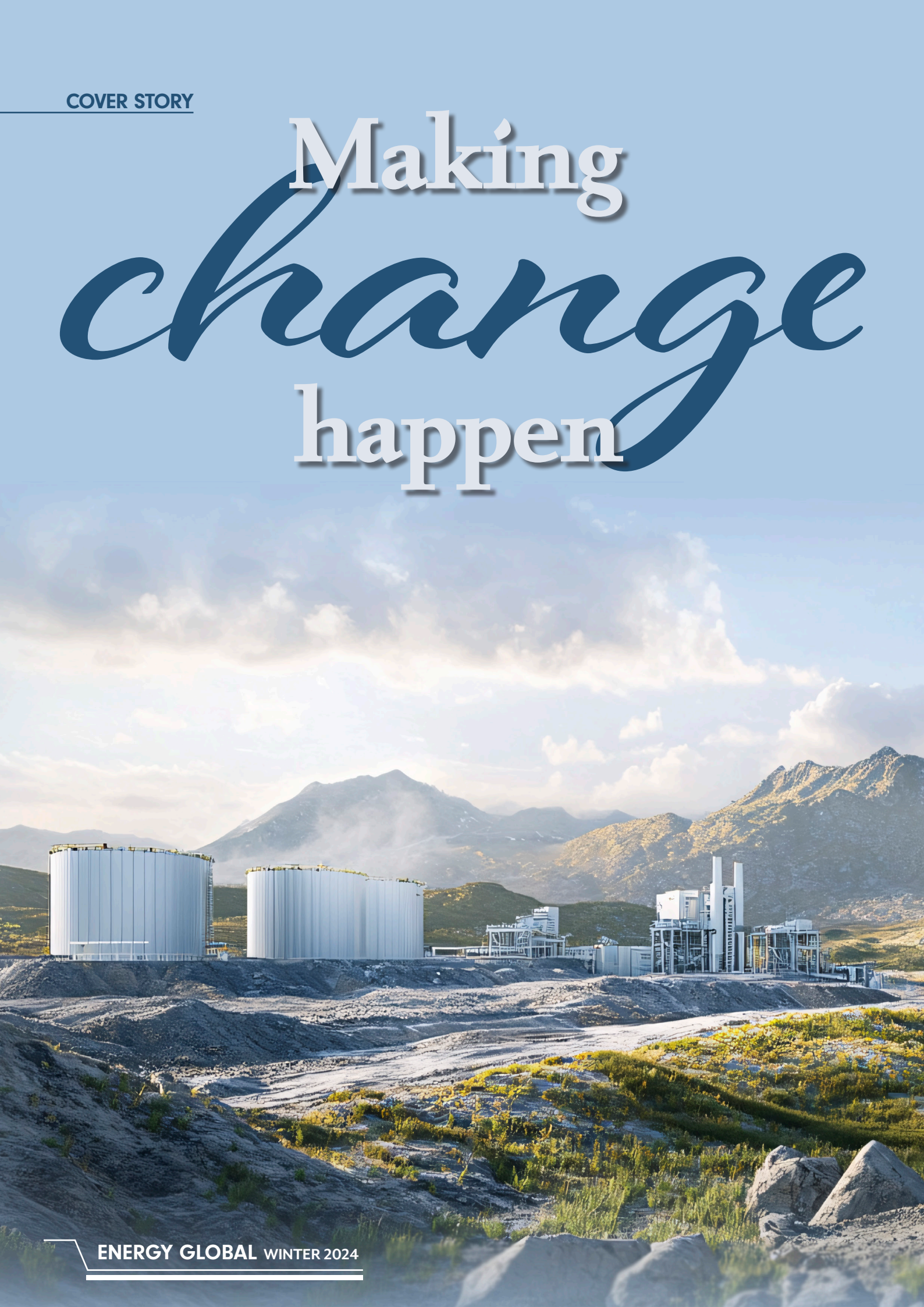
Making change happen



Chris Page, EVP New Businesses Development, Viridien, explains how technologies used to support oil and gas exploration and development are enabling innovations in the energy transition and beyond.

The energy industry is in transition, with many of the companies in this sector expanding into new and exciting markets. Viridien is one such company, having transitioned into a broader technology business (demonstrated by its recent name change from CGG). While the oil and gas industry remains its core focus, the acceleration of the energy transition brings the opportunity to use its established technologies to expedite growth in other sectors, particularly carbon storage, mining, and the search for critical minerals.

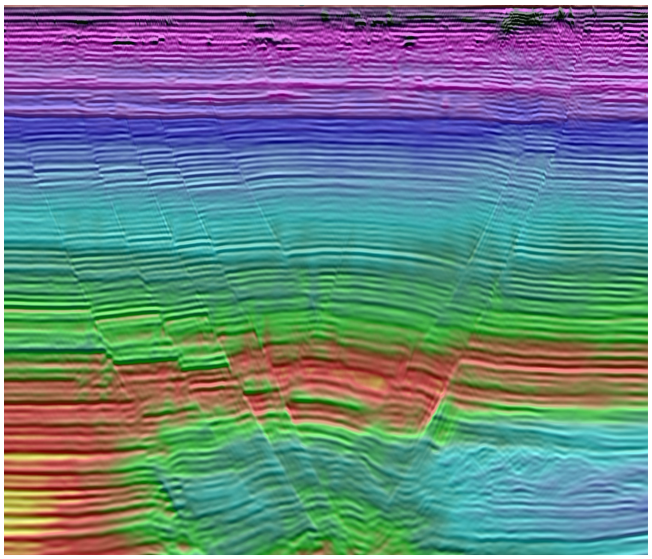


Figure 1. Full-Waveform Inversion imaging (shown co-rendered with velocity model) provides vital subsurface detail for better assessment of carbon storage risks.

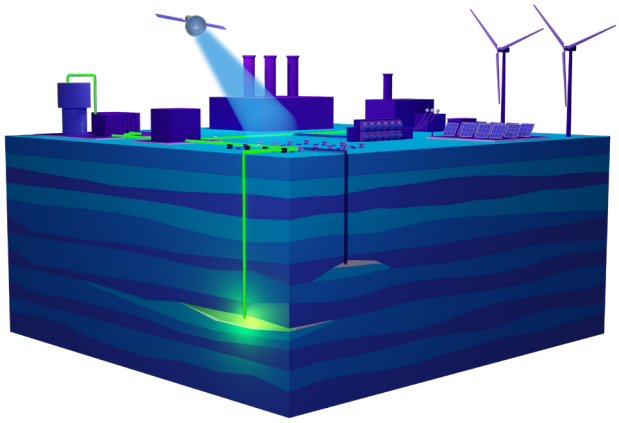


Figure 2. Subsurface storage evaluation, reservoir modelling, and long-term monitoring provide intelligence to make better-informed decisions throughout the life of an underground carbon storage project.

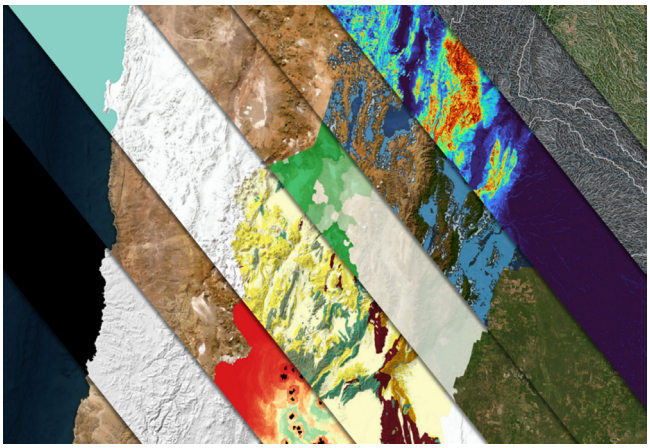


Figure 3. An overview of multidisciplinary geological data utilised to study lithium resource potential for exploration in the renowned lithium triangle in South America.

Geoscience for carbon storage

The carbon storage sector has benefited greatly from the expertise of energy technology companies such as Viridien because the challenges within this industry are very similar to those faced in the oil and gas business. A few years ago, most countries did not have the right regulatory environment for carbon storage or offer carbon credits but, as frameworks for permitting, monitoring, and verification mature, opportunities for the involvement of oil and gas technology companies have increased rapidly. Demand for carbon storage is going up, driven not just by these new policies and regulations but also by growing public pressure to reduce emissions, with many countries now putting in place the regulatory environment needed to encourage the development of appropriate facilities.

As the industrial emitters start to decarbonise their operations and thus seek solutions for long-term subsurface storage, a much wider customer base is opening up to energy technology companies. Unlike their traditional oil and gas clients, however, these new industrial customers have limited knowledge of the subsurface and need help in the identification and characterisation of underground storage sites. Companies like Viridien own large volumes of global geological data, which it uses to produce screening products to provide early identification of regions with high oil and gas potential. The same subsurface data libraries and processes are ideal for industrial emitters to help them find locations with the right subsurface conditions for carbon storage. Established imaging technologies are then used to identify potential storage sites in more detail and de-risk them. Viridien, for example, recently applied high-end imaging technology to a potential storage site in Southeast Asia, where re-imaged seismic data clearly showed that the site the client was looking at was very high risk, leading them to walk away from the area, saving significant time and money.

In the future, geophysical technology will play a major role in monitoring subsurface carbon storage facilities, as it is critical to ensure the carbon dioxide (CO_2) remains securely stored in place. This will satisfy regulators, financial backers, and insurance companies and also provide the public with the knowledge and reassurance needed for them to give their support to these large infrastructure projects.

As well as using or modifying existing technologies, new geophysical approaches specifically for use in the carbon storage industry are already being developed. One such innovation is the use of distributed fibre optic sensing, which can record both active and passive seismic, measure how the injected CO_2 plume expands and record fracturing or other dynamic changes within the reservoir rock or seal. This is expected to prove a much more cost-effective solution to monitoring than the current practice of putting conventional seismic sensors on the ground surface.

Challenges in the carbon storage sector

Large scale industries such as cement and fertilizer manufacturing are endeavouring to reduce their emissions, and technology companies with years of experience in understanding the subsurface can offer

them considerable assistance. The storage of CO_2 requires very specific subsurface conditions. Geologically, a viable underground storage site needs to be deeper than 800 m, the depth at which the gas goes into a supercritical or dense phase state – but it cannot be too deep. It needs a good reliable cap rock and must have retained enough pore space in the host rock to provide the necessary capacity for CO_2 to be stored in the future.

Smarter exploration to bridge the critical minerals supply gap

The growing global demand for critical minerals to support the energy transition highlights the urgent need for expedited resource discovery. The International Energy Agency (IEA) projects that lithium demand will increase approximately sixfold by 2030 compared to 2020 levels, driven by the rapid expansion of electric vehicles (EVs) and renewable energy storage. Similarly, copper demand is expected to double by 2040, fuelled by its critical role in renewable energy infrastructure, as its conductivity makes it essential for wind turbines and solar panels.

Efficient and sustainable extraction of these minerals begins with the proper identification of viable deposits. Advanced geoscience technologies and specialised geological expertise in mineral systems are crucial to these discoveries. Subsurface imaging, geoscience data analysis, and machine learning technologies provide deeper insights during mineral exploration, allowing mining companies to pinpoint high-potential deposits more effectively. This also allows them to reduce risks and costs associated with exploration and accelerate discoveries.

As an established regional prospectivity evaluation partner, Viridien offers technology-driven solutions that optimise early-stage exploration and minimise the uncertainties in resource development, helping to navigate the complexities of mineral exploration to meet growing demand.

One major challenge for selecting carbon storage sites is a lack of subsurface information near big industrial hubs. During its long history, Viridien has accumulated extensive subsurface data, and these can be used to advise companies and provide the insight needed to confidently pursue underground CO_2 storage. Existing technologies make it possible to extract the most value out of the data, whether through re-imaging existing seismic or by extracting key subsurface and engineering data for even more informed decisions.

Ideally, the storage site also needs to be relatively close to the industrial emitter; carbon storage is effectively waste disposal and hence there is no intrinsic value in it, so any significant transportation requirement only adds to the project costs. The company recently demonstrated how its technologies can help solve this problem. A client in the US suspected it could not store CO_2 underground near its facility, but Viridien ran a rapid high-level screening process and demonstrated a potential storage location within 30 km of its operations.

A number of technology companies have begun to work together to create solutions for the carbon storage sector. A good example of this is Viridien's recent collaboration with energy technology and engineering specialist, Baker Hughes, which will bring together leading-edge technologies across the whole carbon value chain, from direct air capture, surface engineering and infrastructure and subsurface characterisation, to storage and long-term measurement, as well as monitoring and verification programmes.

Government policies are pushing industrial emitters towards net zero, and there also appears to be an increasing drive for change from both the public and shareholders, so this business will continue to grow.

Identifying critical minerals

Critical minerals, as the name suggests, are important for the energy transition, from manufacturing batteries and electric vehicles to wind turbines and solar panels, but at the moment they are only mined in select geographies across the world. As demand grows, this is cause for concern for both government and industry. Ensuring a reliable and responsible supply is fundamental to achieving global energy transition goals, so the continuing search for new sources is vital.

Energy technology companies have already developed many products that have been effective in accelerating the discovery of significant oil and gas resources worldwide and the search for critical minerals has many similar challenges to oil exploration. These companies can offer global datasets and expertise for mineral exploration and advanced imaging technology for mine development and production.

Exploration for new sources of lithium, for example, has been

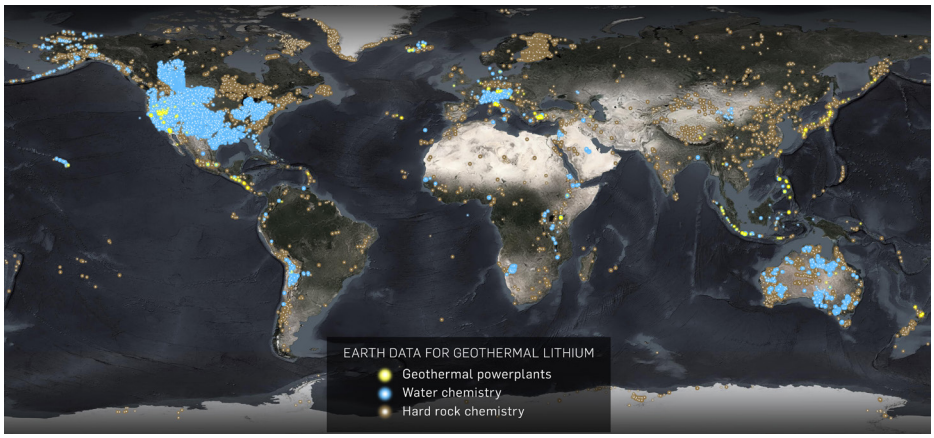


Figure 4. Map of investigated screening locations for lithium brines.

developing fast recently, particularly in regard to looking for places where the mineral might be extracted from brine. This is especially exciting because it ties in with geothermal energy production, since hot geothermal fluids often have high concentrations of lithium, so co-production is a possibility, thus reducing costs.

Global demand for lithium is projected to exceed 700 000 t for batteries alone by 2025, with total demand potentially surpassing 1 million t when accounting for non-battery uses. Meeting this demand requires innovation in discovery and extraction. Viridien, a leader in lithium exploration, combines advanced geoscience workflows, machine learning, and subsurface imaging to pinpoint and assess high-potential deposits. These capabilities enable the identification of resources in regions like South America's palaeosalars while supporting sustainable practices. By delivering actionable insights, the company helps bridge the gap between growing demand and supply constraints, ensuring clients remain ahead in the critical minerals race.

In South America, there is considerable potential for finding lithium, including extracting it from ancient, buried salt plains known as palaeosalars. Identifying such geological features can be helped through the analysis of previously acquired data. Viridien recently assessed the regional potential for lithium and potash mineralisation in Argentina for a client after conducting multi-client screening studies for lithium salars and palaeosalars in South America. It has also been selected by the French government as a technical partner to support the LiMongolia project, a joint initiative by the National Geological Survey of Mongolia and the French geological survey, BRGM, to evaluate the regional prospectivity of Mongolia for critical minerals, particularly uranium and lithium.

Driving efficiency in mining

Although more familiar to the general public, copper is also a mineral critical to the energy transition. For a number of reasons, including its use in batteries and cars, the world urgently needs to bring new supplies online. To find significant ore deposits, mining companies will need to look deeper, which is where technologies like subsurface imaging, developed for oil and gas exploration, will play a vital role.

In addition, it is important to ensure that the best use is made of those ore bodies already discovered, and techniques used for petroleum exploration lend themselves to assisting in this area. Mining organisations have had access to seismic data in the past but have not necessarily benefitted from the algorithms that have been developed by the energy technology companies to define and image the most complex geologies. Miners predominantly use tightly spaced drilling to identify where the minerals lie and quantify the resource size, but there is now potential to fully delineate ore bodies using subsurface imaging techniques like Full-Waveform Inversion (FWI), which will, ultimately, reduce the number of boreholes required, thus lowering costs. Energy technology companies are now working in partnership with major mining companies and have shown the value they can bring to the sector. A recent example of this came from Australia, where Viridien applied high-end FWI technology to help a mining giant redefine the orebody in a copper mine and enabled a greater understanding of the main controlling fault along which the fluids carrying the copper had travelled. This allowed the client to design a more efficient production plan and bring the resource to market more quickly.

A place for hydrogen?

There is much debate at the moment about natural hydrogen and whether it can be found in the subsurface in viable quantities; if so, it would substantially change the energy debate. Expertise from the oil and gas sector is being used in the hunt for commercial hydrogen, using multiphysics and subsurface data, and in the future, seismic will be critical if this industry is successful. Viridien recently undertook a worldwide screening project to better understand why and where hydrogen is produced, using time-lapsed satellite imagery, subsurface geological information and geochemical data, as well as the company's high-performance computing (HPC) capabilities.

An exciting future for energy technology

With their core capabilities based on many decades of experience in the oil and gas sector, Viridien has seen how technology companies can support the mining industry to optimise their operations – but what if new materials and new batteries that reduce or even eliminate our reliance on critical mineral resources could be discovered? Research is already underway into designing such substances using physics-based simulations, and the HPC capabilities and experience that Viridien has built up to solve its own physics-based business challenges make it an ideal partner in such research. Applications and simulations can be run much faster, helping accelerate the discovery of these exciting new materials.

The use of technologies like subsurface imaging, data processing, artificial intelligence, machine learning, and HPC developed for use in the oil and gas industry have huge potential to help companies accelerate breakthroughs in many markets, from carbon storage and conventional mining to finding critical minerals or even the development of completely new substances.

A time of transition

This is an exciting time in the energy industry and one that is bringing many opportunities to technology companies looking to grow beyond the boundaries of their core business areas to accompany transformational changes across society, including the challenges of the energy transition, and really make a difference.

Oil and gas technologies are making change happen and the future is bright.

References

1. 'Global Critical Minerals Outlook 2024', *International Energy Agency*, (2024), www.iea.org/reports/global-critical-minerals-outlook-2024