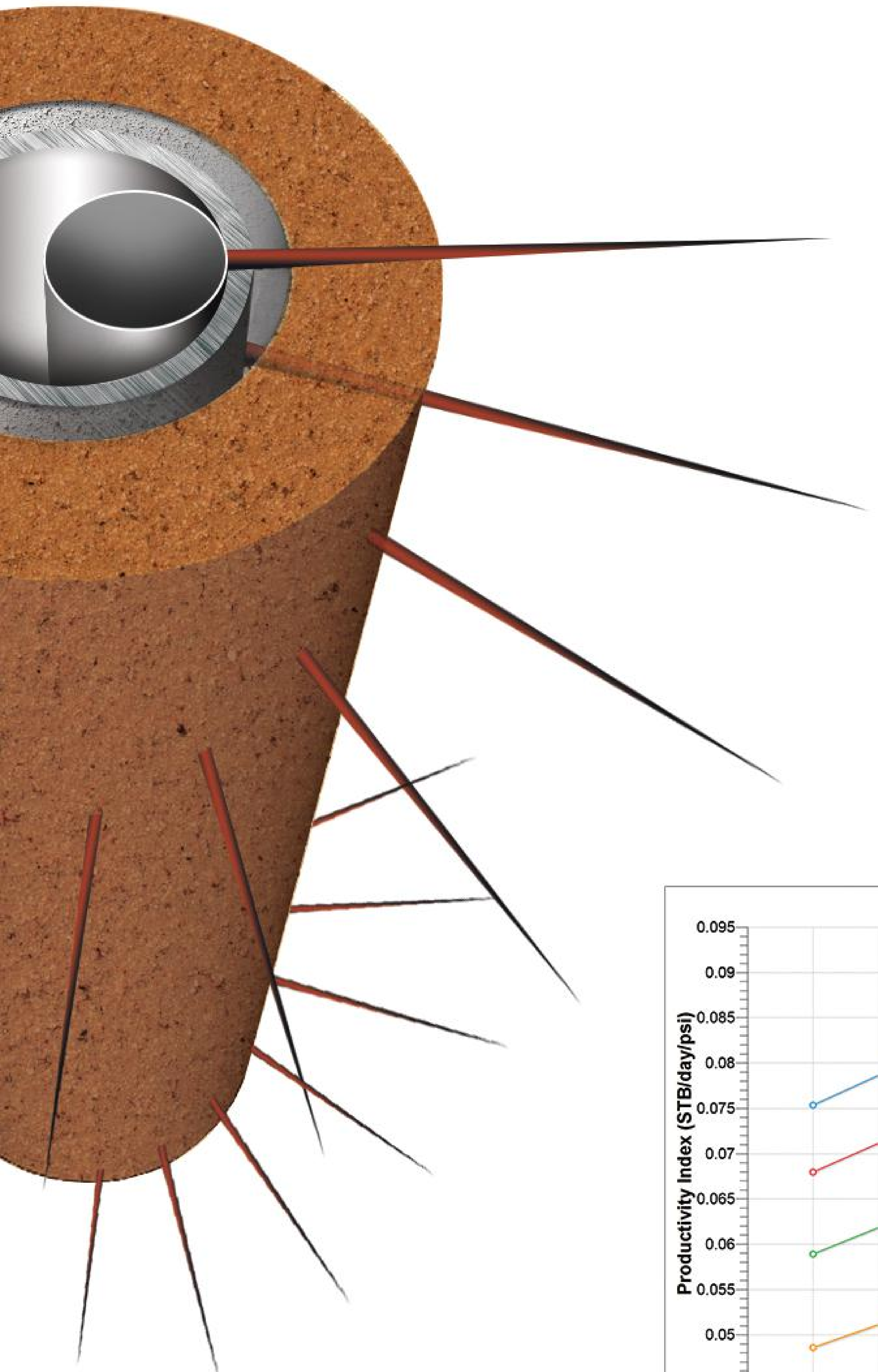
Simulation

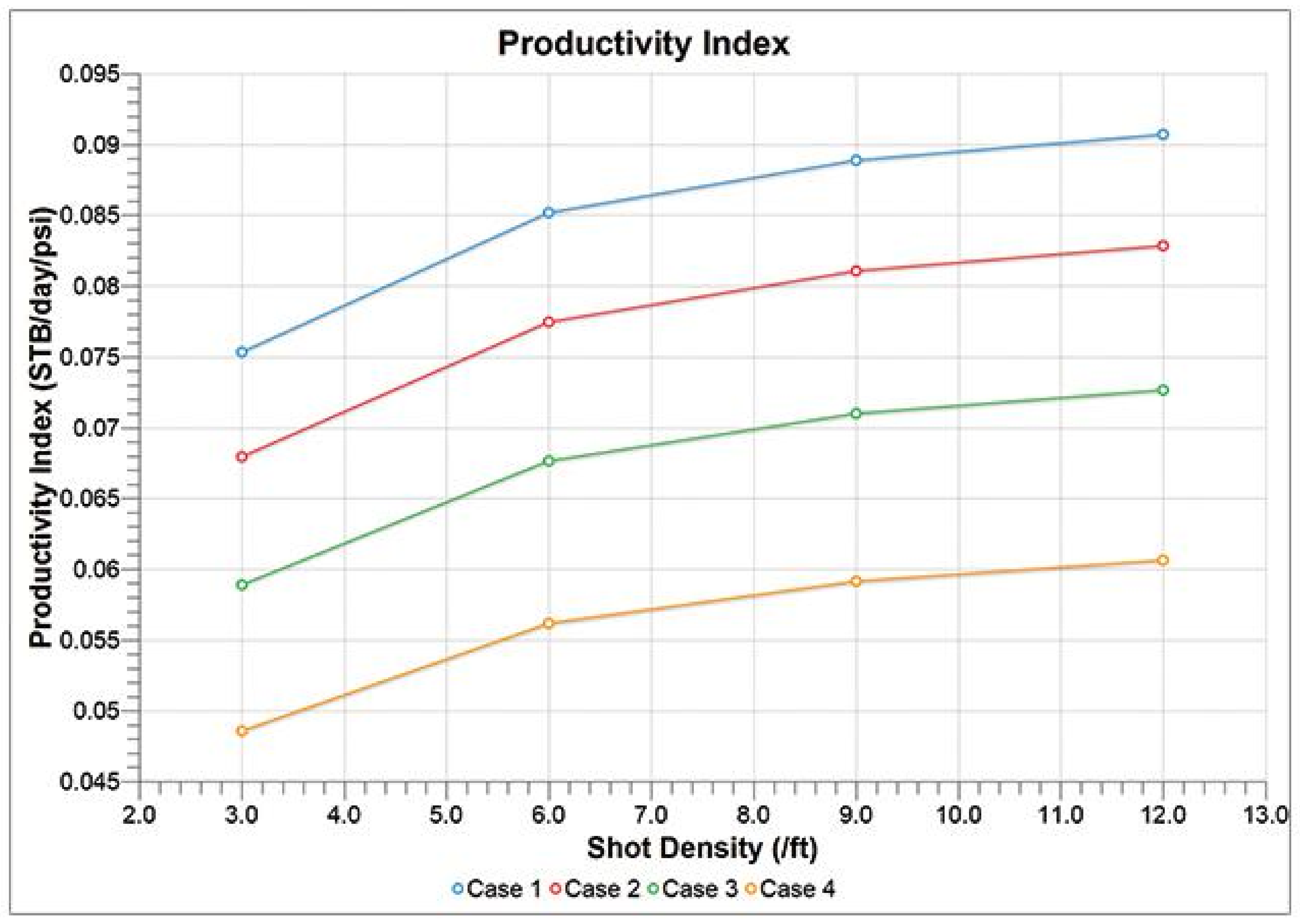
1. Classical penetration theory
2. Casing and cement effect on perforations
3. Effect of rock compressibility, density and stresses on perforations
4. Skin/Productivity calculations based on semi-analytical correlations developed through extensive 3D finite element models
5. Gas volume released in explosion, gun internal temperature, and remaining gas in gun for dynamic underbalance perforation
6. Coupled solution for transient partial differential equations (PDEs) of pressure and flow in reservoir, well, and gun
7. Geometric combustion law for Flame propagation
8. Modeling fractures initiated by propellant gas as a set of wedge-shaped radial fractures
9. Instantaneous thermodynamic properties of fluids in all stimulation methods
10. Linear elastic fracture mechanics in addition to fracture fluid flow and continuity equations for hydraulic fracturing and non-linear PDE for fracture length and width

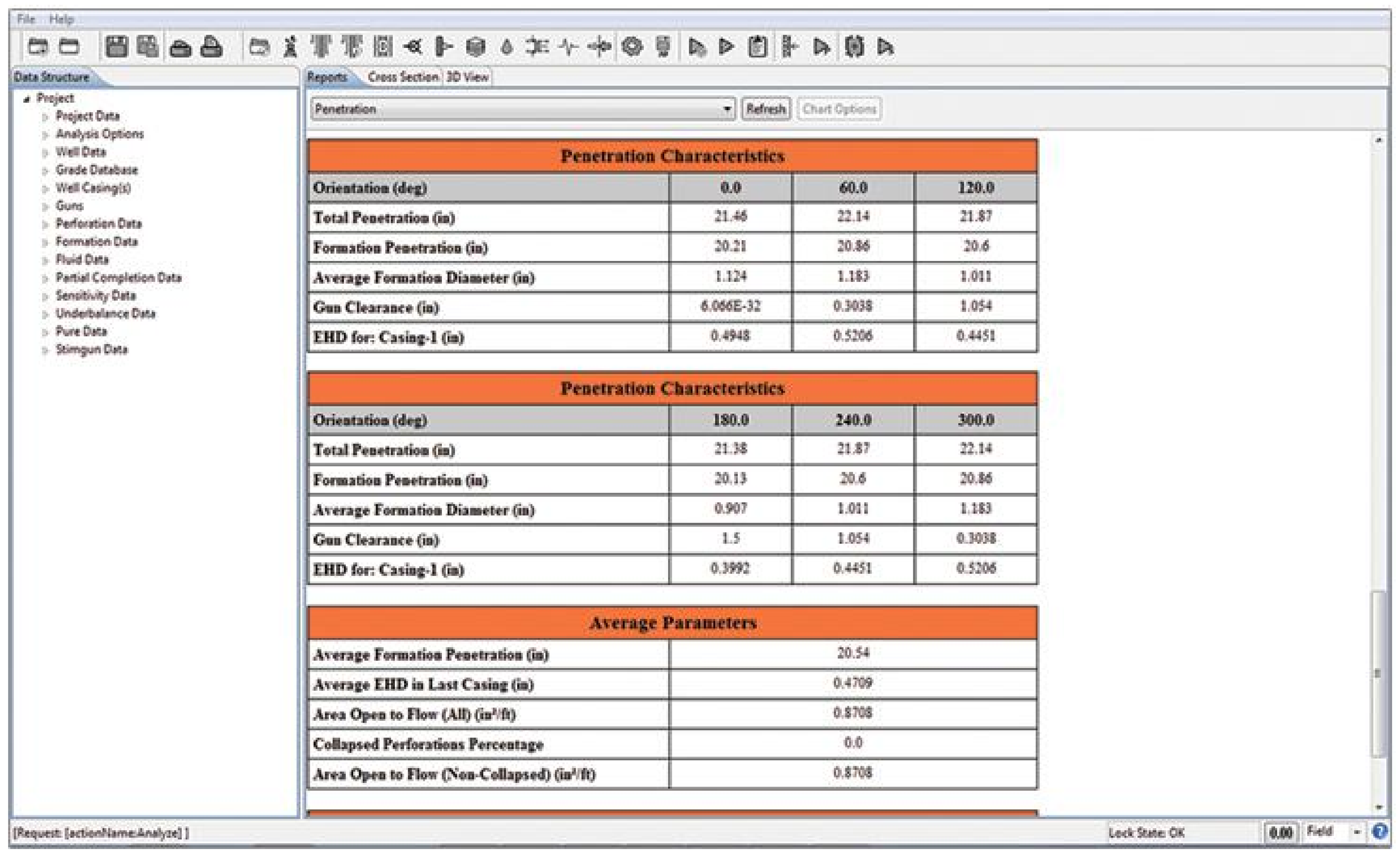
features

Post-Process

1. 2D cross section and 3D visualization
2. Penetration reports
3. Productivity reports
4. Well stimulation reports
5. Result plots
6. Sensitivity analysis reports and plots



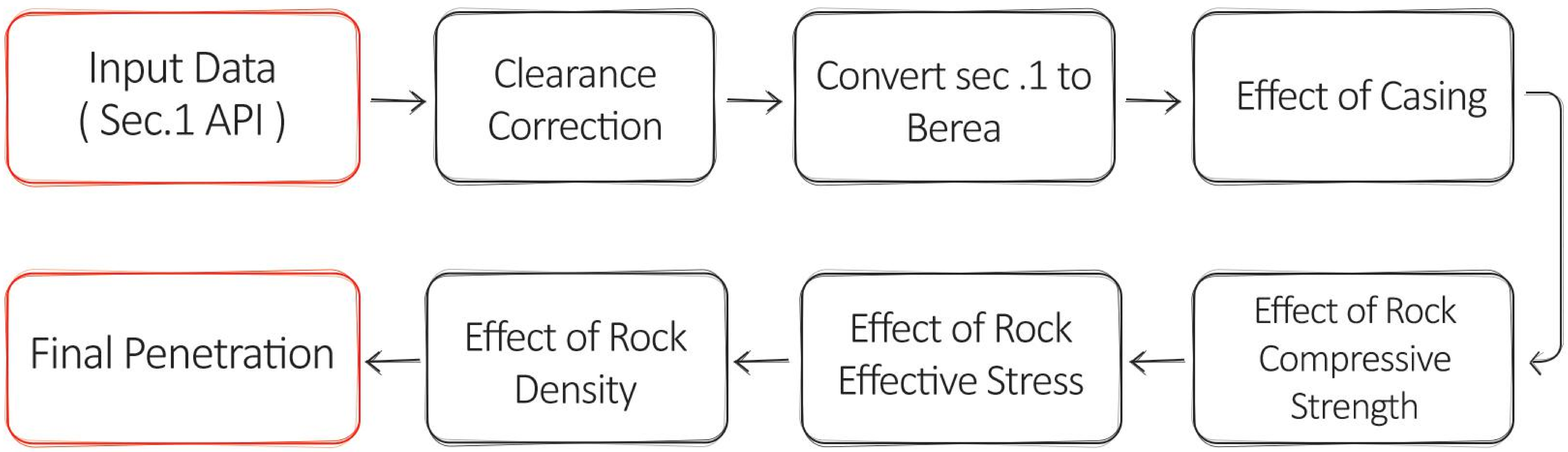


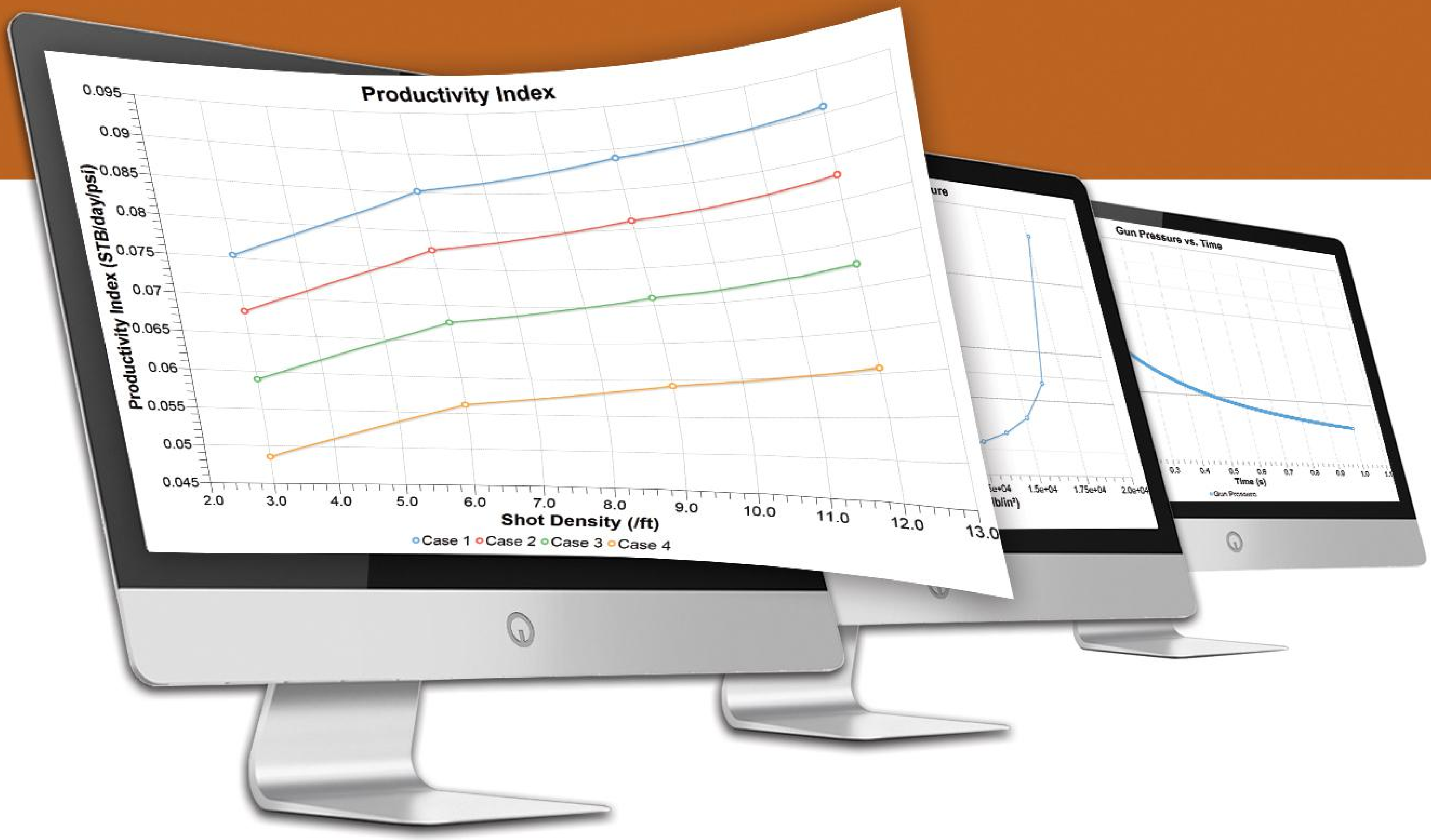


Capabilities and Advantages

Perforation prediction

RETINA Stimulation™ penetration and entrance-hole diameter calculations are based on API section 1 and Berea slab experiments. All Berea penetrations are calculated from Section 1 via a curve fit to the related data. This data is then adjusted, using classical penetration theory. All penetration and entrance-hole computations are made assuming the shaped-charge jet impacts normal to the casing/cement/formation. Experimental data has been obtained in most cases to calculate entrance-hole diameter and penetration for large clearances. The flow of modifications prformed on API sections to calculate formation penetration is presented here:



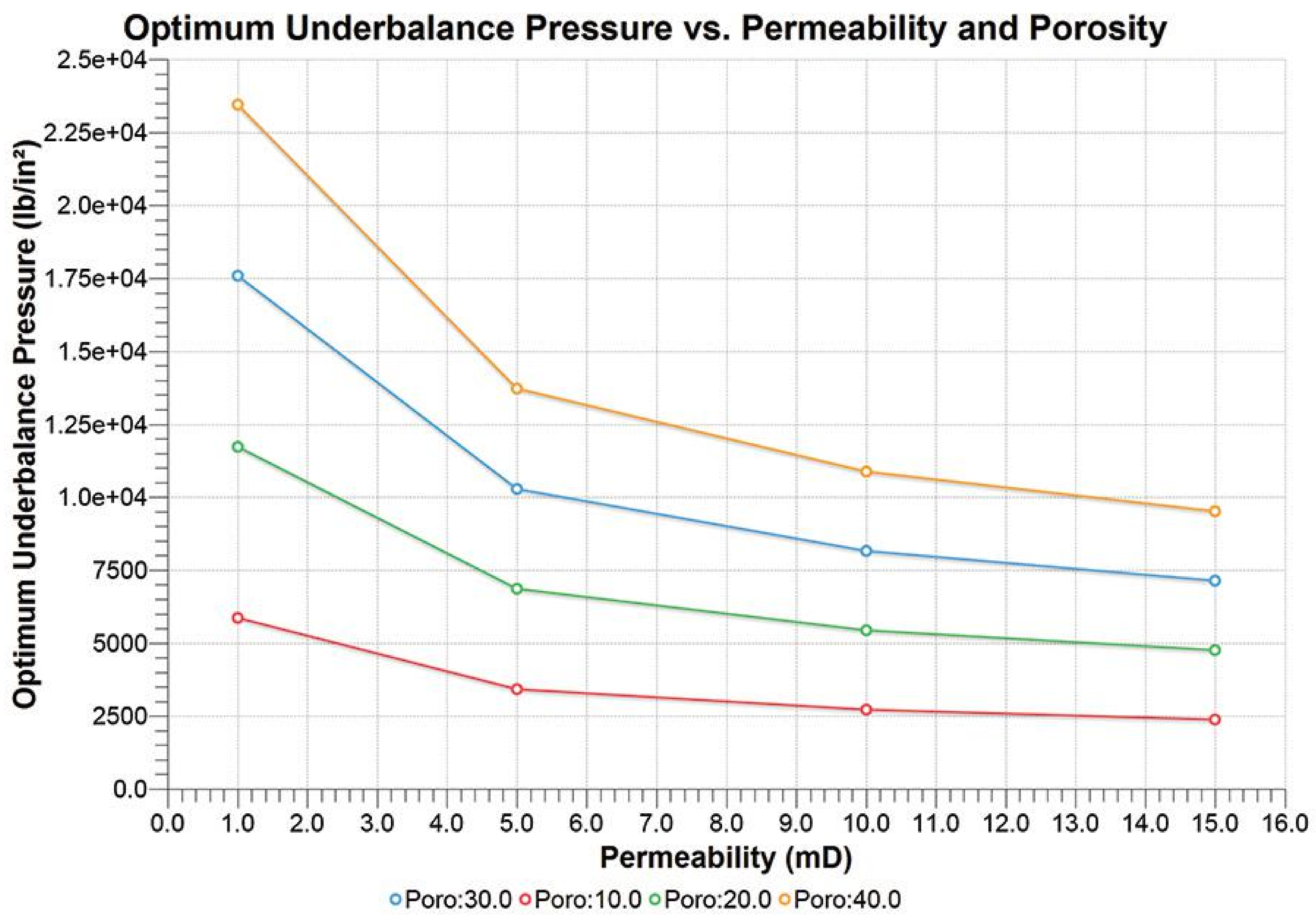


Productivity

Productivity Ratio (PR) is a measure of the perforated completion efficiency relative to the ideal open-hole completion (Damage Skin=0). In reality, the penetration patterns are nonsymmetrical. So, productivity ratios for each perforation tunnel will be different based on its length and diameter. No productivity ratio is calculated for charges that do not penetrate the formation. Productivity ratio is a good theoretical measure for the efficiency of a completion, however, the pseudo-steady-state Productivity Index (PI) and Flow Efficiency (FE) for the non-Darcy cases are also calculated. The user can perform sensitivity analysis on Productivity Index, Productivity Ratio, and Flow Efficiency.

Optimum Underbalance Pressure Prediction

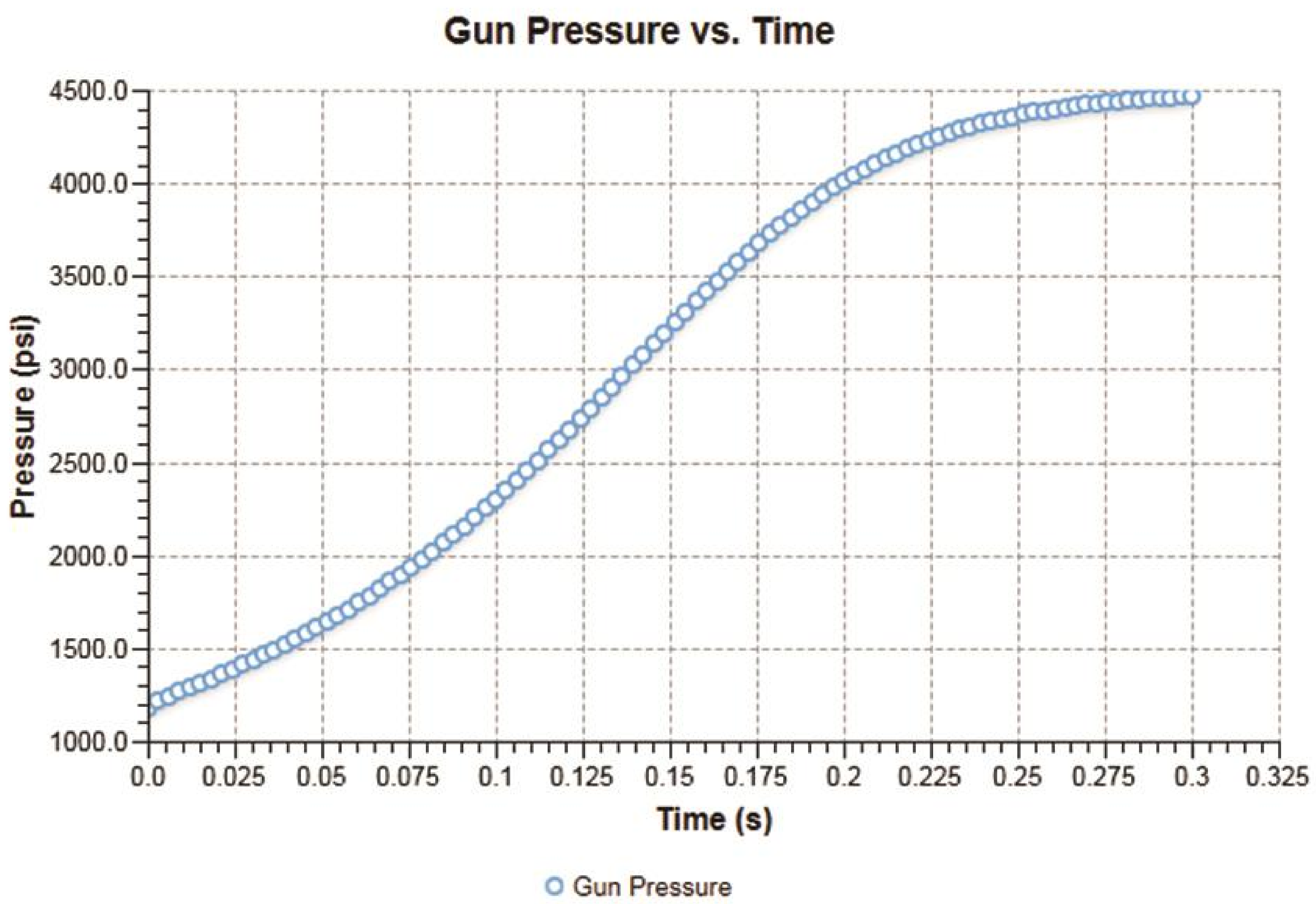
Assume that after the creation of the perforation tunnel there is only loose fractured sand (no liquid or high pressure gas) in the tunnel, so a differential pressure boundary condition exists at the tunnel walls equal to the reservoir pressure. A decompression wave moves radially from the tunnel wall, reducing the reservoir pressure. This pressure reduction is a function of the fluid and rock properties. If the pressure reduction at any given radius is fast enough, then a substantial pressure differential across a fractured sand grain can be developed. These calculations are based on equations developed on the basis of traditional static underbalance perforation theory.

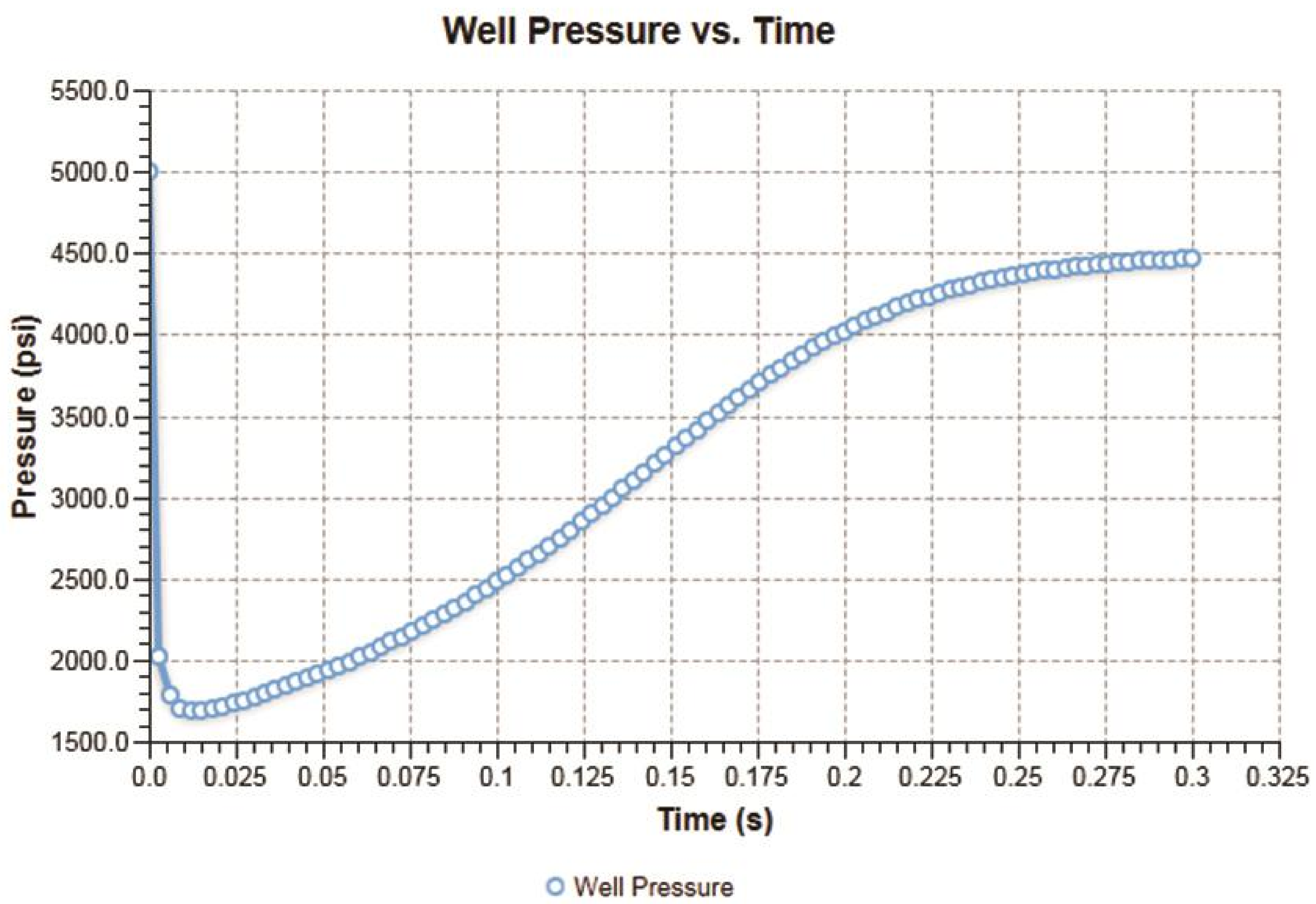


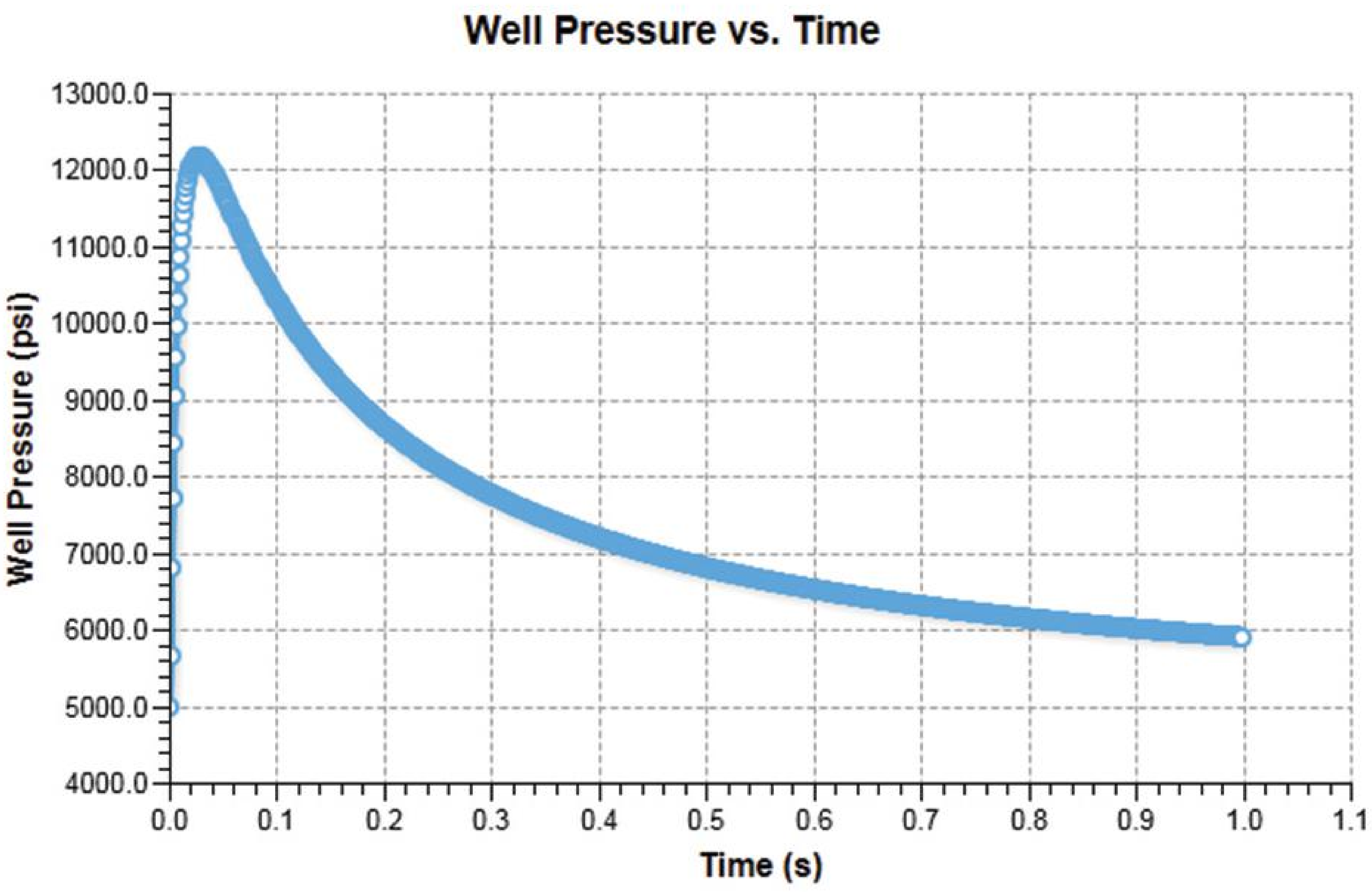
Dynamic Underbalanced Perforation

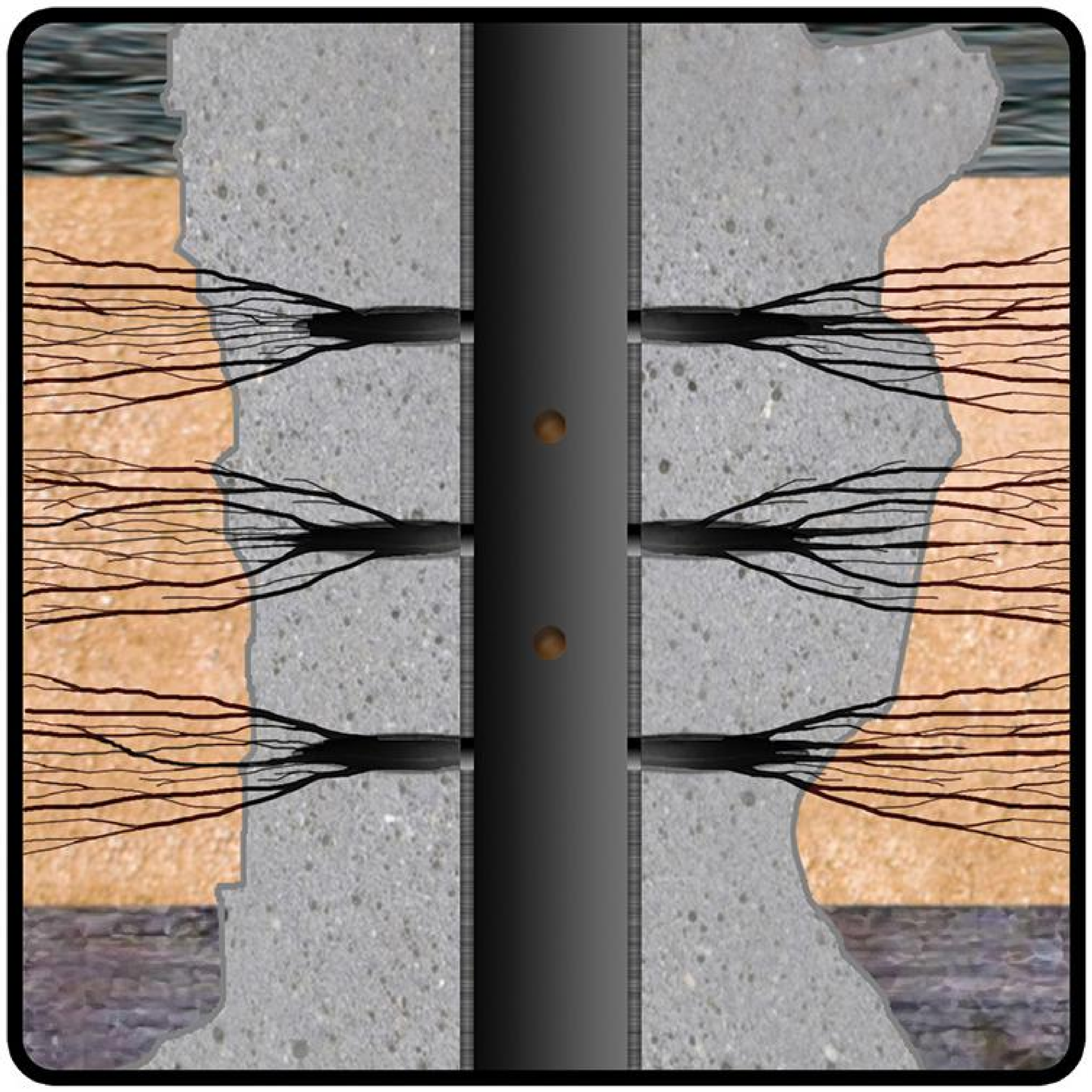
Recent research and field results indicate that a static underbalance pressure alone is insufficient to achieve clean perforations. So, a dynamic underbalance technique is designed to achieve an underbalance pressure immediately after perforation occurs. This can provide perforations with a very high kc/k ratio and larger tunnel diameter which, is the preferred method of perforation job design. There are five main calculation steps in modeling of this technique:

- Detonation released gas volume
- Gun internal temperature calculations
- Remaining gas and energy amount in the gun
- Gun internal pressure calculations and casing stability analysis
- Skin calculations





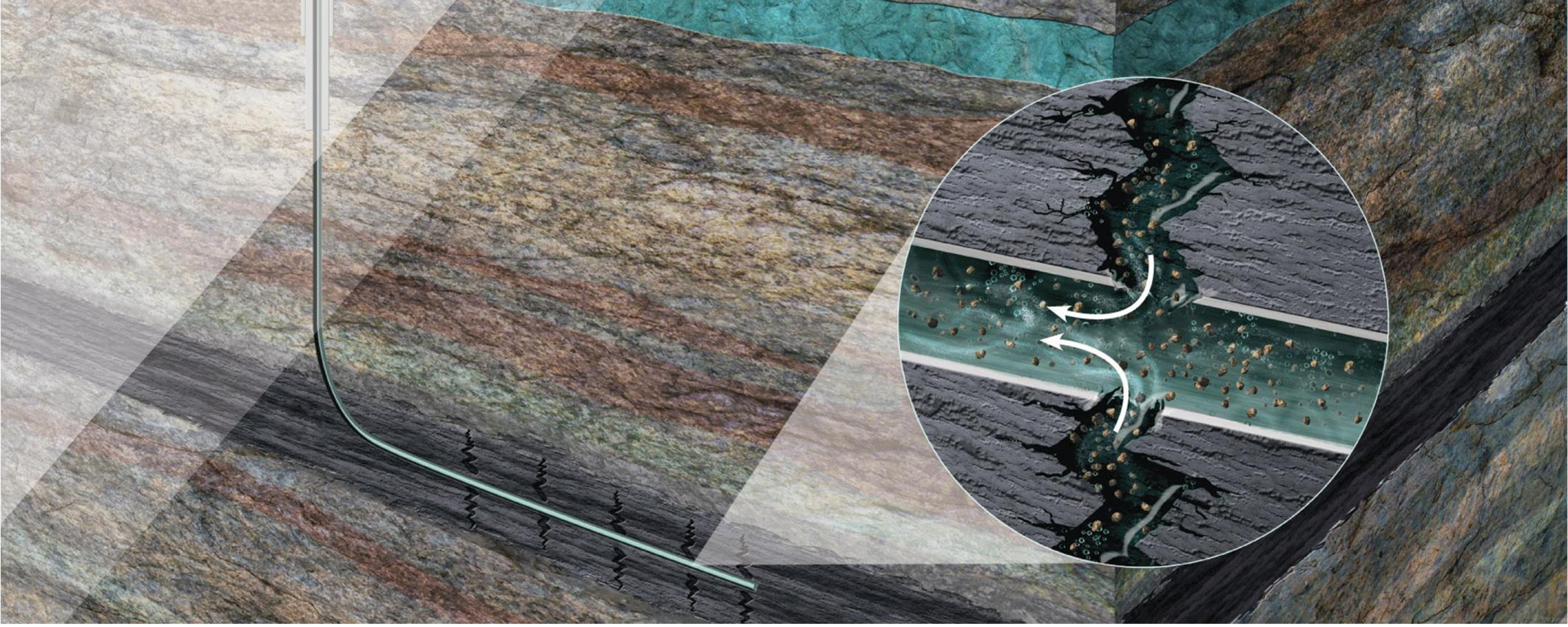




Propellant Gas Fracturing

“Propellant Gas Fracturing” is a technique that makes use of fast burning chemicals in wells to fracture the formation near the wellbore and stimulate the well productivity or injectivity. The process of propellant gas fracturing normally takes less than one second. Because of the compressibility of gas and the highly dynamic behavior of the process, the pressures in the charging canister (if the cased propellant-charge is employed), the wellbore and the fractures vary with time and position. The geometric combustion law governs the flame propagation into propellant solid. This law applies until the propellant solid is burnt through and the main combustion is finished.

The geometry of fractures initiated and propagated by propellant gas has been modelled as a set of wedge-shaped radial fractures with a constant height. In cased and perforated wells, the fractures are initiated in the same direction of perforations and are connected to the wellbore through perforations.



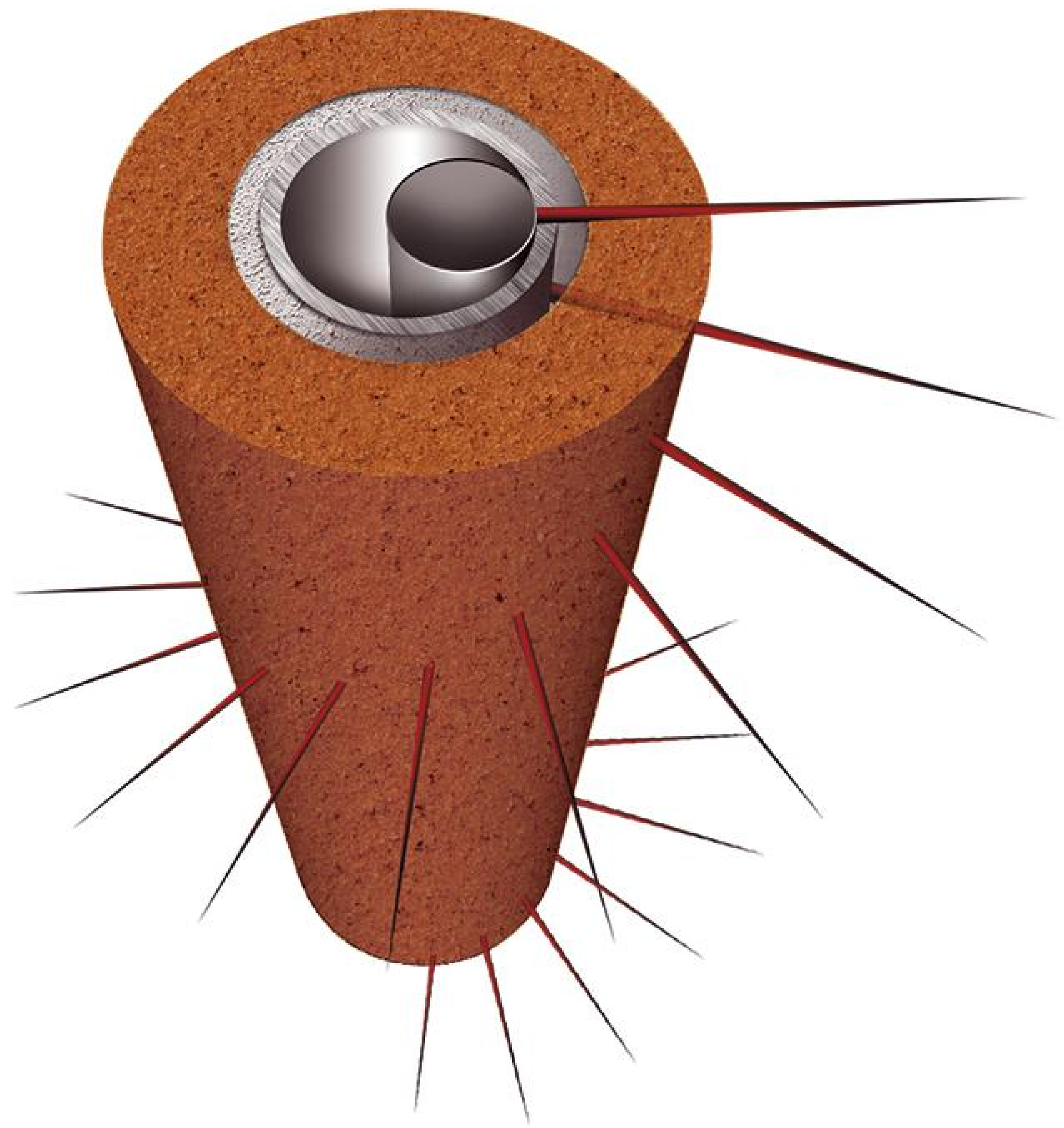
Hydraulic Fracturing

Wells in low to moderate-permeability reservoirs are candidates for hydraulic fracturing as a means of stimulating their performance. Like any other method of well stimulation, hydraulic fracturing, adjusts the skin effect (or the related effective wellbore radius). Hydraulic fractures bypass the near-wellbore damage zone. Modeling of hydraulic fracturing employs three fundamental equations of continuity, momentum (Fracture Fluid Flow) and LEFM (Linear Elastic Fracture Mechanics). The three sets of equations need to be coupled to simulate the propagation of the fracture. The material balance and fluid flow are coupled using the relation between the fracture width and fluid pressure. The resulting deformation is modeled through LEFM. Two models of "Perkins-Kern-Nordgren (PKN)" and " Geertsma-de Klerk (GDK) " both including non-Newtonian fluid effects and leak-off from the face of the fracture normal to the formation are used for dynamic fracture propagation and hydraulic fracturing design.

Case Study:

The three aforementioned stimulation methods, namely, “dynamic underbalance”, “propellant gas fracturing” and “hydraulic fracturing” are evaluated in a case study to determine the most efficient method for a well drilled in a carbonate reservoir. The well has been perforated by a 3-3/8 inch, 22.5 HMX SDP gun with phasing of 60 degrees and shot density of 6 shot/ft. The productivity and skin reports have been presented here for all the methods:

Method	Skin	Productivity Ratio	Comments
Conventional Perforation	11.0	0.42	
Dynamic Underbalance Perforation	6.06	0.57	DUP charge ratio : 0.3
Propellant Gas Fracturing	4.46	0.65	Propellant loading ratio : 0.25
Hydraulic Fracturing	-3.68	1.84	Pump power : 2500 hp



ESTD
Engineering Support & Technology Development

Tehran : Unit 313, No 450, Mirdamad Boulevard, Tehran, Iran
Phone : +9821 8888 4437

Dubai : Office 31-B, Silver Tower, Cluster I, JLT, Dubai, UAE
Phone : +971 56811 3141

Sofia : App 26, Entrance A, Block25E, Goce Delchev, Sofia, Bulgaria
Phone : +359 88412 4966

Website : www.estdco.com
Email : info@estdco.com