leapfrog | GEO

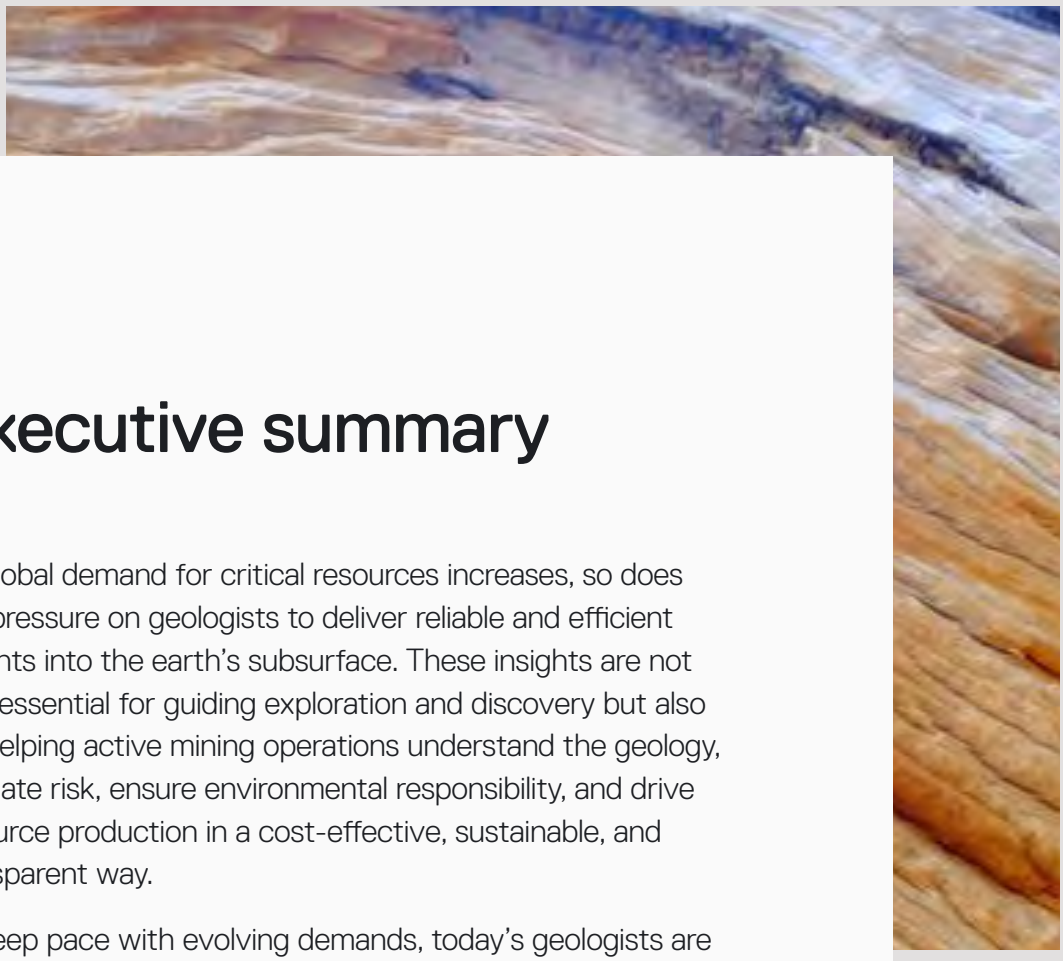
WHITE PAPER

THE STANDARD IN 3D GEOLOGICAL MODELLING FOR EXPLORATION AND PRODUCTION

How geological modelling in Leapfrog Geo empowers geoscientists to shape the future of exploration and mining

SEEQUENT

Seequent, The Bentley Subsurface Company



Executive summary

As global demand for critical resources increases, so does the pressure on geologists to deliver reliable and efficient insights into the earth's subsurface. These insights are not only essential for guiding exploration and discovery but also for helping active mining operations understand the geology, mitigate risk, ensure environmental responsibility, and drive resource production in a cost-effective, sustainable, and transparent way.

To keep pace with evolving demands, today's geologists are turning to advanced 3D modelling tools that streamline data management workflows and facilitate clear communication with a diverse set of stakeholders. Leapfrog Geo, a leading 3D geological modelling solution, helps geologists tackle these challenges by integrating vast datasets, visualising complex subsurface environments in greater detail, and enabling real-time collaboration across teams.

In this white paper, we explore the primary challenges geologists face in both exploration and production settings and how they leverage modelling tools to improve decision-making and operational efficiency. From minimising uncertainty in exploration to dynamically updating models in active mining operations, we present real-world examples of geologists transforming their work to meet today's demands.

CHAPTER 1

Tackling challenges in exploration geology

Exploration geologists are tasked with gaining a comprehensive understanding of the subsurface—including key lithologies, mineralisation, alteration, and structures—to help locate commercially viable mineral resources in the shortest possible time and at the lowest possible cost.

This requires managing and interpreting vast amounts of data collected from drillholes, geophysical surveys, and geological mapping. In addition, exploration projects deal with a high level of uncertainty, as only a fraction of exploration efforts lead to viable resource discoveries.

Success in exploration depends on several factors including securing adequate funding and—perhaps most importantly—leveraging the most advanced exploration technologies available.

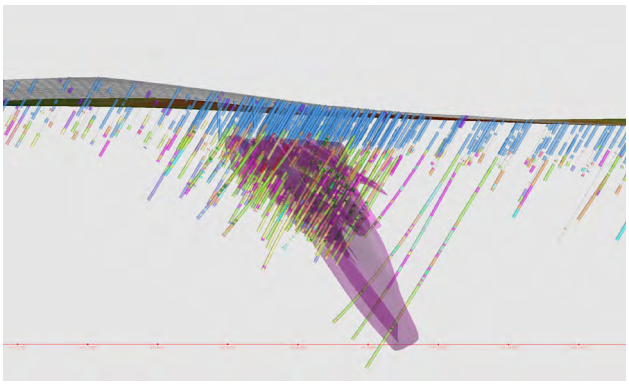
The role of 3D implicit modelling in exploration

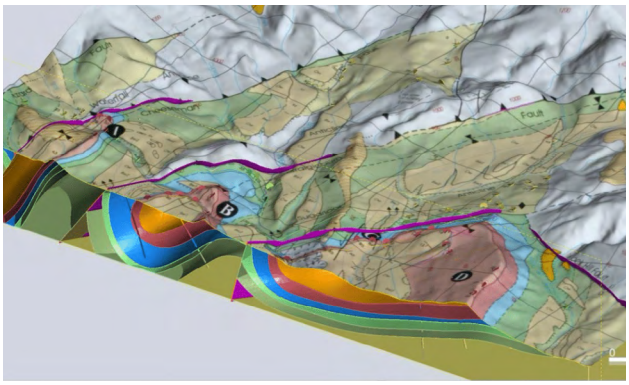
Over the past few decades, modelling technologies, in particular, have evolved significantly. Advanced 3D modelling solutions are now essential tools for modern exploration programs. These tools allow geologists to rapidly visualise and interpret complex subsurface structures, unlike older, explicit modelling techniques. Solutions like Leapfrog Geo enable geologists to efficiently interpret vast datasets, combining information from drillholes, geophysics, and geochemical data.

This integration of diverse datasets helps geologists create comprehensive 3D models that serve multiple purposes. The models not only refine exploration strategies and help identify high-potential lithologies, they also play a key role in mitigating financial risk by informing drillhole targeting.

Clear and precise visualisations are another significant benefit. These 3D models enhance communication with stakeholders, providing the transparency needed to align geologists, management, investors, regulatory bodies, and local communities. Geologists can present a clear picture of subsurface findings, making it easier for stakeholders to understand and support exploration efforts.

Ultimately, these tools allow geologists to shift their focus from time-consuming manual data processing to higher-level strategic decision-making. This leads to more efficient workflows and a better understanding of resource potential, which is crucial for estimating value and making informed exploration decisions.





How Mundoro Capital Inc. enabled stronger stakeholder communications with 3D modelling

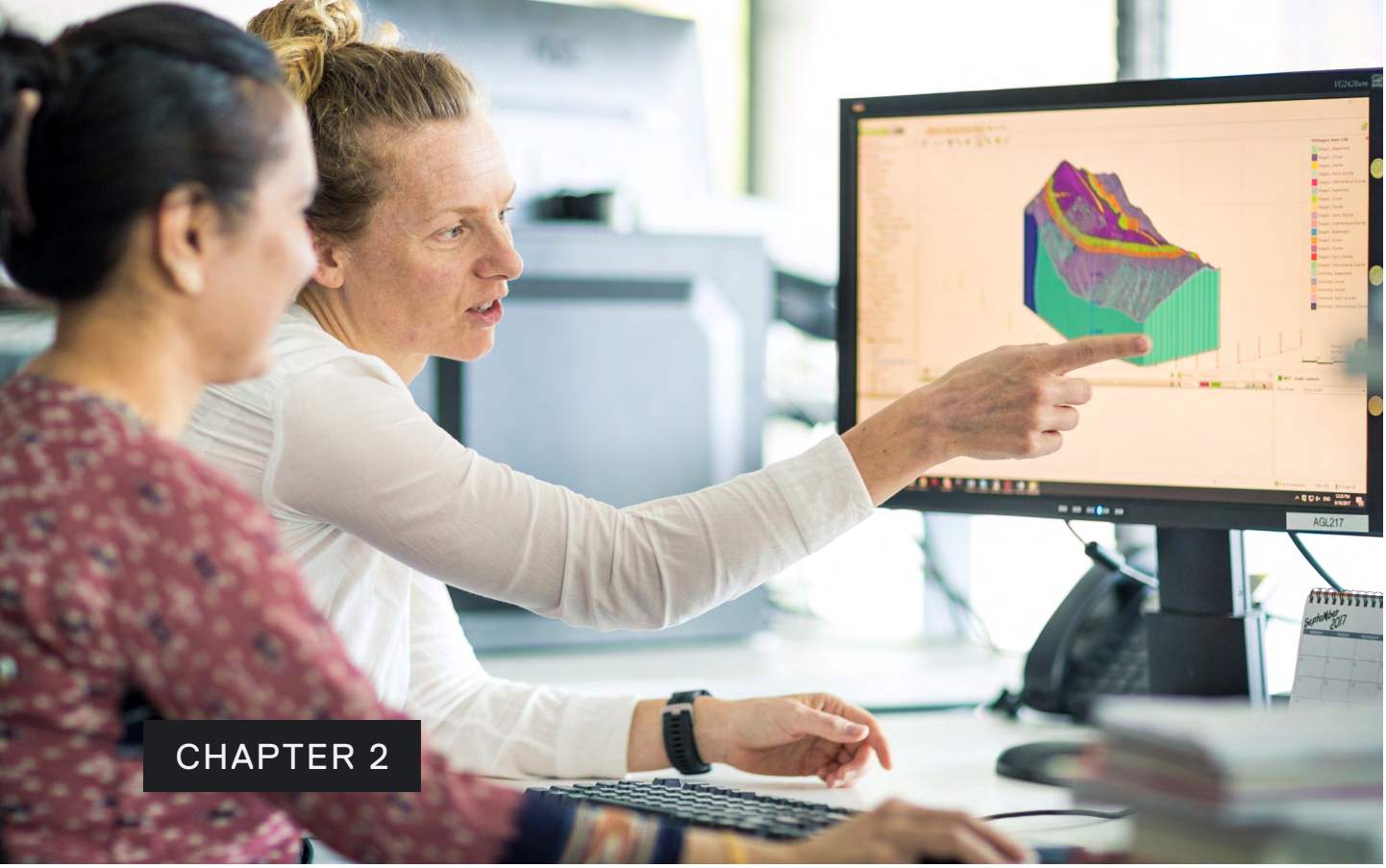
Mundoro Capital Inc., a Canadian-listed exploration company, faced the challenge of managing and sharing large geoscientific datasets across multiple projects.

Historically, the company prepared separate data sets such as maps, reports, and files, but this approach proved insufficient for conveying complex information effectively. According to Mundoro's Senior Data Manager, the traditional method lacked interactivity and clarity, especially for non-technical stakeholders who found it difficult to visualise 3D geological information from isolated 2D data presentations.

To overcome these challenges, Mundoro implemented an advanced 3D modelling and data management solution to streamline their workflows. By centralising their data and visualising it in 3D, Mundoro created an interactive environment that brought transformative improvements, including:

- **Improved data interpretation efficiency**: Stakeholders can review projects in their entirety, exploring data in real-time and gaining a complete understanding of each project's scope and quality.
- **Accelerated decision-making**: Geologists can more effectively refine and communicate insights and interpretations, reducing the time it takes for partners to evaluate projects and make investment decisions.
- **Better collaboration**: The integrated data environment facilitates more cohesive weekly strategy sessions for the technical team, enabling a synchronised approach to exploration targeting.

Read the full story →



CHAPTER 2

Overcoming production geology challenges

Geologists within active mining sites are tasked with continuously updating geological models based on real-time data to ensure safe operations and inform decisions about the mine's resource production, waste management, and environmental sustainability.

A key challenge in production geology is the dynamic nature of subsurface conditions. As grade control data is collected daily, geological models must be continuously updated to reflect the latest information. Without comprehensive, real-time models, mining operations risk making costly errors, such as drilling outside the mineral deposit or mismanaging ore and waste materials.

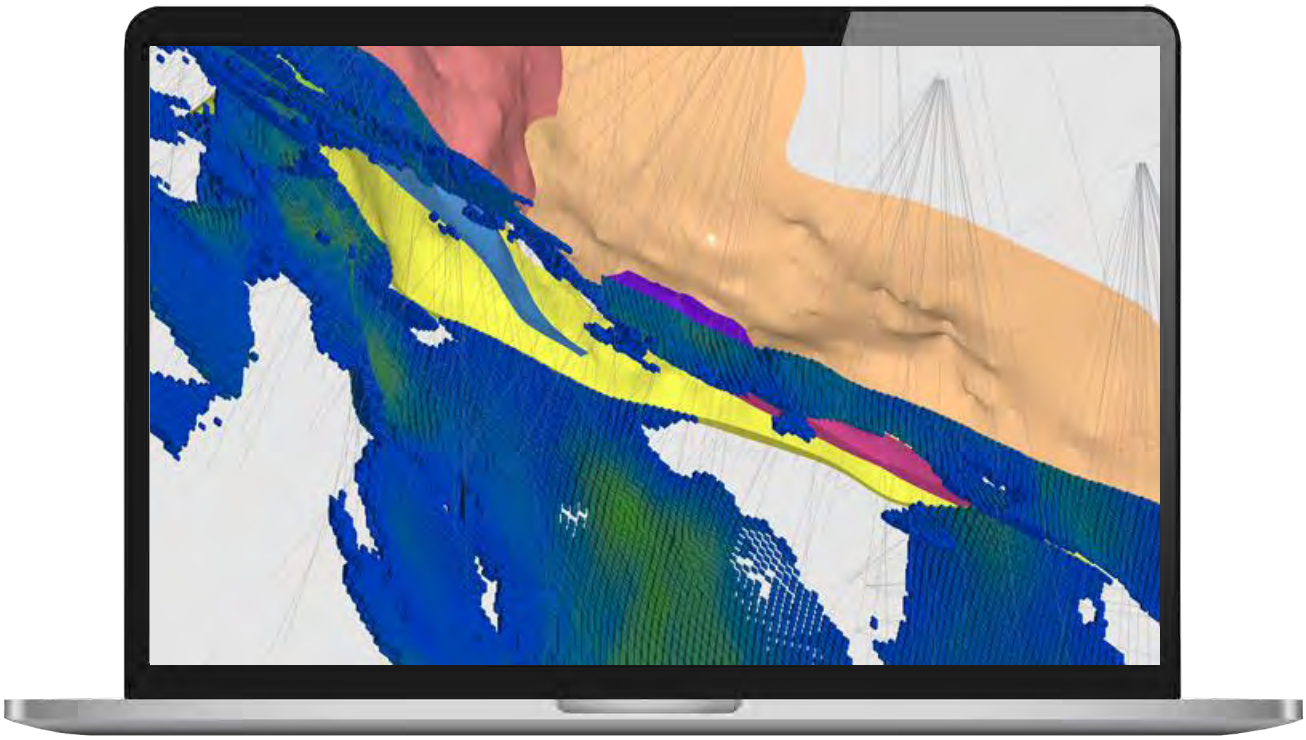
Traditional 2D modelling methods often fall short in capturing the complexity of deposit geology, resulting in misinterpretations and operational inefficiencies. To address this, production geologists are adopting more advanced modelling methods that help them facilitate clear communication and alignment between process plant operators, mine engineers, and other stakeholders to support informed decision-making.

The role of 3D geological modelling in production

Advanced 3D modelling solutions are well-suited to the dynamic needs of production geologists. The ability to update models as new data is collected enables geologists to stay responsive to changing conditions within the mine.

Seamless integration with grade control systems provides more precise insights into ore body distribution, supporting optimised resource extraction and waste management.

The visualisation capabilities of 3D software help reduce the risk of misinterpretation by providing detailed and up-to-date representations of deposit geology. This real-time understanding facilitates better planning and decision-making, reduces environmental impacts, and minimises operational disruptions.



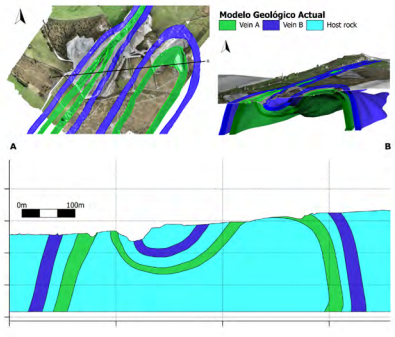
How Asturmine ensured the viability of kaolin mine with 3D modelling

Asturmine, an engineering geology consultancy, worked with a kaolin open-pit mine, facing two primary challenges:

1. **Uncertain deposit continuity**: Newly gathered geophysical data raised doubts about the continuity and pattern of mineralisation, previously understood through traditional geological models.
2. **Heterogeneous material**: The mine's diverse range of kaolin deposits needed to cater to specific client requirements, which demanded a better understanding of the resource composition.

Traditional 2D methods were insufficient to capture the complexity of the deposit, which posed a threat to the mine's long-term viability.

Asturmine used advanced 3D modelling to gain a comprehensive understanding of the deposit's grade and distribution. Within just five days, they developed a detailed 3D model that revealed a previously hidden folded clay layer, providing the information needed for more targeted exploration and mining efforts.



The model helped Asturmine create client-specific mining strategies based on the ore composition, reducing waste and minimising the mine's environmental impact. This precise understanding of the deposit's geology translated into cost savings and contributed to more efficient and sustainable operations.

The bottom line: The new model secured the mine's future and facilitated additional targeted exploration.

Read the full story →

CHAPTER 3

How better insights support sustainable mining and responsible resource production

As the demand for minerals escalates, so does the need to responsibly manage resource exploration and production. Today's geologists and mining companies are not only tasked with finding and producing valuable resources, but they must also ensure that their operations respect the environment, protect cultural heritage, and engage with local communities in a transparent and collaborative manner.

Efficient modelling is essential to achieve these goals. Geologists use advanced 3D modelling tools to better understand the subsurface and guide decisions that reduce unnecessary environmental impact.

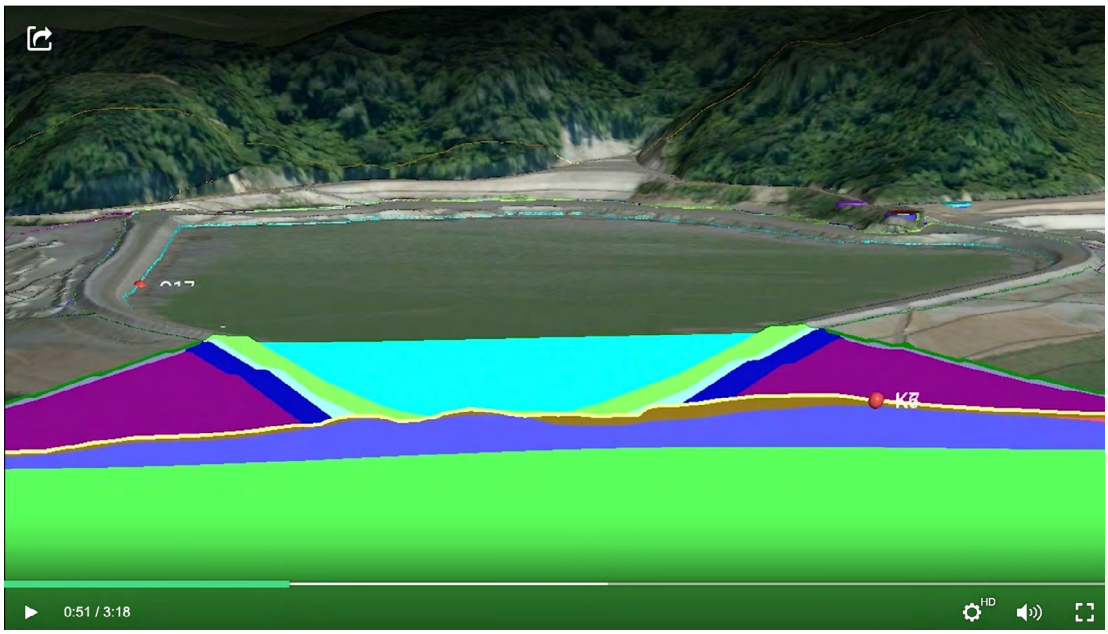
These models also enhance communication with stakeholders, making it easier for companies to obtain—and maintain—their license to operate. From visualising potential environmental impacts to fostering transparency with local communities, environmental groups, and regulators, advanced modelling helps mining operations make more informed decisions while mitigating risks to the environment and society.

OceanaGold Waihi TSF: Enhancing safety, collaboration, and regulatory compliance

OceanaGold, a multinational producer of resources such as gold and copper, faced the challenge of managing the Tailings Storage Facility (TSF) at their Waihi operations while ensuring the safety of the environment and the local community.

To achieve this, the team used advanced 3D modelling to develop a comprehensive digital twin of the TSF, integrating real-time geotechnical and environmental data. This approach enabled proactive monitoring of critical factors such as slope stability and water levels.

The digital twin also provided a 3D view of the TSF's structure, fostering collaboration among internal teams, regulatory bodies, and local communities. By enhancing understanding and transparency, the digital twin helped OceanaGold align its operations with environmental standards and maintain its license to operate, all while reducing risks and supporting long-term sustainability. This innovative approach made OceanaGold a finalist in Bentley's Going Digital Awards in Infrastructure in 2023.



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CHAPTER 4

Market-leading solutions for the mining industry

Seequent's Leapfrog Geo is recognised as the leading 3D modelling solution in the mining industry. Trusted by thousands of geoscientists worldwide, the software has become essential in both exploration and production geology due to its combination of speed, flexibility, and user-friendly interface.

Pioneering RBF technology

Leapfrog Geo'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.

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Understanding the underground with a complete geoscience solution

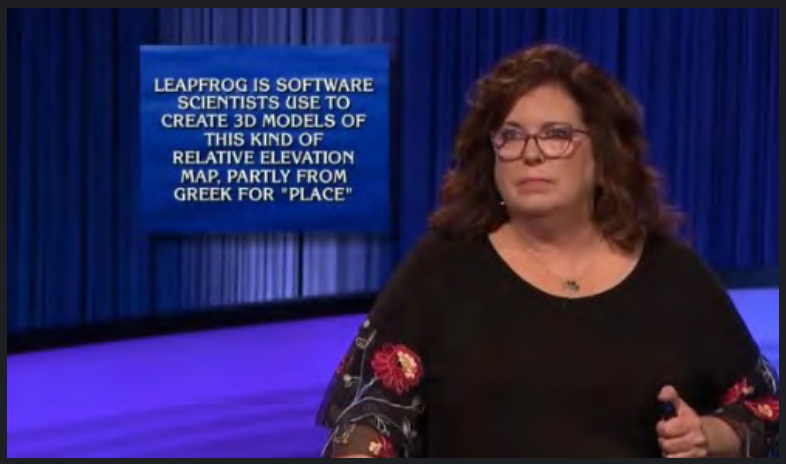
Leapfrog Geo is more than just a powerful geological modelling tool—it forms part of a comprehensive suite of solutions designed to enhance subsurface understanding and streamline geoscientific workflows.

By combining Leapfrog Geo with other Seequent tools, users can unlock even greater value from their geological data. Whether you're capturing high-quality images in the field, managing vast amounts of drillhole data, or incorporating geophysics into your models, Seequent's broader ecosystem offers a seamless and interconnected workflow that maximises efficiency, accuracy, and insight.

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

8/10
of the world's largest mining companies use Seequent

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



FUN FACT

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

Add intelligence to your model with geophysical data

Geophysics plays a critical role in mining exploration, providing essential subsurface insights that guide drilling decisions and resource evaluations. By combining Leapfrog Geo with Oasis montaj and Aarhus GeoSoftware (AGS), users can enrich their geological models with high-quality geophysical data.

Oasis montaj and AGS enable geoscientists to process, analyse, invert, and visualise geophysical and geological datasets, allowing for deeper insights into the subsurface. The combination of these tools allows for the creation of more comprehensive, data-driven models that lead to better decision-making and more effective exploration strategies.

Capture data with Imago

The quality and accuracy of geological models depend heavily on the data that feeds into them. With Imago, Leapfrog Geo users can capture, manage, and share high-resolution images of core samples, outcrops, and other geological features in real time. Imago's ability to work seamlessly with Leapfrog Geo means that these images can be directly linked to geological data, enhancing both the model's visual quality and the geologist's ability to make informed decisions. This real-time image capture not only saves time but also ensures that geoscientists are working with the most up-to-date and detailed data available.

Manage data with MX Deposit

Managing drillhole and sample data is a crucial part of any exploration project. MX Deposit is a cloud-based solution that simplifies the collection, management, and sharing of this data, ensuring that all stakeholders have access to a single, reliable source of information. Used with Leapfrog Geo, MX Deposit allows users to bring vast amounts of drillhole data into their 3D models, streamlining the process of data management and interpretation. This ensures that geoscientists can quickly update their models with the latest drilling information, driving better decision-making and reducing project timelines.

Understand soil-structure interaction with GeoStudio and PLAXIS

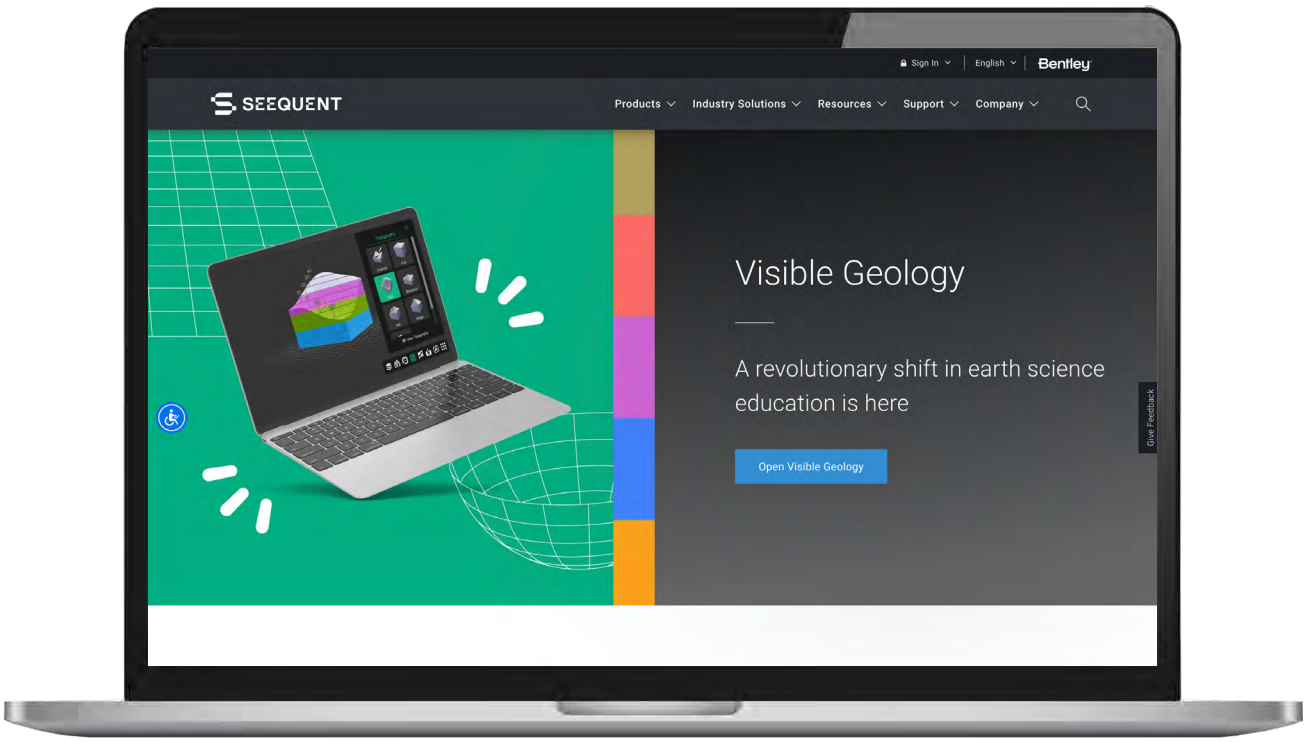
In mining and civil engineering projects, understanding soil-structure interaction is critical for safety, efficiency, and project success. GeoStudio and PLAXIS, two advanced geotechnical analysis tools, offer the ability to model slope stability, groundwater flow, and heat and mass transfer in soil and rock. By combining these tools with Leapfrog Geo, users can incorporate detailed geotechnical data into their geological models, providing a comprehensive understanding of the interaction between subsurface materials and engineered structures.

This is especially valuable for mine planning, tailings storage facilities, and other infrastructure-related projects where geotechnical concerns must be carefully considered.

CHAPTER 5

Leading the future of geoscience: innovation, education, and collaboration

At Seequent, our commitment to geology 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 that not only enhance the way we understand the subsurface but also make complex geological processes more 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.

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Discover the power of Leapfrog Geo for mining today

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

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