

FRACMAN[®]

HYDRAULIC FRACTURE STIMULATION GEOMECHANICS/HYDRODYNAMICS ANALYSIS

Around the world
Under the earth
Above & beyond

Golder Associates is one of the world's premier consulting groups serving the oil and gas industry with key technologies for upstream development, unconventional resources, pipelines, geotechnics, and environmental compliance. Golder's 7,000+ employees provide local solutions through our network of offices in Australia, Europe, North America, Asia and South America.

Golder Associates has been providing geomechanics and hydrodynamics modelling services to the upstream oil and gas industry since 1977. These services include well bore stability, sanding, soil/structure interaction, single and multiphase hydrodynamics, rock mechanics and soil mechanics.

Hydraulic Fracture Modelling and Analysis

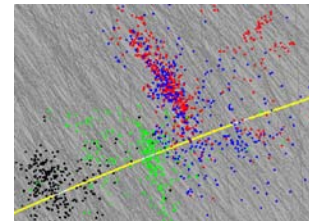
Golder Associates has developed unique capabilities for analysis and modelling of hydraulic fractures, integrating our world standard FracMan discrete fracture network modelling capabilities with the ELFEN continuum/discontinuum geomechanics model from RockField Software Ltd.

Golder's modelling service allows detailed analysis of the interaction of natural and hydraulic fractures, hydraulic fracture geometry, and natural fracture reactivation. Golder's technologies make it possible to evaluate the effectiveness of hydraulic fracturing techniques for improved recovery in shale gas, carbonate, sandstone, fractured basement, tight gas, and unconventional reservoirs. Our FracMan-ELFEN approach includes frac-fluid and proppant modelling, integrated flow/geomechanics, and microseismic simulation.

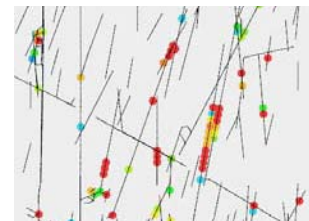
Golder Associates discrete fracture network (DFN) hydraulic fracture analysis can be applied to reservoirs with hundreds to thousands of frac stages.

Golder provides practical answers to important reservoir issues for frac'ed reservoirs including

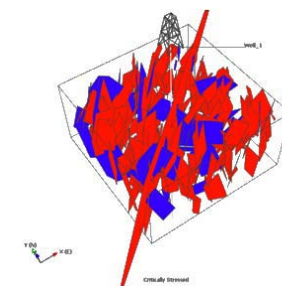
- Infill drilling, completion, and frac'ing strategies
- Evaluation of exploration prospects
- Tributary drainage volumes and recovery factors
- Estimates of ultimate recovery and fracture effective porosity



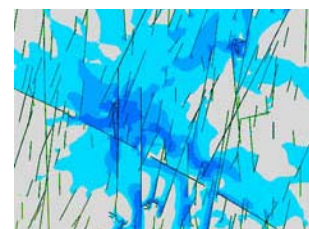
Microseismic Modeling and Conditioning



ELFEN Fracture Propagation showing Simulated Microseismic Response



Natural and Hydraulic Fractures Showing reactivation (red)



Rock matrix influenced by hydraulic fracturing stress redistribution



FracMan Contact Information

USA +1 425 883 0777

Canada +1 604 296 4200

UK +44 1628 586200

Golder Associates is a premier group of professional services firms operating in the areas of the earth and the environment. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of our clients' needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australia, Europe, North America and South America.

Africa + 27 11 254 4800

Asia +852 2562 3658

Australasia + 61 7 3721 5400

Europe + 356 21 42 30 20

North America + 1 800 275 3281

South America + 55 21 3095 9500



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Selected Services:

Fractured Reservoir Geology

- ▶ Analysis of Faults and Fractures
- ▶ Fracture Analysis from Geophysics
- ▶ Discrete Fracture Reservoir Modeling
- ▶ Field Scale Fracture Extrapolation
- ▶ Fracture Data Analysis
- ▶ Reservoir Architecture Assessment

Fractured Reservoir Engineering

- ▶ Development Strategies
- ▶ Well Trajectory Optimization
- ▶ Upscaling of Fracture Permeability
- ▶ Fracture Porosity Analysis
- ▶ Stress/Permeability Coupling
- ▶ Anisotropy and Heterogeneity
- ▶ Uncertainty Analysis
- ▶ Risk Assessment
- ▶ IOR Strategy Development
- ▶ Hydraulic Fracture Modeling and Analysis

Fracture Reservoir Static Modeling

- ▶ Reservoir Volumetrics
- ▶ Tributary Drainage Volumes
- ▶ Compartmentalization Analysis
- ▶ Matrix-Fracture Interaction

Fractured Reservoir Dynamic Modeling

- ▶ True Multiple Porosity/Multiple Permeability Dynamic Simulation
- ▶ Production Test, PLT, and DST Analysis and Interpretation
- ▶ Multiphase Discrete Fracture Network Flow Modeling
- ▶ Calibration and Conditioning to Dynamic Data
- ▶ Dynamic Upscaling

www.fracturedreservoirs.com

fracman@golder.com

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