INTRODUCING

FracMap Clarity™

by

esg solutions

a spectris company

Today's Challenge:

Information available today has stopped short of allowing operators to identify individual producing fractures.

Without knowing which fractures are producing, operators have been limited in their ability to improve reservoir coverage, completion strategies and overall production.

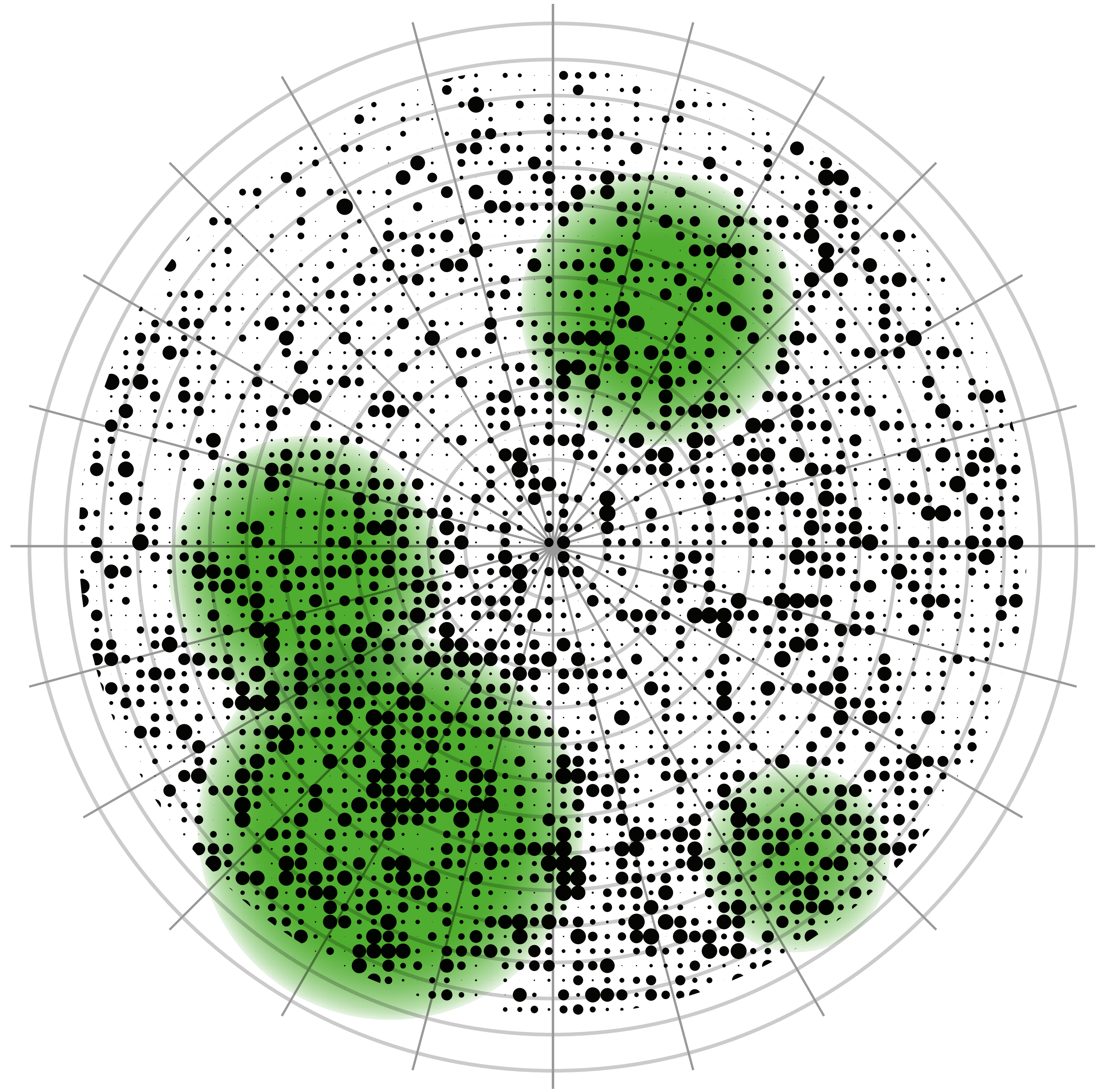
esg
a spectris company

The Conventional Data Cloud

Industry standard microseismic data has given operators a cloud-like set of detected events during a fracture operation. But it has certain limitations:

- This data cloud provides a broad view of all microseismic events during the fracture operation
- It does not provide the level of detail needed to identify productive fractures
- It does not provide the level of detail needed to calculate accurate frac heights

With these critical pieces of information, microseismic analysis would be able to better help operators improve field development decisions.



Introducing FracMap Clarity™

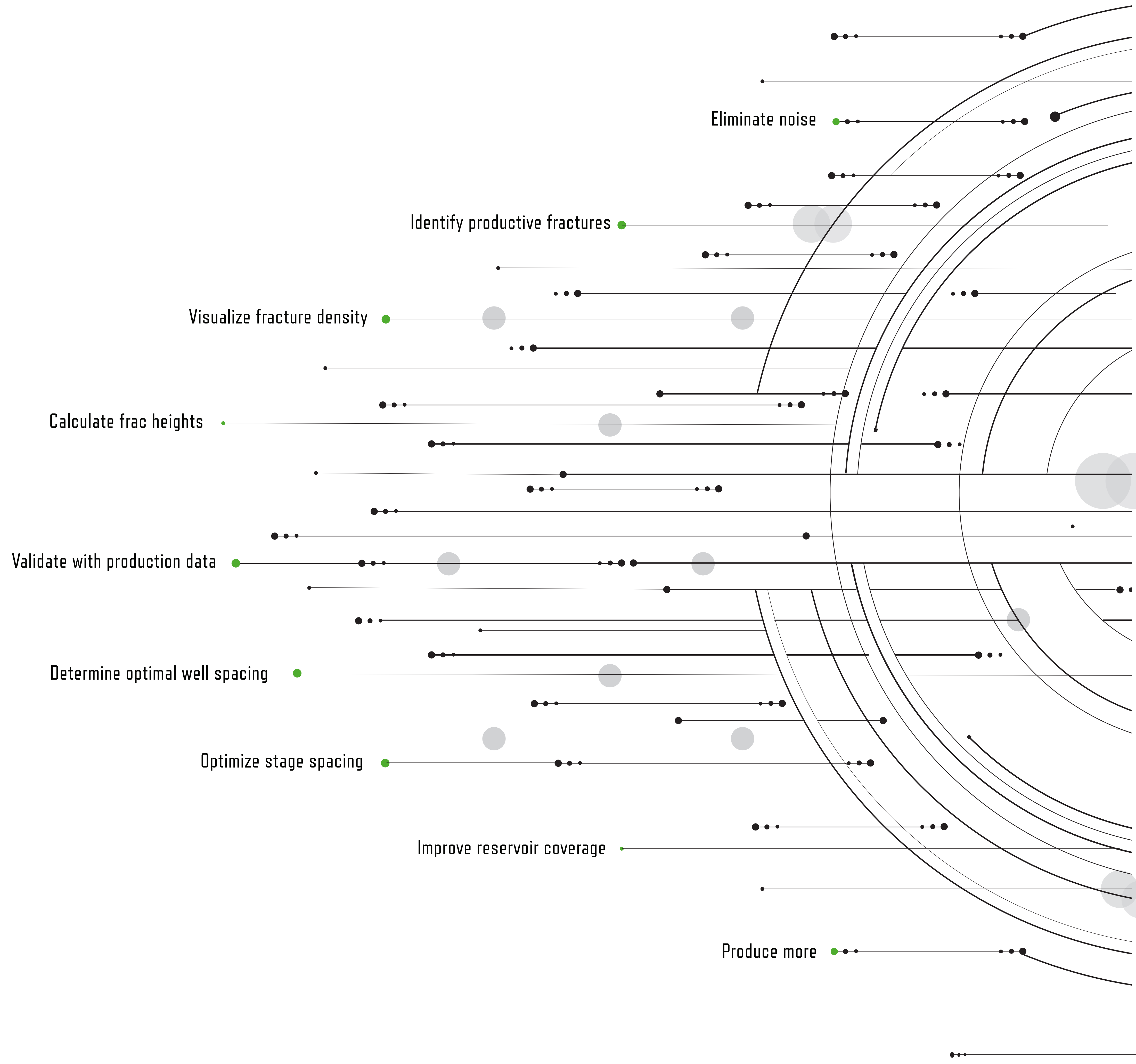
FracMap Clarity™ is an innovative new approach that goes beyond the cloud to give you more insight than ever into your productive fracture network. Using a more rigorous and contextualized characterization methodology, we're able to:

- Proprietary analysis of mircroseismic events enables differentiation between stress-induced and fluid-induced events
- Calibrate our interpretation with Rate Transient Analysis (RTA) to confirm validity of fluid-induced events
- Calculate frac heights along the entire length of the well
- Create a clear visualization of the productive fracture network

esg
a spectris company

SO WHAT DOES THAT MEAN FOR OPERATORS?

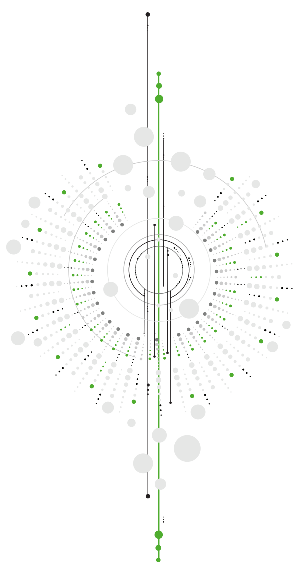
More information.
Less estimation.



Achieving Clarity, Step-by-Step

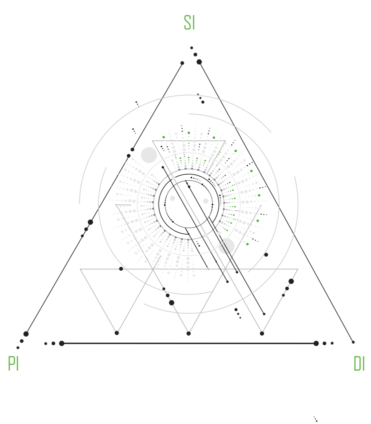
FracMap Clarity™ by ESG Solutions

Feasibility Study



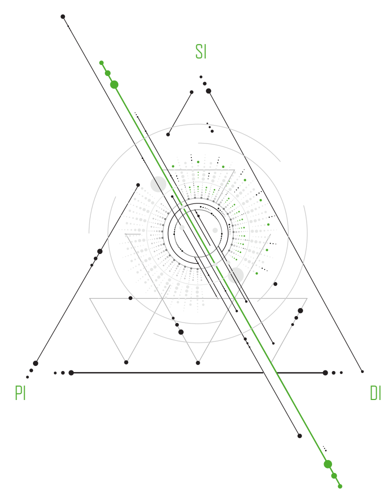
- Audit event number
- Assess event quality
- Eliminate noise

DPA Calculation



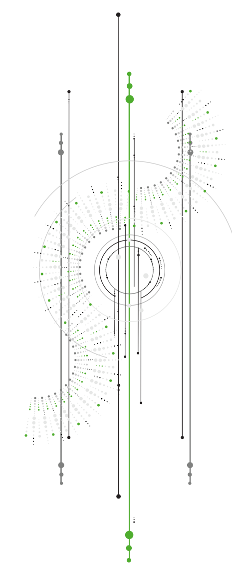
- Analyze stress, plasticity and diffusion
- Proprietary DPA calculations
- Clusters and volume applied

RTA Calibration



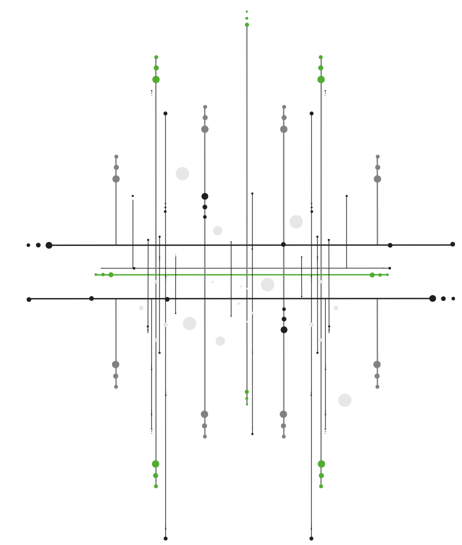
- Constraints applied to volume
- Cluster volume calibrated
- Elimination of non-productive events

Parameter Visualization



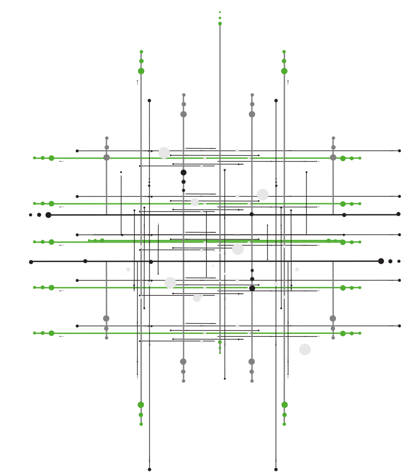
- Clusters plotted against well
- Visualization of productive fractures
- Full spatial distribution

Frac Height Determination



- Calculations applied
- Stage characteristics presented
- Frac density revealed

Analysis + Insight

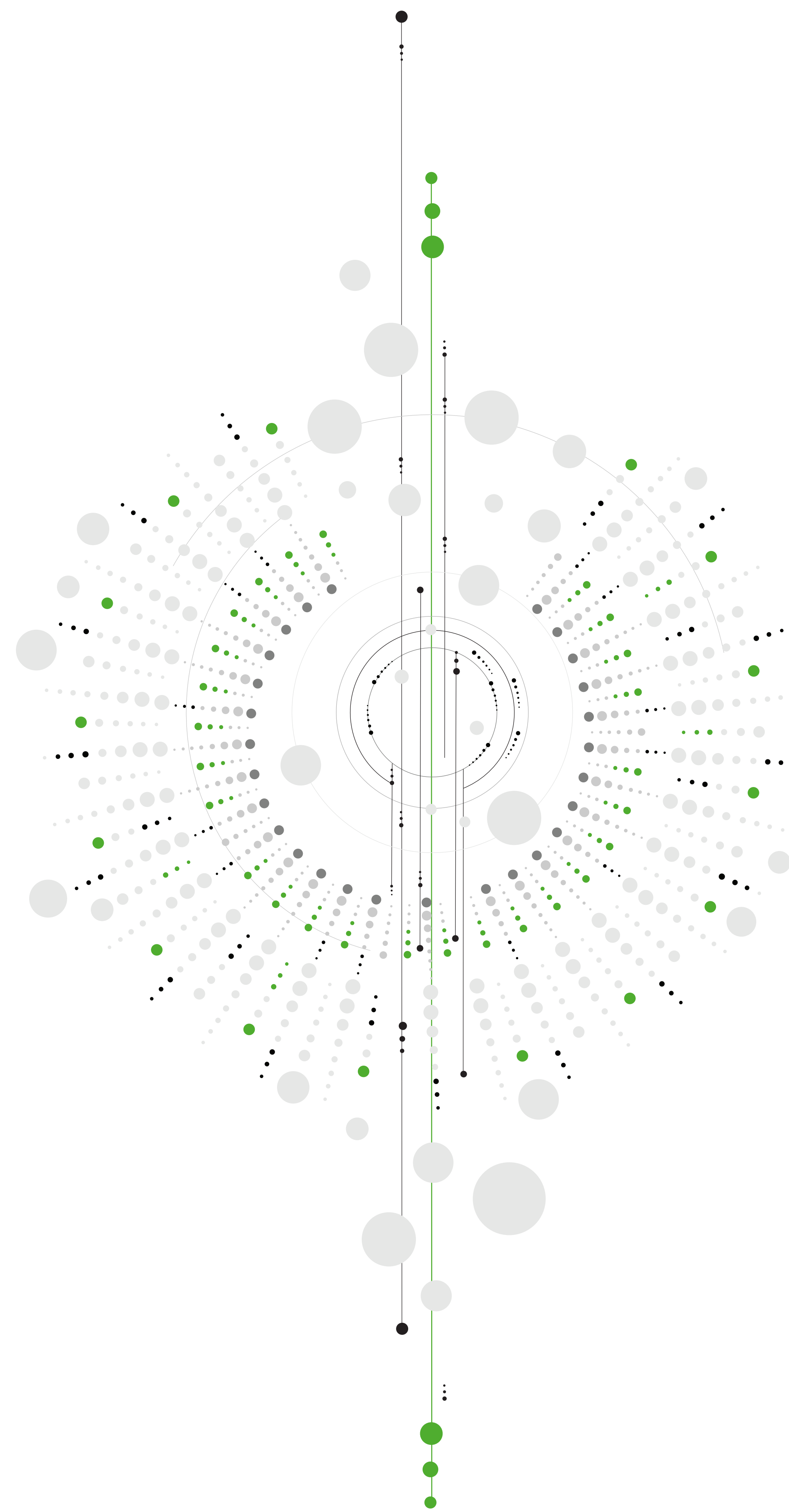


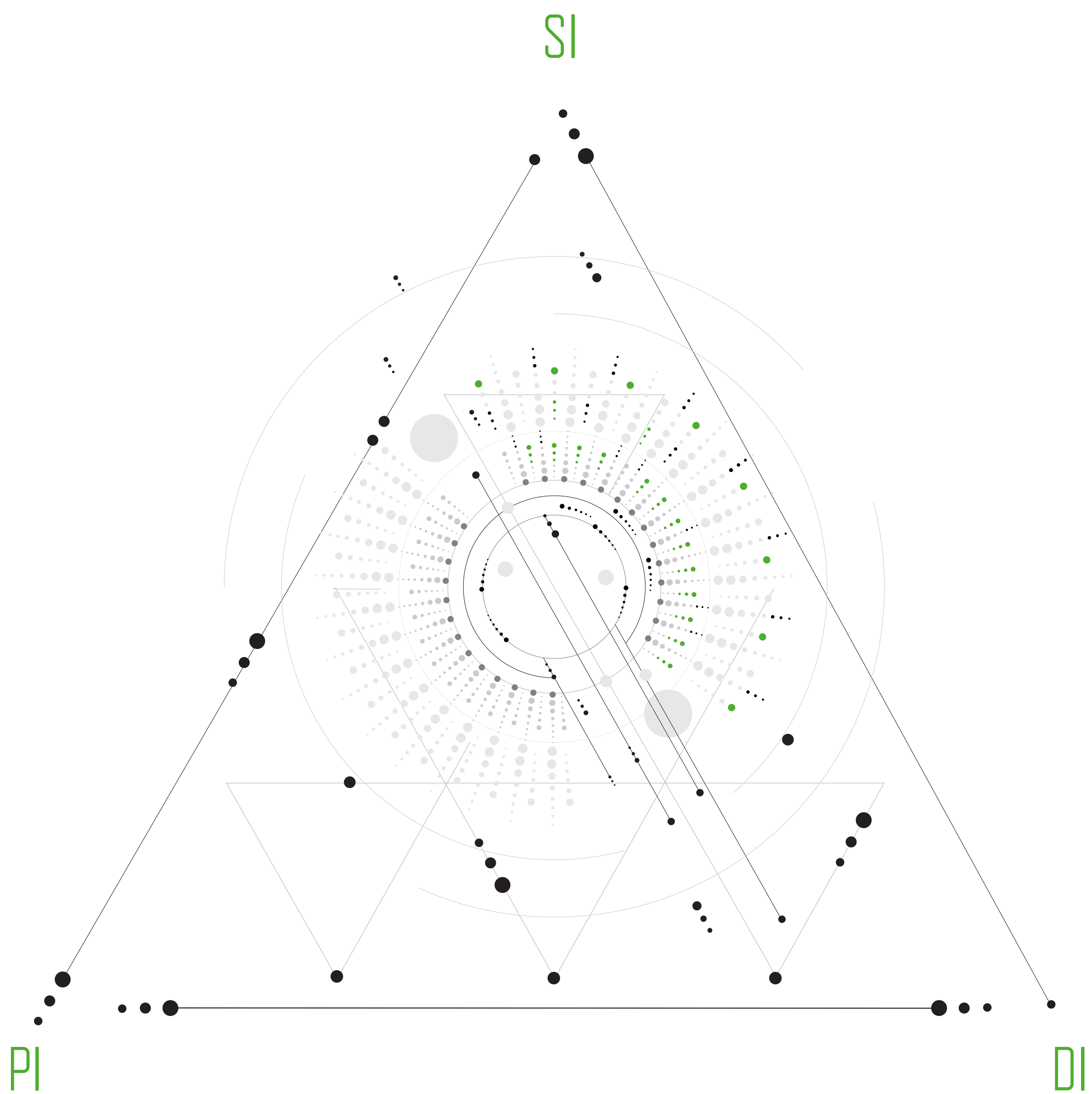
- Refined network characteristics
- Stage and spatial trends
- Pathways to optimization revealed

01 Feasibility Study

In this step we determine the feasibility that an individual event can contribute to the productive fracture network. Specifically we:

- Qualify events against confidence criteria by analyzing the energy, signal noise and magnitude of each event to ensure a relevant data set





02 Dynamic Parameter Analysis

Dynamic Parameters Analysis (DPA) is a method of cataloging all seismic events to identify fluid-driven vs. stress-driven events through analysis of spatial and temporal clustering.

- Rupture Dynamics indicate that as stress is released into the rock, it will be released outward in a heterogeneous fashion until the stress is relieved
- The resulting seismic waves radiating out from the point of initiation reveal differences in the rupture process
- By analyzing the seismic waveforms we can define parameters to identify the role of friction vs. fluid on fracture development

Waveform Analysis

Event-specific signal analysis provides a critical rupture-to-cessation wave radiation snapshot revealing the relationship between total radiated energy and the event's seismic moment.

- Map attributes of each event's signal behavior
- Determine events exhibiting low apparent stress (more likely to be fluid induced)
- Proprietary equations are used to calculate parameter indexes using analyzed inputs

DPA Inputs

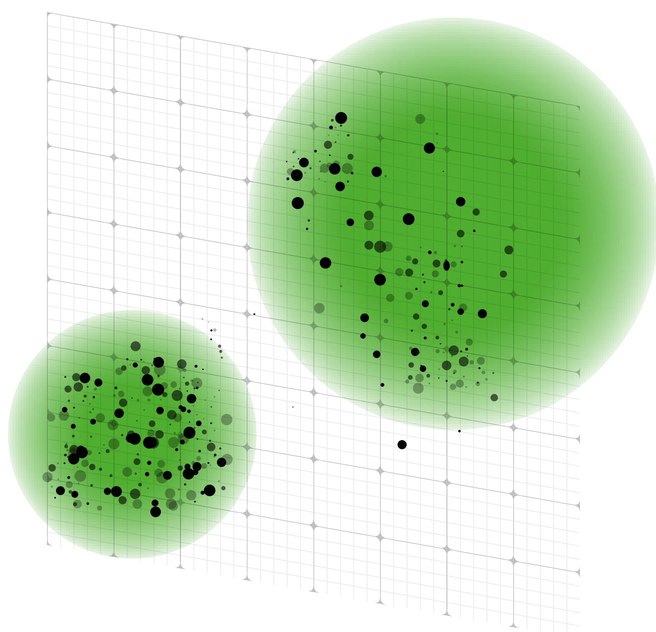
- 01: Seismic Moment, M_0
- 02: Energy, E
- 03: Event Location
- 04: Δ X, Y, and Z
- 05: Δ Time
- 06: Static Stress Drop
- 07: Apparent Stress
- 08: Seismic Efficiency
- 09: Shear Modulus, μ
- 10: Density, ρ

Dynamic Parameter Indexes

DYNAMIC PARAMETERS IN DETAIL

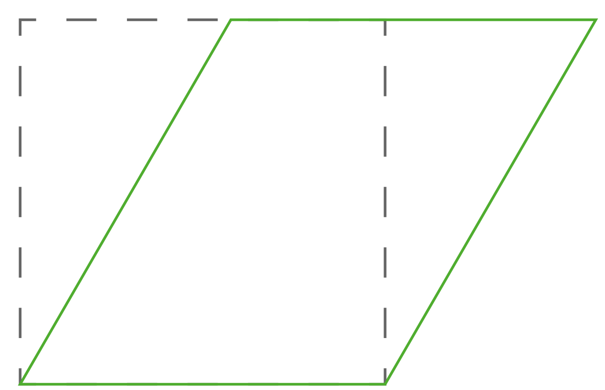
SI: Stress Index

Here we index how stress is released throughout the reservoir for a given cluster. A low SI denotes a gradual release of stress, indicating a fluid-driven event.



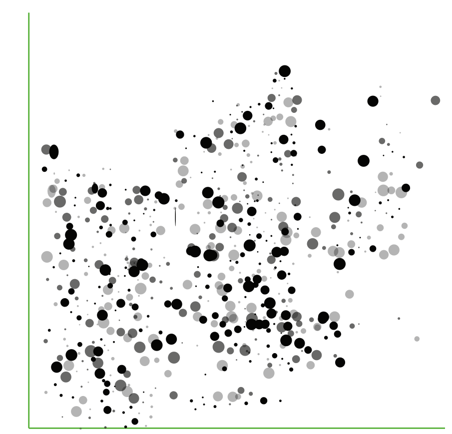
PI: Plasticity Index

A measure of deformation, PI explores stress vs. strain across a cluster's moments and energies. High PI means that the reservoir was deformed more easily, introducing more fracture complexity.



DI: Diffusion Index

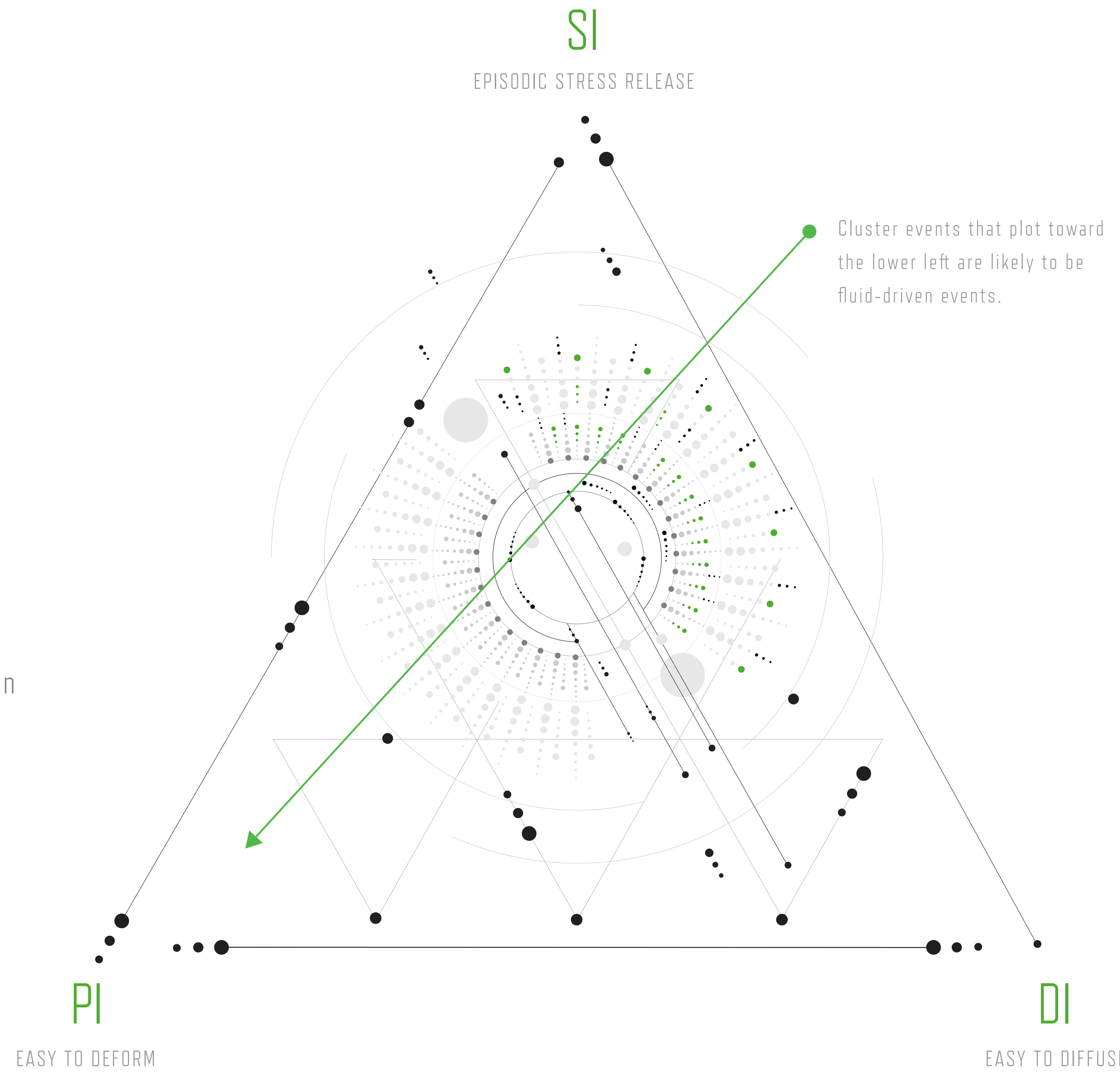
A cluster's DI measures how seismicity is diffused into the reservoir over time, revealing the effectiveness of the reservoir in transferring stress. High DI reflects rapid diffusion, which is more likely a stress driven process.

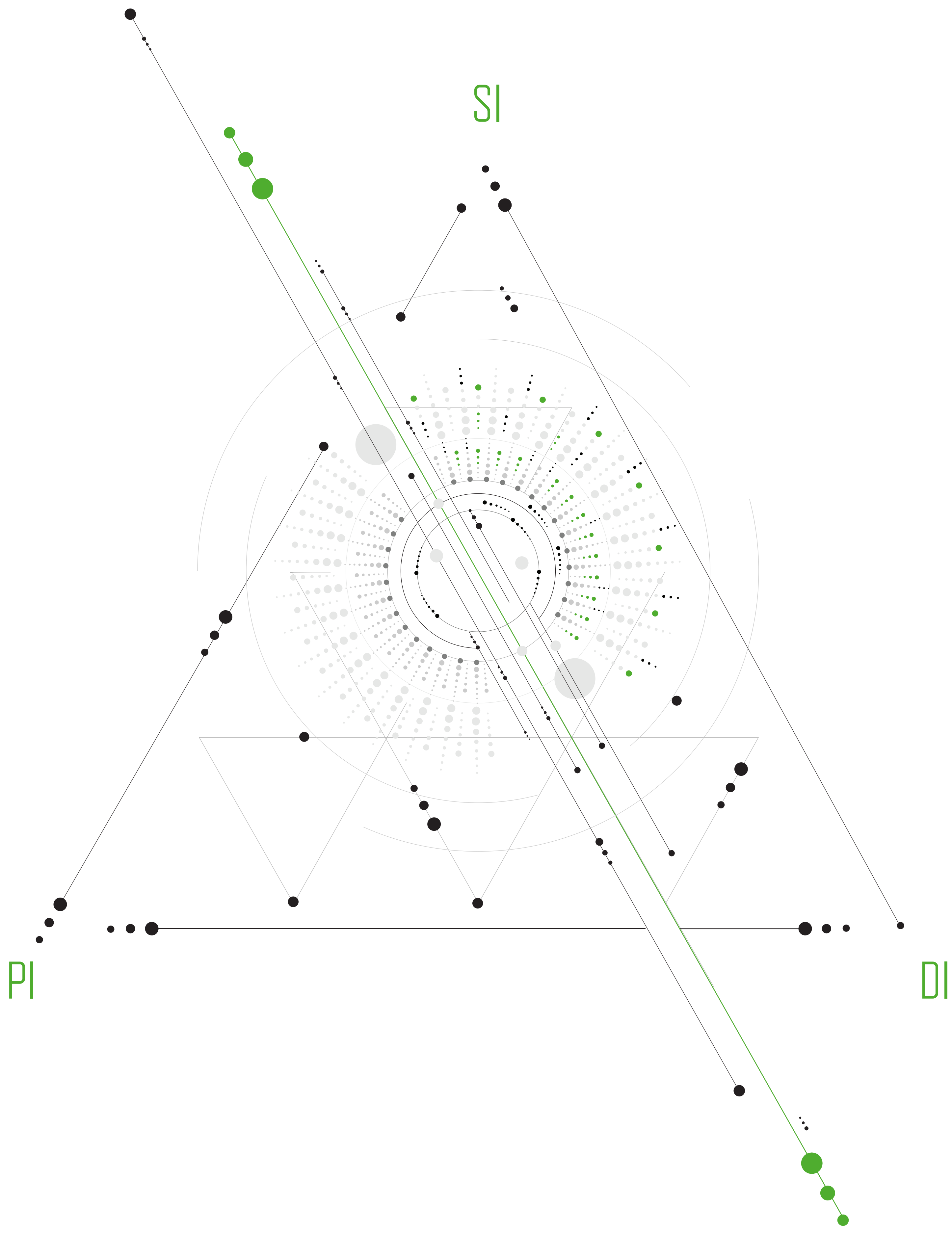


DPA in Application

By this point, clustered microseismic events will each have their own stress, diffusion and plasticity indices. Together, these values produce a quantifiable "Ternary Index" revealing the likelihood of a fluid-induced event.

- Low SI = stress gradually released through the formation = fluid driven
- High PI = low stress/high strain = increased fracture complexity
- Low DI = Slower diffusion into rock = fluid driven





03 Rate Transient Analysis

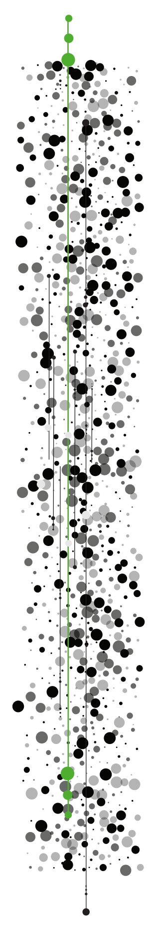
RTA is essentially a decline curve, forecasting production by matching historical rate-time data on the appropriate typecurve—or multiple typecurves averaged out. Great for determining Estimated Ultimate Recovery (EUR), it falls short of helping with completion and well spacing optimization.

- RTA assumes frac lengths to be homogenous
- Alone, this analysis cannot create a picture of the fracture network
- The production data from RTA provides critical constraints for Dynamic Parameters in the identification of producing fractures and their volume for each cluster

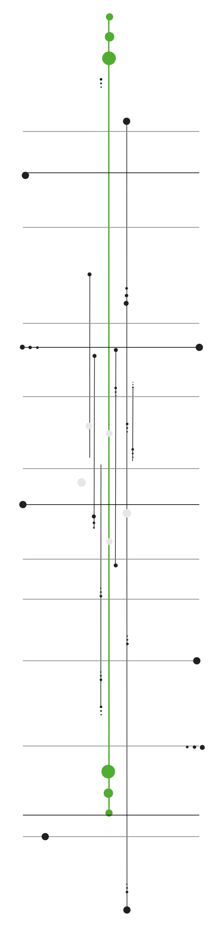
04 Parameter Visualization

Cloud

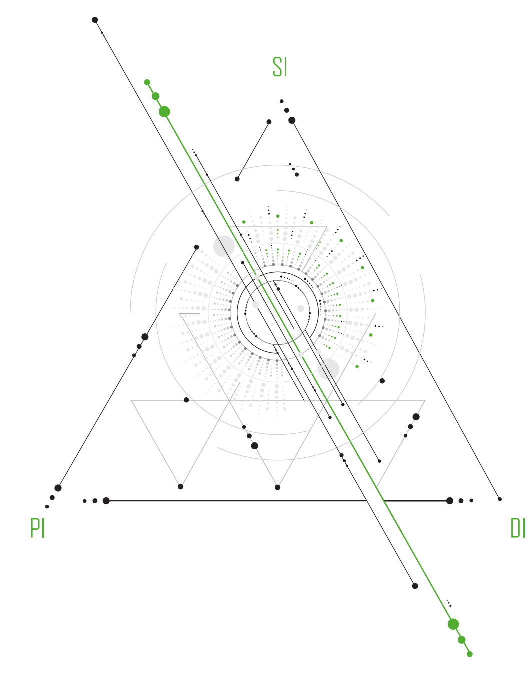
Clarity



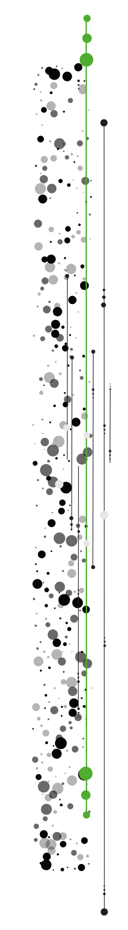
All microseismic events alone



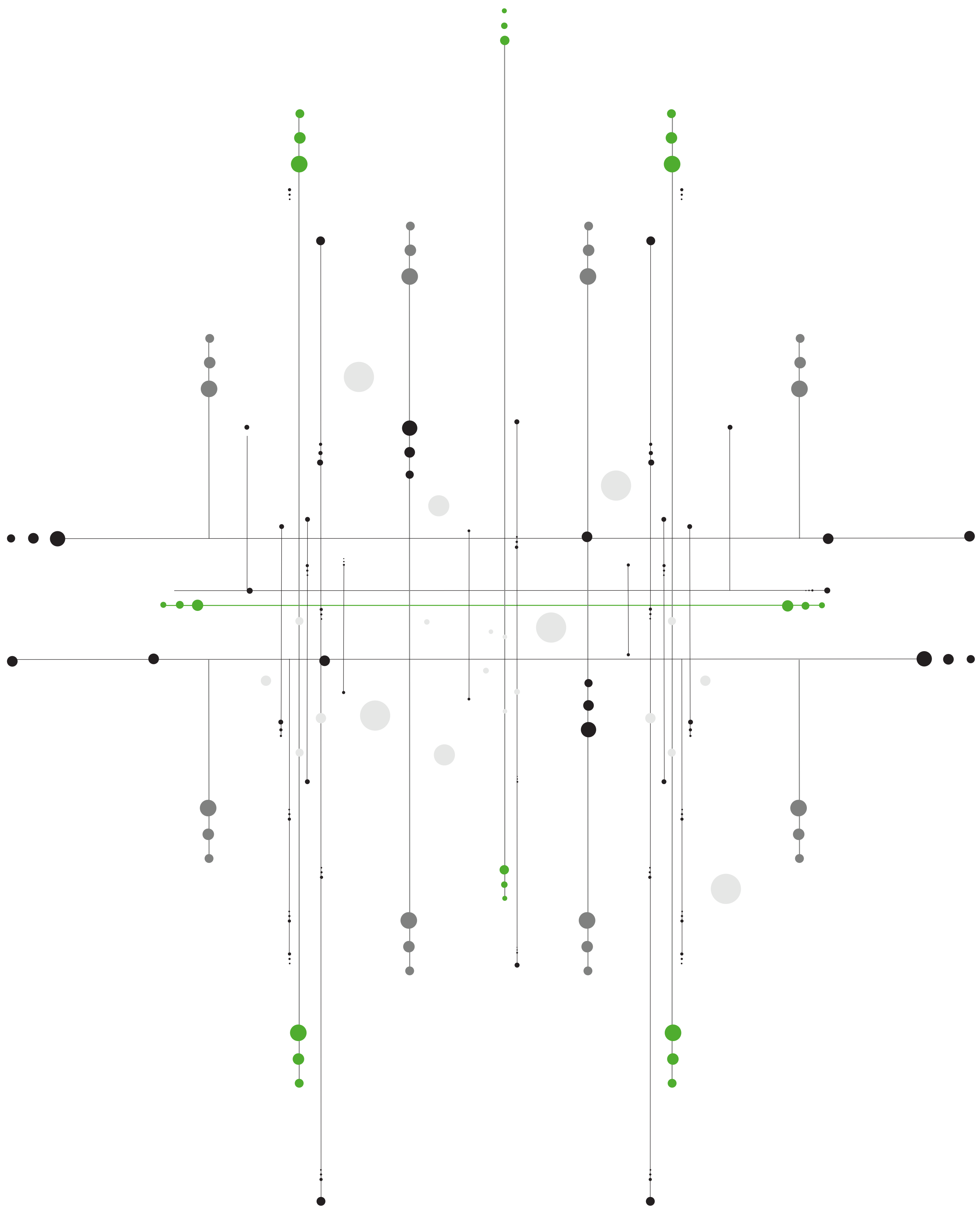
RTA alone



Microseismic events plotted with dynamic parameters



Microseismic events constrained by RTA cutoff



05 Frac Height Determination

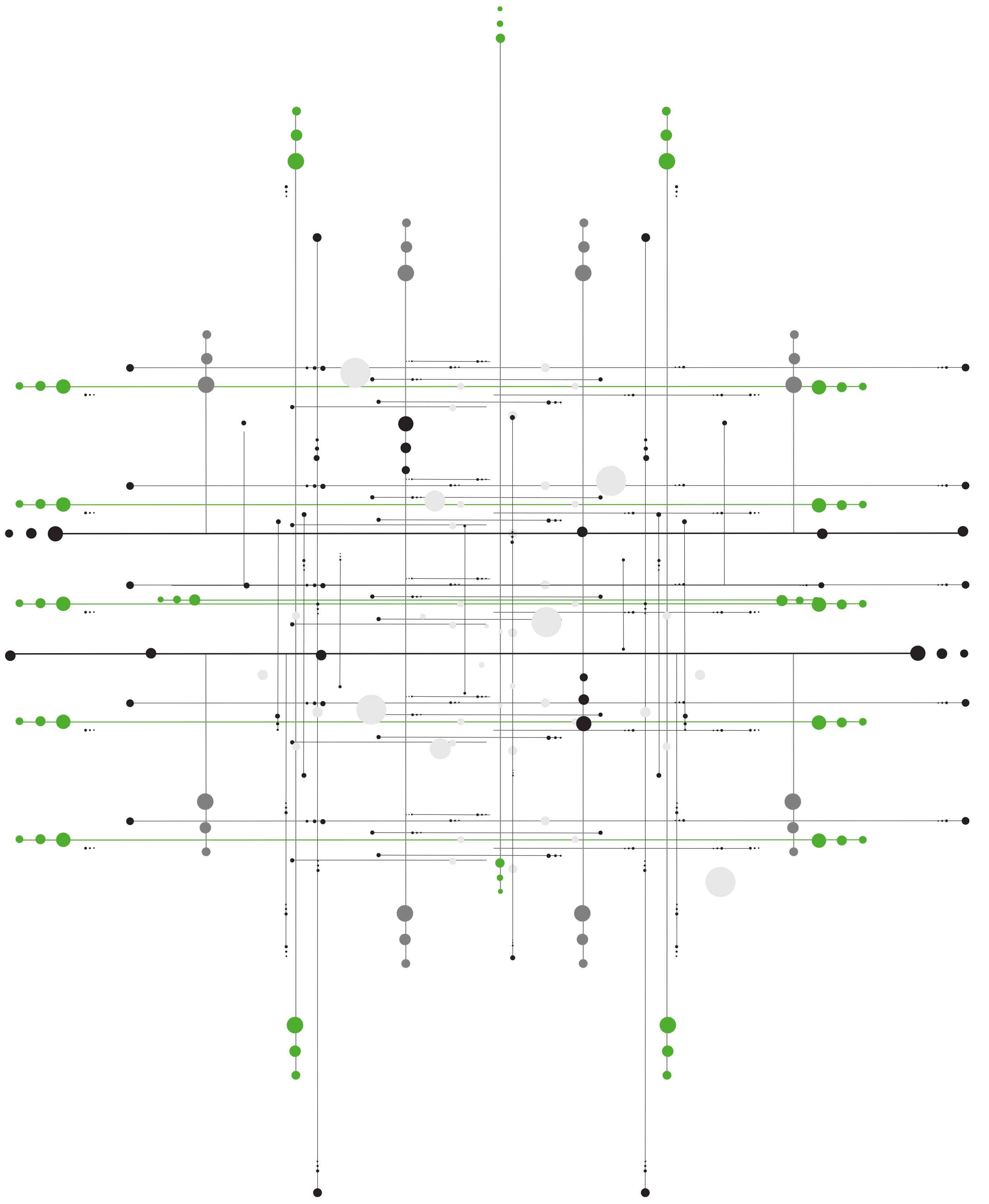
Informed by the TI and RTA, we're now able to look at the heterogeneous fracture network, rather than just an assumed homogenous frac height across all stages. This means much more detail, including an effective frac height for each stage. With more insight into stage-by-stage fracture network characteristics, you're able to better plan complementary well and stage placement.

- Frac heights calculated for each stage
- Stage characteristics presented
- Frac density revealed

06 Analysis + Insight

FracMap ClarityTM is helping operators improve reservoir coverage by gaining more insight from microseismic data. This new approach is transforming the value of microseismic for the industry.

- Better visualize your productive fracture network
- Place frac stages more strategically
- Develop fields more efficiently
- Improve reservoir coverage
- Maximize Estimated Ultimate Recovery (EUR)



The Result:
Better Field Development Decisions

esg

a spectris company