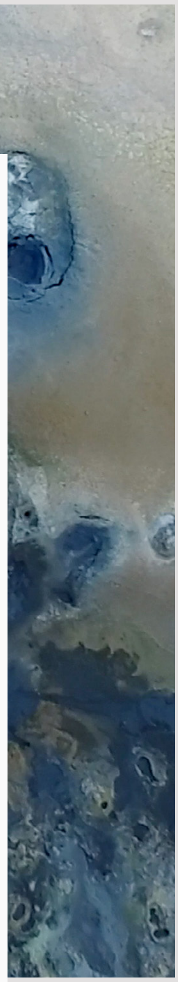
SEEQUENT

WHITE PAPER

# THE NEW STANDARD IN GEOTHERMAL INTELLIGENCE

How Seequent’s connected workflow streamlines exploration, de-risks drilling, and optimises field performance.

Seequent, The Bentley Subsurface Company



# Executive summary

Every geothermal project begins with a single, critical question: how well do we understand the subsurface?

An inadequate understanding of the reservoir leads to suboptimal development strategies, poor well targeting, and low confidence in predictions of future power production. This increases capital and operational costs while putting future revenue at risk, eroding a project's bottom line, long before the first megawatt reaches the grid.

Despite this risk, many reservoir teams still work in silos. Geophysical survey data sits in one application, 3D geology in another, and flow simulation in a third, held together by spreadsheets and ad-hoc scripts. Version histories are unclear, and important physical processes and feedback loops are often missed, and the final model is difficult to defend when board approvals or lender reviews require transparency.

This white paper is written for geothermal reservoir engineers, geoscientists, and project developers who need to reduce uncertainty, accelerate development, and justify investment decisions. It outlines a connected Seequent workflow—between Oasis montaj, Leapfrog Energy, and Volsung—that integrates geophysical and geological modelling, interpretation, and reservoir simulation, enabling faster, more auditable decisions.

The pages that follow detail how this connected workflow streamlines exploration, de-risks drilling, and maximises asset value, illustrated by real-world results from Fervo (green-field EGS), Contact Energy (fast-tracked development), and Ormat (field optimisation).


# From exploration risk to bankable resource

Before plant design, power-purchase talks, or environmental consent, geothermal success is decided by the first few wells. A single deep producer or injector typically costs between $4 million and $12 million[1], and if it intersects a tight or under-temperature zone, that capital is written off and project progress slows before concrete is poured.

Portfolio studies show that for hard-rock enhanced geothermal systems (EGS) or deep sedimentary plays, exploration CAPEX can consume 15% of total project spend while commercial well-success rates remain near 50%.[2]

Miss early and the project stalls; hit early and everything downstream—financing, construction, commissioning—accelerates.

1. Stanford, "2025 Geothermal Drilling Cost Curves Update," 2025.
2. Climate Policy Initiative, "The Role of Public Finance in Deploying Geothermal: Background Paper," 2014.

## The challenges with legacy workflows

Exploration workflows still look remarkably like those of a decade ago:

- **Geophysics:** Inversions run in specialist packages are exported as raster grids.
- **Geology:** Cross-sections and implicit models are rebuilt from scratch in a separate tool.
- **Reservoir pre-screening:** Volumetrics and simple heat-in-place estimates are calculated in spreadsheets.

Every hand-off between tools often requires reformatting or interpolating data, such as adjusting grid resolutions, converting units, and manually documenting assumptions. Version histories fragment, assumptions are hidden in macros, and testing a conceptual theory can take months. The result is an interpret-freeze-drill cycle instead of a data-driven loop that refines structures, re-ranks pads, and aligns geology with economics in real time.

Speed matters. The International Renewable Energy Agency projects that geothermal generation could account for 15% of energy by 2050,[3] but only if subsurface uncertainty is materially reduced and development timelines are compressed.

Each month spent reconciling inconsistent inversions or reformatting models to move between tools raises financing costs and risks license expiry. In geothermal, the real constraint on growth isn't the heat in the ground; it's the clarity and speed with which we can demonstrate its potential.

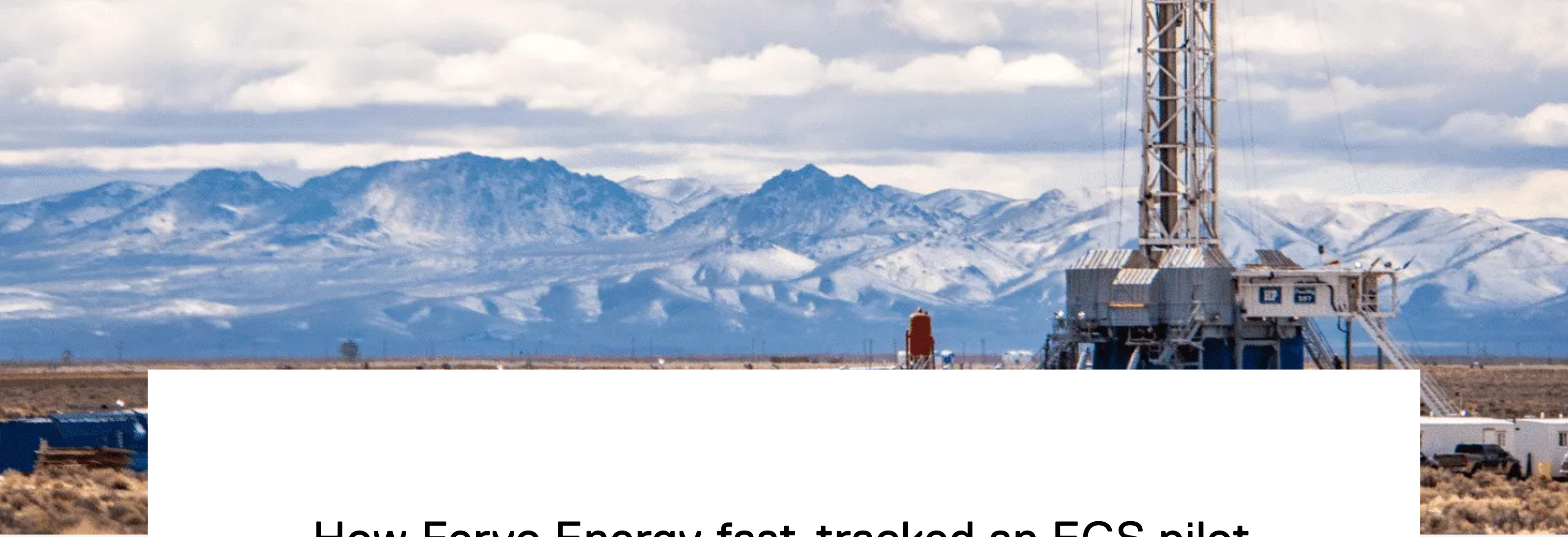
3. IEA, "The Future of Geothermal Energy," 2024.

## Introducing a connected exploration technology stack

Seequent's connected workflow helps close the clarity and speed gap:

- **Oasis montaj supports geothermal exploration by processing and visualising gravity, magnetic and electromagnetic (EM) data. Magnetotelluric (MT) resistivity models can be imported and viewed alongside these datasets to help geoscientists interpret subsurface structures, refine geological hypotheses and inform conceptual modelling.**
- **Leapfrog Energy ingests that data, along with mud-logs, alteration data, and PTS surveys, to create a live, implicit 3D geological model.**
- **Volsung imports the Leapfrog model, runs a finite-volume reservoir simulation that couples wellbore and surface facilities models, generates history matches and production forecasts—all within the same ecosystem.**

Because each step shares a common data structure, teams move from inversion to forecast in days, not months, and maintain a single audit trail throughout the project life cycle.



## How Fervo Energy fast-tracked an EGS pilot that now powers Google data centres

To demonstrate that horizontal-well EGS could deliver continuous carbon-free power, Fervo Energy first had to image fracture corridors in Nevada's granitic basement — a setting where drilling information is limited. Geophysicists used Oasis montaj to interpret gravity, magnetic and electromagnetic data, shaping a conceptual understanding of the basin. This data was passed to geologists, who built an implicit 3D model in Leapfrog Energy and refined it with surface geological observations and drilling data. The integrated interpretation supported iterative adjustments to well trajectories and informed broader development decisions.

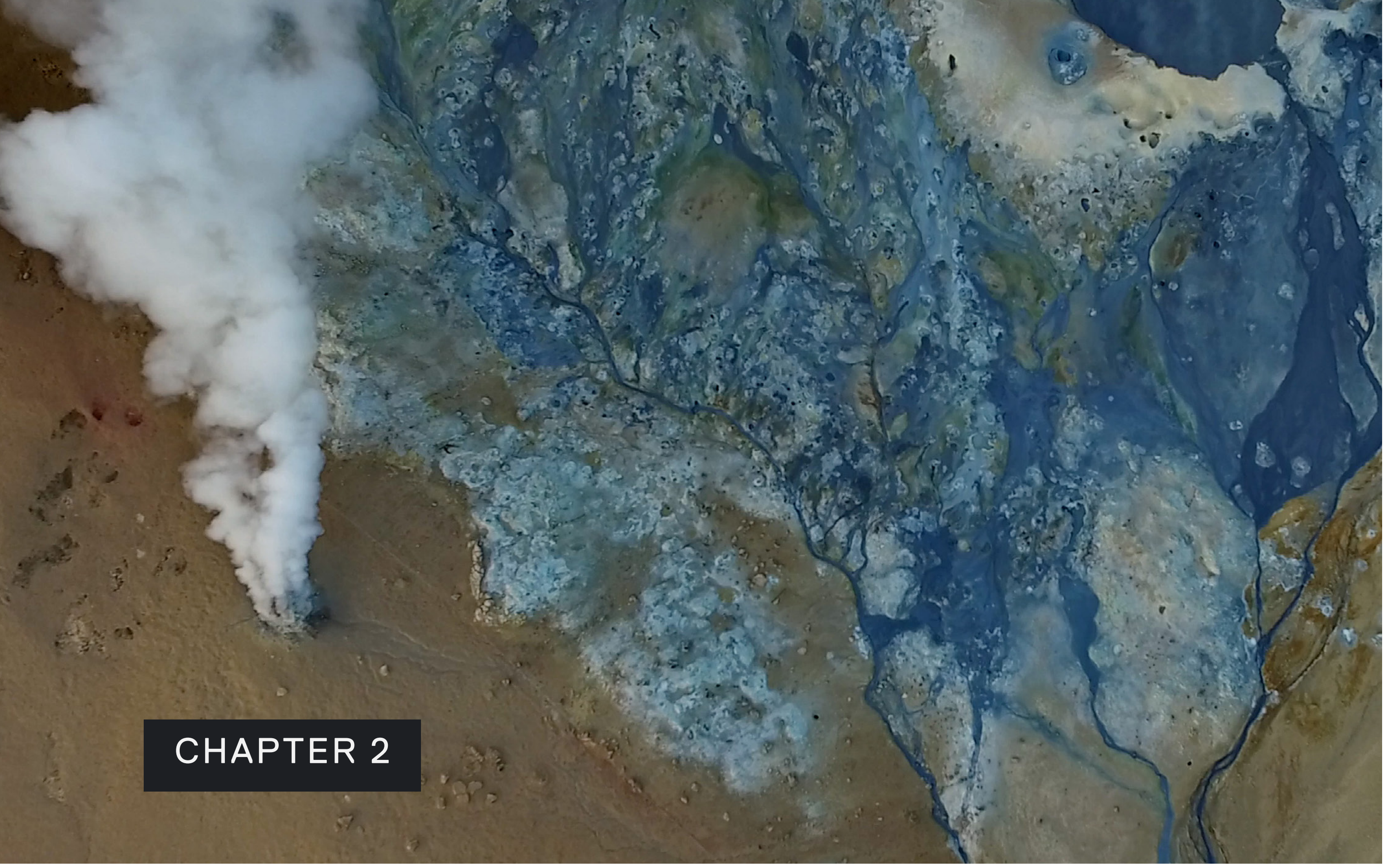
This shift delivered key benefits, including:

- **Targeted drilling and fewer surprises:** High-resolution resistivity volumes pinpointed the most permeable zones for paired 8,000-ft horizontals.
- **Rapid iteration:** Updated inversions flowed into Leapfrog models in hours, supporting geometry tweaks before spudding.
- **Offtaker confidence:** Auditable forecasts underpinned Fervo's 24/7 carbon-free energy agreement with Google.

Read the full story →

> "Leapfrog Energy and Oasis montaj can intuitively talk to each other via Seequent Central and has allowed us to seamlessly connect multiple individuals with essential communication and collaboration across five offices spanning the US and many different time zones."

**Steve Fercho**
Exploration Geoscience Lead, Fervo Energy




# Turning multi-disciplinary data into a living 3D model

The value of traditional cross sections cannot be underestimated. However, with fast-paced projects gaining new data every quarter, keeping pace is a struggle.

As part of a connected workflow, Leapfrog Energy's radial basis function (RBF) engine generates geological surfaces directly from downhole points and structural geophysical constraints, honouring complex geological settings. Whether the reservoir is a faulted caldera, a sediment-hosted system, or a fractured granitic basement, geologists move from raw data to a structurally coherent model in hours rather than weeks, freeing specialist time for interpretation instead of drafting.

## Pioneering RBF technology

Leapfrog's roots trace back to a technology originally designed for prosthetics and medical imaging. This technology, known as the radial basis function (RBF), was soon applied to various industries, including Hollywood for special effects in films such as The Lord of the Rings, and even NASA for mapping asteroids.

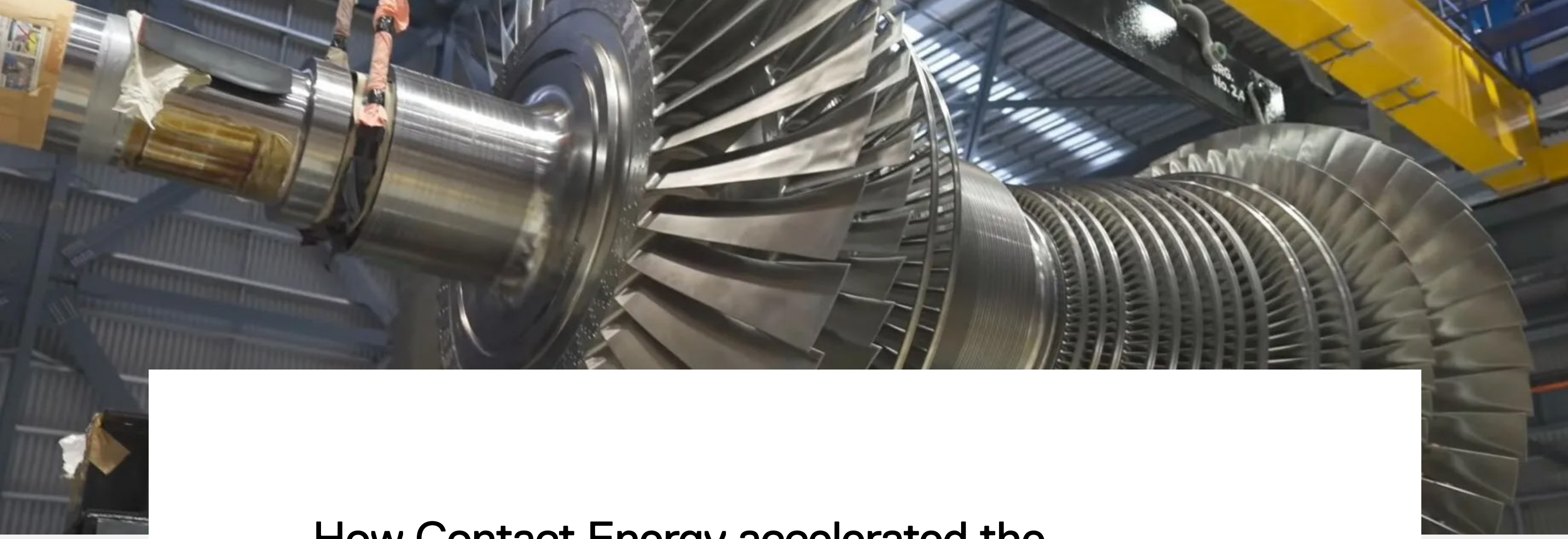
A range of 2D and 3D data from geological, geophysical, geochemical, and surface mapping sources is analysed to identify relationships (e.g. lithology vs. temperature, alteration vs. resistivity), which inform the construction of integrated models. Once the geological model is defined, Leapfrog's numeric model assigns static variables such as temperature, porosity, and others. This modelling approach keeps geometries and properties within a single, unified object throughout the workflow.

Any change to a contact, fault, or numeric parameter triggers automatic regeneration of surfaces, volumes, and calculated grids. Live volumetrics, swath plots, and stereonets refresh in seconds, showing how a new fault or well intercept alters subsurface interpretation. Leapfrog exports planned well graphs and conceptual communication of the resource, meeting the traceability bar set by lenders and independent engineers.

When ready for dynamic simulation and forecasting, Leapfrog can convert implicit surfaces into a discretised grid and populate rock parameters linked to the conceptual model. Because the data stays inside the same coordinate system, no global re-gridding is needed before exporting to Volsung, TOUGH2, Eclipse, or CMG. Subsequent geological updates repeat the export in minutes, integrating geoscience and reservoir modelling, sustaining data fidelity.


**FUN FACT**

Leapfrog was once featured in an answer on the U.S. quiz show, Jeopardy!



## How Contact Energy accelerated the development of the 174 MW Tauhara project

Contact Energy's Tauhara Stage 2 development is New Zealand's largest single-flash geothermal power station built in over a decade. To confirm well-pad locations and secure environmental approvals, the subsurface team needed an integrated 3D model that could ingest new data quickly and withstand regulatory scrutiny.

Using Leapfrog Energy, geologists merged layers, gravity models, MT inversions, and more than 70 exploration wells—totalling 60,000 lithology interval points and 1,200 pressure–temperature profiles—into a single implicit framework. Updates propagated in minutes, allowing engineers to test alternative deviation plans during drilling.

Key benefits, included:

- **Four-day model cycles cut to four hours:** new temperature logs, lithology, and alteration picks regenerated the entire model before the next morning's drilling call.
- **Optimised well-pad layout:** dynamic models helped relocate two pads, reducing expected make-up drilling by ≈15%.
- **Regulatory confidence:** Leapfrog provides a complete audit trail for the fast-tracked resource consent.

Read the full story →

"Dynamic modelling in Leapfrog gave us the agility to refine targets while the rigs were still turning—without compromising the audit trail required by regulators."

**Senior Development Geologist**
Contact Energy (Tauhara Project)

CHAPTER 3

# Simulating flow, pressure, and power output with confidence

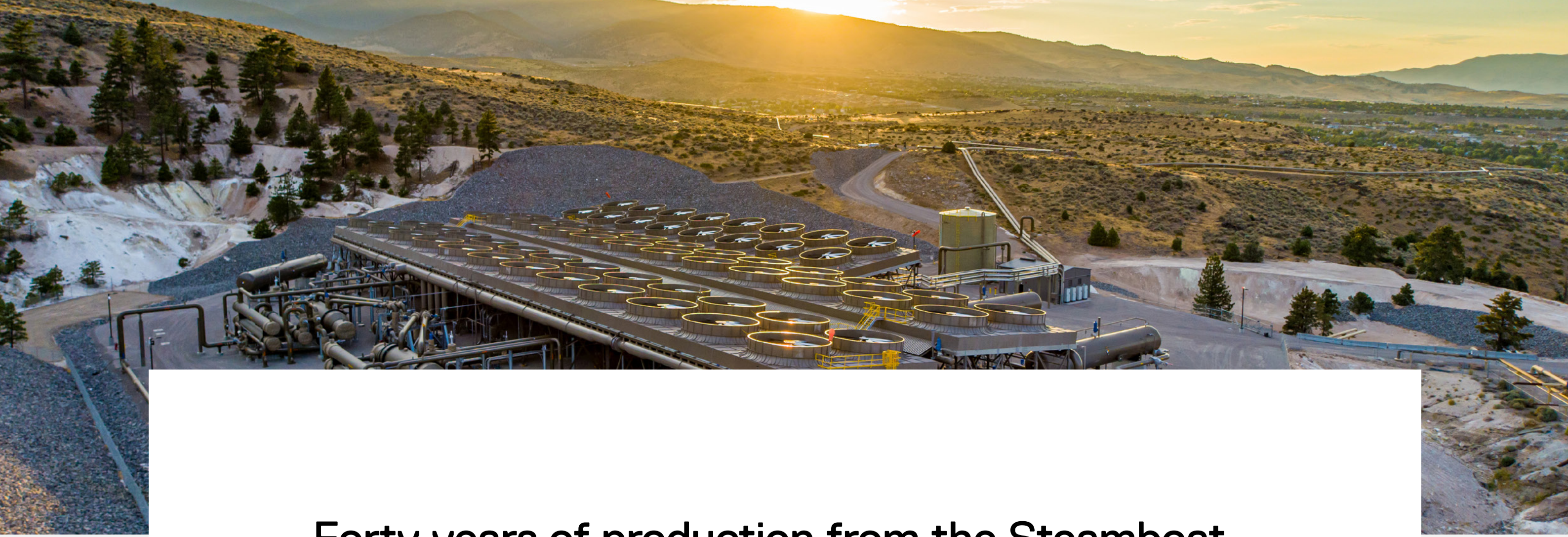
Volumetric heat-in-place, power density, and decline curve analysis give estimates of resource potential, but they do not capture the feedback loops between reservoir drawdown, well production, and reinjection, or how non-condensable gases (NCG) might impact generation.

Commercial lenders now insist on field-wide forecasts that honour these interactions, report P10/P50/P90 megawatts, and demonstrate that induced seismicity and subsidence limits will be met. Delivering that evidence calls for a simulator that ingests the geological interpretation from Leapfrog Energy and iterates quickly as new data arrives.

Volsung applies a finite-volume formulation to solve the mass and energy balance equations to calculate mass and heat flow through reservoir rock, including porous and fractured media.

Wellbore models can be coupled with reservoir models to predict well deliverability based on reservoir thermodynamics and well conditions, which in turn informs surface facilities models to calculate power generation.  The solver handles single- or two-phase water/steam flow, supercritical conditions, mixtures of water, salt, and non-condensable gases, tracer transport, and micro-gravity and subsidence responses. Parallel computing approaches on CPU and GPU acceleration reduce solve time by up to 25x compared to traditional approaches, which helps engineers develop more detailed models in less time.

Calibration workflows begin with matching reservoir model output to measured well temperature and pressure data in a process known as natural state calibration. Calibration continues by simulating the production history of a resource and comparing modelled and measured well production, enthalpy, and reservoir pressure drawdown. Calibration can also include microgravity responses and tracer test data. Calibration can be performed manually or via inverse modelling methods. Once a satisfactory calibration is achieved, forecasts can be run simulating future reservoir responses and well performance under various development strategies. Monte-Carlo methods can be employed to make these forecasts under uncertainty. Stakeholders can then compare the results to assess the optimal resource development strategy. Volsung reports well-by-well enthalpy, steam fraction, brine flow, and power generation.



## Forty years of production from the Steamboat geothermal field

Ormat Technologies developed a numerical reservoir model to maintain sustainable temperature and pressure levels. Numerical modelling was used to understand fluid flow pathways better, predict long-term performance under various scenarios, and optimise reinjection strategies for sustainable production.

The application of the model resulted in stronger alignment between field observations and computer models, enhanced understanding of the relationship between reservoir structures and fluid flow pathways, and informed decision making for resource forecasting and management.

“Our numerical model has been instrumental in guiding our operational and reservoir management decisions at Steamboat. It has provided valuable insights into the complex behaviour of the geothermal system.”

**Sulav Dhakal**
Geothermal Reservoir Engineer, Ormat Technologies

To learn more about how Ormat used Volsung to optimise 40 years of geothermal production and improve reservoir management at the Steamboat site **read the full story →**

This case study was developed independently by **Ormat and reflects Ormat’s internal analysis and operational experience →**


# Understanding the underground with a complete geothermal solution

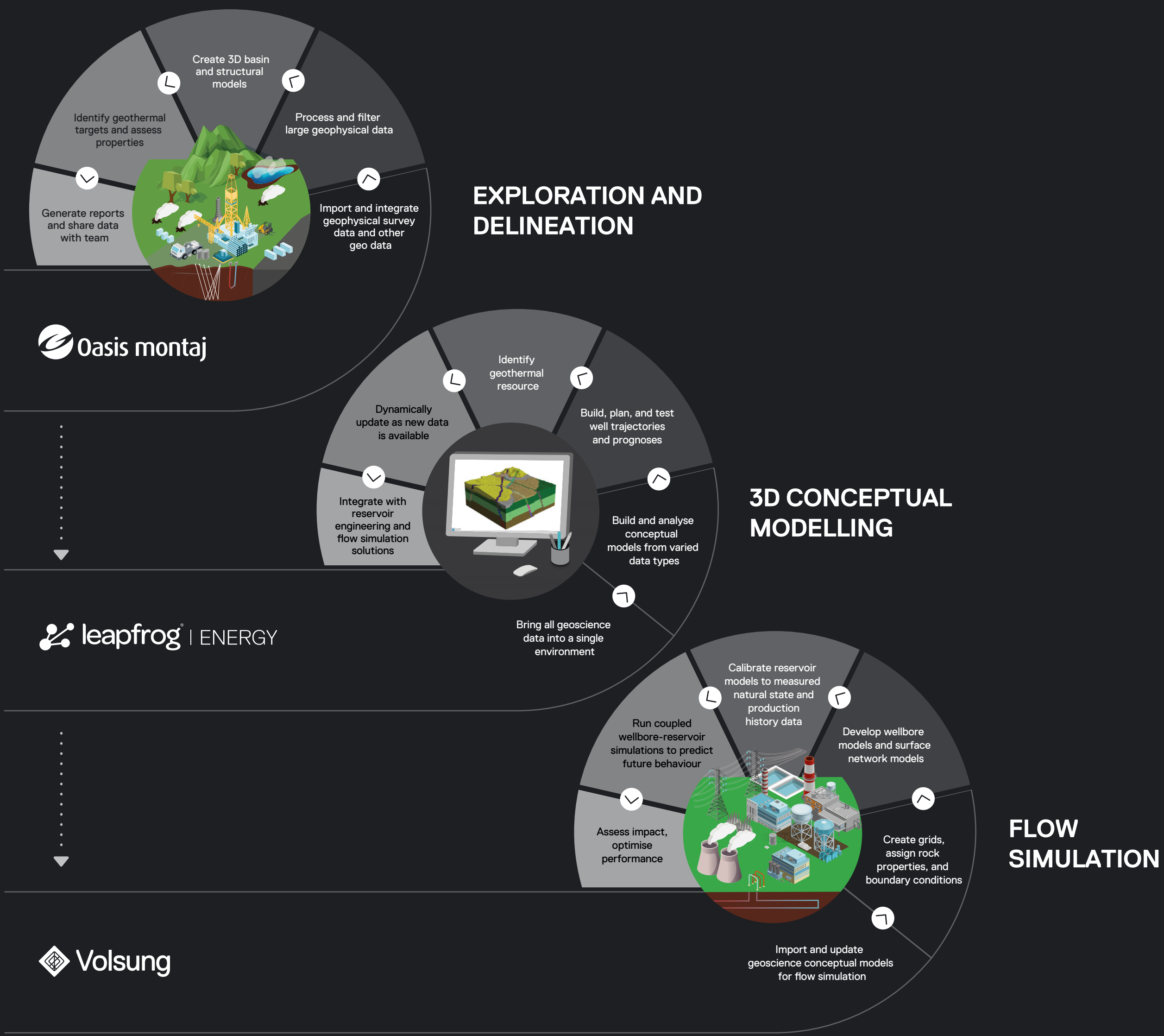
Exploration, modelling, and simulation move fastest when every discipline sees the right data in the same workspace, without hunting for the latest folder.

In Seequent's geothermal workflow, Oasis montaj supports early-stage geothermal exploration by processing and modelling gravity and magnetic data and visualising externally generated MT resistivity volumes. This helps geoscientists interpret subsurface structures and identify features such as faults, alteration zones or fluid pathways—key inputs for refining conceptual models before geological modelling begins.

These datasets are exported and brought into Leapfrog Energy, where geologists integrate them with well logs, alteration data, and PTS surveys to build a dynamic 3D conceptual model. That model is then imported into Volsung, which simulates reservoir flow, well performance, and power generation using a finite-volume approach.

While data exchange between tools involves manual steps, Seequent Central provides a shared, auditable environment for version control, model comparison, and collaboration, ensuring that multidisciplinary teams stay aligned throughout the project lifecycle.

# Geothermal connected product workflow




## 7,400+
customers use Seequent software in over 140 countries

## Leapfrog Energy
is utilised by 60% of the geothermal power generated in the world

## 95%+
satisfaction rate with our front-line help and support


# Leading the future of geoscience: Innovation, education, and collaboration

At Seequent, our commitment to geothermal runs deep. As a company built by geoscientists for geoscientists, we are constantly pushing the boundaries of what's possible with innovative tools and technologies. By combining technical expertise with user-centered design, we have created a portfolio of solutions, like Oasis montaj, Leapfrog Energy, and Volsung, that not only enhance the way we understand the subsurface but also make historically disparate processes more integrated, accessible, and intuitive.

## Inspiring the next generation of geoscientists

We recognise the need to inspire and equip the next generation of geoscientists. This is why we developed Visible Geology, a free, web-based application designed to bring geological concepts to life for students and educators alike. Visible Geology moves beyond traditional 2D teaching methods and empowers students with an immersive 3D learning experience.

With its intuitive 3D modelling capabilities, collaborative classroom features, and digitised stereonets, Visible Geology helps students grasp fundamental geological concepts in a captivating way. Educators can seamlessly integrate this tool into their curriculum, modernising the learning experience and engaging students with interactive topographies, cross-sections, core samples, and more.

By encouraging students to explore the subsurface world in an innovative digital environment, Seequent is playing a key role in shaping the future of the geoscience field.

See Visible Geology for more →

## Discover the power of a connected geothermal technology workflow today

Visit seequent.com/leapfrog-energy to explore product videos, customer success stories, or request a free 14-day trial or live demo.

## Understand the underground to build a better world.

Seequent, The Bentley Subsurface Company, helps organisations to understand the underground, giving them the confidence to make better decisions faster.

Seequent builds world-leading technology that is at the forefront of Earth sciences, transforming the way our customers work.

Every day we help them develop critical mineral resources more sustainably, design and build better infrastructure, source renewable energy, and reduce their impact on the environment.

Seequent operates in 145+ countries while proudly maintaining headquarters in New Zealand.

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