ISSUE 6

SEEQUENT

UNEARTHED

THE POWER OF CONNECTION

How shared understanding between geo-professionals, stakeholders, and communities is changing the world.

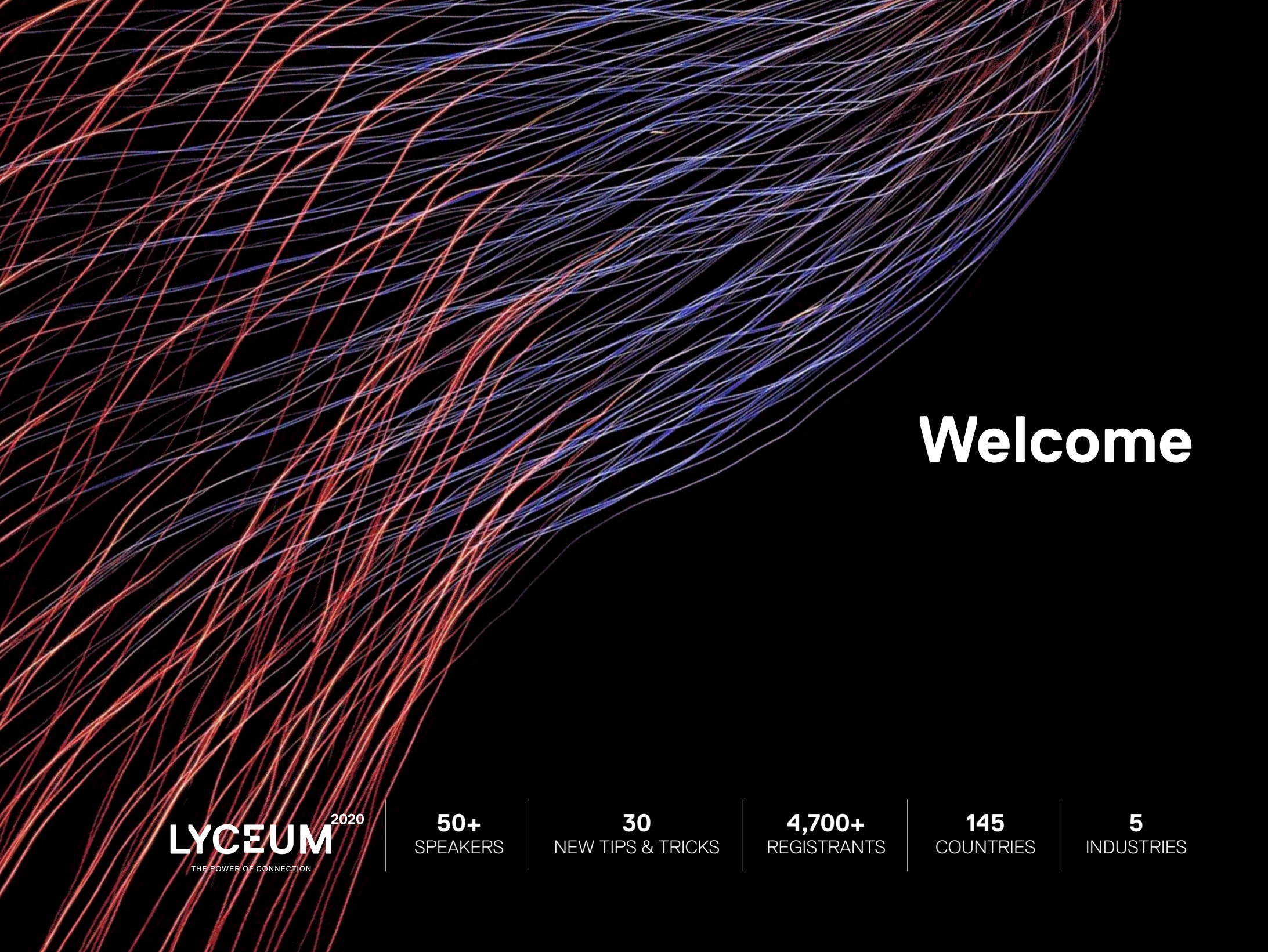
Microsoft and Seequent discuss THE FUTURE OF WORK

PLUS

- The search for trust in Tailings Storage Facilities
- How to communicate complexity in civil projects
- Groundwater mapping with airborne geophysics
- Navigating the energy transition

LYCEUM 2020

Brought to you by Seequent



Welcome

LYCEUM 2020
THE POWER OF CONNECTION

50+	30	4,700+	145	5
SPEAKERS	NEW TIPS & TRICKS	REGISTRANTS	COUNTRIES	INDUSTRIES

HELLO

Welcome to UnEarthed – a unique insight into the challenges and innovations of geoscience for everyone connected to the industry.

Part of our passion at Seequent is to find new ways of helping all the sectors we work with, from civil infrastructure, mining and exploration to environmental and energy.

UnEarthed is our way of communicating the latest ideas, trends and technologies we come across, and explore the best ways of turning them into success stories – not just for companies and clients, but for the world in which they operate and the people they strive to help.

This time we look at the power of connection and the promise better connectivity holds in revolutionising how we all work.

If you have an issue you'd like us to examine or a solution you'd be keen to see discussed, we'd very much like to hear from you. Contact us at unearthed@seequent.com

Enjoy UnEarthed, and if you're new to our publication, you can find our back issues here **Seequent.com/community/research-reports/**

The Power of Connection

2020 has shown us the power of connection when faced with adversity. We all continue to be impacted by the COVID-19 pandemic, making our work and home lives dramatically different.

At Seequent our mission was clear – after doing all we could to ensure the safety of our global teams, we set our focus on enabling our users to continue working, and to make the impact on their lives as minimal as possible. We changed our development priorities and accelerated Cloud-based solutions so users could work from home without disruption and provided free access to our collaboration software.

Prior to Covid-19, we were already making great progress with the development of Seequent Evo – connecting our Cloud and desktop solutions, and partners to create personalised workflows and layered data. Announcing Evo was one of several highlights of Lyceum 2020, our annual user event historically done in-person at three locations around the globe.

Due to COVID-19, we delivered Lyceum virtually bringing our global community together, including registrants from over 80 countries. Talks featured more than 50 expert speakers from partner companies such as Microsoft, Autodesk, and Bentley, as well as our customers' organisations.

Lyceum delivered inspiring stories from our users on how they tackled challenging geoscience projects, as well as engaging panel discussions from industry leaders on what opportunities they see ahead.

The spirit of Lyceum is to engage in meaningful conversations and that was delivered in abundance thanks to the outstanding effort of our partners and user community. We are fortunate to have such advocates who all contribute to the wider good of geoscience.

Daniel Wallace
Chief Revenue Officer, Seequent

This edition of UnEarthed offers a glimpse into sessions that attendees highlighted as particularly interesting.

We hope it inspires you like it has inspired us.

Watch Lyceum On Demand anytime:

Seequent.com/Lyceum

BIG, DEEP, AND WIDE

CONNECTED BY: **WATER**

The Jing-Hang Grand Canal is the largest and longest artificial waterway in the world, connecting Beijing with Hangzhou via the provinces of Hebei, Shandong, Jiangsu and Zhejiang. That's a watery grand tour of 1776km. Now a UNESCO World Heritage Site, it can date its earliest stretches to the 5th century, and was employed to transport grain from the agriculturally rich Yangtze and Huai river valleys to cities (and soldiers) in northern China. Today it's also used for diverting water from the Yangtze to improve irrigation of drier areas and boost the rice crop. There are times when the flow of water within the Grand Canal is actually reversed – even running uphill – in order to achieve this. The 1950s and 1960s saw considerable work to straighten, dredge, and widen key parts of the waterway to allow larger ships to use it. The idea of linking Beijing (then Dadu) with Hangzou via a direct waterway is credited to Kublai Khan©. Little can he have realised that the canal he conceived would coincidentally go on to connect a disparate collection of regions with different languages and customs, thereby ultimately giving birth to the unified nation of China that we know today.

CONNECTED BY: **CABLE**

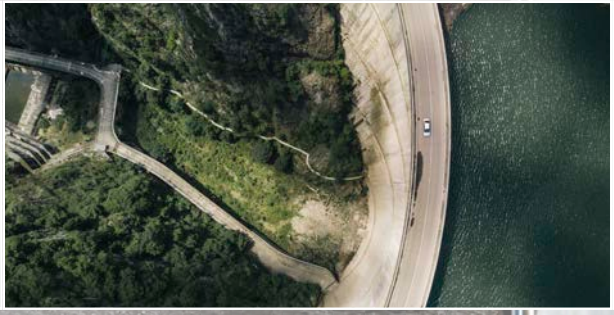
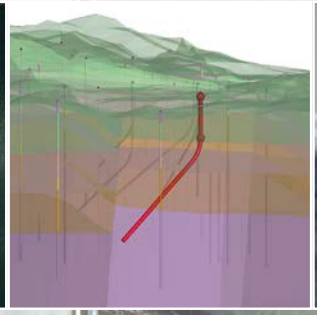
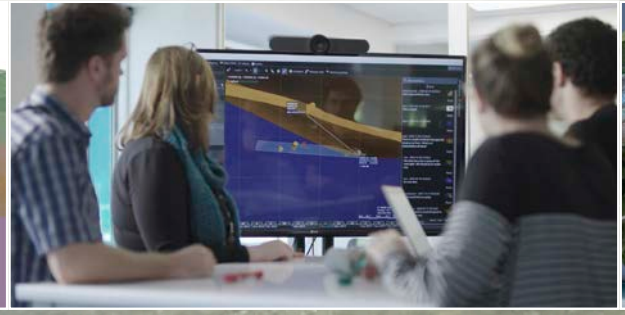
This July saw work begin on Viking Link, a 1.4 GW HVDC submarine power cable set to become the longest in the world. At 765km it will easily beat the current NorNed record holder – a mere 580km that links Norway with the Netherlands. The £1.8bn power line, due to be completed in 2023, will run under the North Sea from Lincolnshire in the UK to South Jutland in Denmark, allowing the two countries to share clean energy (and in particular giving the UK access to Denmark's considerable wind power resources). The two parallel single core, mass-impregnated paper-insulated cables that make up the link will operate at ± 525 kV DC providing more than 1.4 million homes with sustainable energy.

THE FUTURE OF WORK

In unprecedented times, how can you be ready for what's next?






COMMUNICATE, COLLABORATE, INNOVATE

3 ways to get ahead of the game

1

CONNECT TO **COMMUNICATE**

How to manage your digital revolution

Uwa Airhiavbere
Managing Director, Microsoft's
Worldwide Energy Industry Practice

> "We call it tech intensity, the ability to bring technology into the company, adopt that technology very quickly, and then use that technology to drive value in the company."

Better communication leads to more informed and successful decisions, and digital transformation is key to making that happen. Yet companies still struggle when making the digital switch and sometimes even seem to resist it. We speak to Uwa Airhiavbere, a Managing Director within Microsoft's Worldwide Energy Industry Practice, on why that's the case and how to get internal buy in for the digital shift.

Resisting technology is now more work than embracing it. We're all connecting remotely, processing huge data sets, and communicating with wider groups of stakeholders.

So, what's holding companies back? One thing is perception.

Tasks that might have taken hours or days can now be done in minutes. But, it's not only about higher speed – it's about higher quality.

"There's also the idea of making higher quality decisions, because compute power is now broader and more scalable. Especially when you're using a hyperscale Cloud like Azure," says Uwa Airhiavbere.

The impressive successes of early adopters have proven that switching to digital technology is more productive, lucrative, and leads to more informed decisions.

Yet, there's still resistance. How can you get the internal buy-in you need for new tech to succeed?

Uwa partners with corporate leaders and teams across the energy and mining industries to implement digital tools. He shares what can make or break a digital revolution.

FOCUS: FIND HIGH VALUE PROJECTS THAT GET QUICK WINS

"Pick the outcome where you think digital transformation can drive the most change," says Uwa.

"Because there are also people in the organisation who might be skeptical about digital transition. They need to see a quick success, and it helps to really drive change across the organisation."

Select areas where people start experiencing the benefits right away. If new technology saves them time and makes their jobs easier, employees will become your biggest digital adopters.

Then, when their results show in progress reports, new discoveries, or your company budget, you'll gain support from the wider company.

"Seequent Central is a good example of technology that can be brought into the organisation and ramped up pretty quickly. And then, used to drive value immediately in the company," says Uwa.

Central allows teams to collaborate on building geoscience models, iterate ideas rapidly, version control files, share web visualisations, and access a single source of truth for their projects.

Erasing years of frustration searching for current files is a process win that'll be felt instantly.

"We call it tech intensity, the ability to bring technology into the company, adopt that technology very quickly, and then use that technology to drive value in the company."

The more powerful the impact, the more buy-in you'll receive – so focus on a big win area.

THINK BIG FROM THE BEGINNING

While you should pinpoint a high value area at first, don't stop there. Consider how the same new tools can be implemented widely right from the start.

"Don't think of it like a little siloed project," says Uwa.

"Companies get stuck in this phase where they're doing a lot of pilots, but they're all siloed and it's not possible to bring the value from all the pilots together."

You need to keep the momentum going to get the most

value from new technology. Make sure you have a plan that rolls out the tools across teams or processes so that more people can experience the benefits.

"Think of it broadly. Like, 'I'm trying to reduce costs broadly across this department or this division,' and take on initiatives that actually help to do that. Then, it's scalable."

A major advantage of digital tools is their flexibility to be applied across both departments and tasks. Take advantage of cascading wins by planning for them from the start.

MAKE DIGITAL YOUR COMPETITIVE ADVANTAGE

Besides your own time, cost, and frustration saved, consider how new digital tools and processes could also appeal or be sold to prospective clients or stakeholders.

"Think of areas where the company thrives," suggests Uwa.

"Maybe there's a process you have used internally. Can you actually leverage that technology to now create a new solution that can generate revenue for your company?"

Ask: Can technology you already use benefit others outside your team or company?

Whether it's winning new clients, assuring regulators, or creating new services and revenue streams – imagine how your new technology can become a differentiator.

INFUSE DIGITAL FROM THE TOP DOWN

Technology isn't a standalone item, it's a part of doing business. Digital needs to be at your company's core to reflect that.

Leadership needs to strongly support technology initiatives. The good news is: It's now much harder to argue with the necessity and results of digital tools in the last decade.

What can leaders do to ensure the transformation doesn't stop with them?

"Whatever the mission of the company is or the goals of the company – infuse digital at the most basic level," says Uwa.

When technology is embedded in your corporate mission, it will then be part of every initiative, team, and decision going forward.

FINALLY, FIND TRUSTED ADVISORS

Don't go it alone. You aren't the first to struggle with getting buy-in or onboarding people to a new way of working.

The best technology providers focus on understanding each company's needs – so they can find ways to support them. They have deep knowledge of potential regional and industry specific challenges.

"Companies like Seequent and Microsoft can help to figure out what those challenges are and meet our customers halfway to help them accelerate their digital transformation journey," says Uwa.

Can you make data more accessible while ensuring you meet local legal regulations? Do you need to upskill workers to get value from new technology?

Reach out to trusted tech companies for their advice. They've likely helped others overcome similar barriers and, after all, their success is based on your success – they want you to thrive.

"When you align to industry outcomes, it's quite powerful," says Uwa.

Digital transformation isn't new, it's already part of your work. The only question is: How can you make the most of it?

5 KEYS TO DIGITAL TRANSFORMATION

1. Focus on high value, quick wins
Start where people will immediately see benefits

2. Think big
How can new tech scale and multiply the benefits?

3. Make it an asset
Where can digital tools create a competitive advantage?

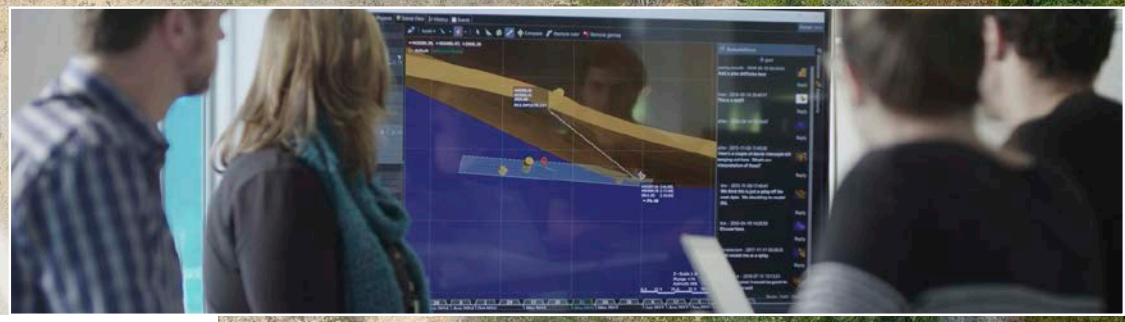
4. Lead from the top
Infuse tech into your company's mission and goals

5. Don't do it alone
Work with tech partners to get set up for success

CONNECTED BY: **PROTEINS**

$C_{169723}H_{270464}N_{45688}O_{52243}S_{912}$

That mammoth chemical formula is better known by its rather more manageable name of Titin. It's the largest protein we know of, connecting 244 individual protein domains that fold and unfold like molecular springs within our bodies. It's essential to the elasticity of our muscles, and remarkably each one of us contains up to 0.5kg of the stuff. Its full description would be the longest word in the English language, if technical terms were allowed, and reading all 189,819 letters takes around three and a half hours. (Yes people have done it. You can watch them on YouTube.) If you want to practise with the first 40, here they are: METHIONYLTHREONYLTHREONYLGLUTAMINYLALANY. In human terms it's tiny – just over a micrometre in length – but for proteins that is colossal, tying together 34,350 amino acids. The existence of such a protein, which could account for the ability of muscle to return to a resting state after being stretched, was first mooted in 1954, but it took until 2001 for the complete sequence of the human Titin gene to be determined.



2

CONNECT TO **COLLABORATE**

How companies are getting more value from less data

Penny Swords
Vice President, Central at Seequent

> “It’s the combination of the geologist and the machine.”

The pandemic has made it harder for companies to collect data in the field. But by connecting their teams more effectively, there’s still more to be gained from the data they already have, argues Penny Swords, Vice President, Central at Seequent.

Switching to digital used to be simply an option, or even a luxury. Some saw it as too complicated, too risky, or perhaps too much of an investment.

For many companies, it was never the right time – then the pandemic hit.

“All of a sudden it became the right timing because everyone was forced to work remotely. People started to implement and use remote collaboration solutions,” says Penny Swords.

The obvious first steps were connecting people effectively and allowing them to continue to work. Video conferencing, messaging, and Cloud-hosting went from being high tech to day-to-day.

But then companies turned to the work itself. With limited access to collect data in the field and more experts working at home, how could teams do more work with less?

Penny shares insights from recent conversations with customers.

OLD DATA, NEW DISCOVERIES

“Because people couldn’t go out on site as much anymore, they started to turn towards the data they had already collected to find more insights.”

One silver lining of remote work was that it freed up space for teams to delve into the data they already had – and find hidden value.

“Over the years, companies collect a huge amount of data. The data is not always used to its full potential, especially when teams are busy travelling to site.”

“As people have moved to working remotely from home, they have been digging out data previously collected and analysing it further to try to find something that they may have missed the first time.”

MANAGING BIG DATA

Once people began looking at their old data, they realised – it’s a lot, certainly more than any one person or even team could process effectively.

“When you process a huge amount of data that’s been collected in the past, there may be discoveries in your data that you’ve missed.”

Computers, however, can find patterns in massive data sets quickly. So, what technologies are people using?

“We find that increasingly more of our customers are turning to Artificial intelligence (AI) to automate tasks and look for new insights in their data to inform decisions. They are, for example, using AI to automatically classify pieces of data.”

A computer can identify an image in an instant based on what it’s learned from looking at previous images. The computer can then be trained to name or classify a piece of data.

AUTOMATING THE MUNDANE

Pattern finding and classification are things machines do best. Computers can automatically log core, as an example.

“By automating the process of loading the data into a model and being able to visualise it, you get a faster result from the moment you put a hole in the ground to the moment that you’re making decisions.”

Even when collecting field data, machines can make the turnaround time from logging to decision-making nearly instant.

“The computer is spotting patterns and trends that wouldn’t have otherwise been spotted by human brain, with greater speed.”

THE VALUE OF EXPERTISE

But, the goal of this technology isn’t to replace people – quite the contrary. It actually frees up their time for applying their expertise, not just logging numbers or scribbling names.

Technology gives experts more space to test ideas, collaborate, and focus on decision making. And computers need someone to catch their mistakes, too.

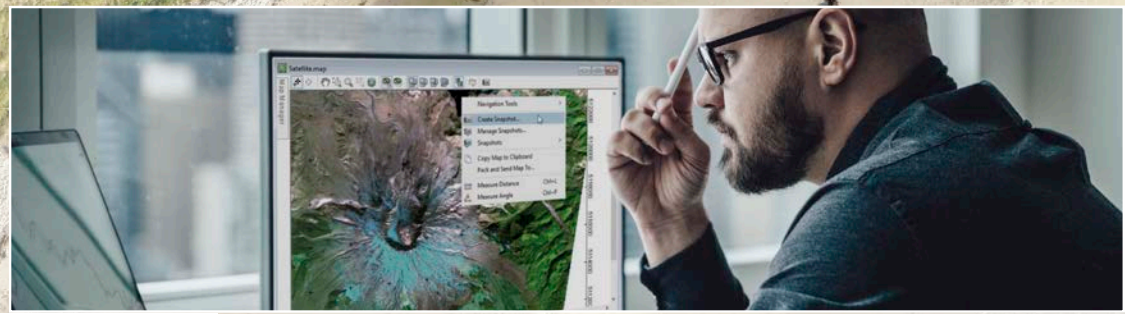
In this new digital age, it’s not one or the other:

“It’s the combination of the geologist and the machine.”

3

CONNECT TO **INNOVATE**

How working from home can kick start a new digital era



Watch Shaun and Uwa's Lyceum 2020 keynote:
Seequent.com/Lyceum

Shaun Maloney
CEO of Seequent

> “Humans work best as a collective, collaborative, and cohesive group. We solve problems and we innovate. The result is we evolve our thinking and actions.”

Covid-19 has forced us to innovate in the way we work and especially how we work from home. But if we get it right, this necessity, as the old saying goes, could be the mother of a new age of invention. We are in the midst of a ‘megatrend’, says Shaun Maloney, CEO of Seequent, and the secret to mastering it will lie in preserving company culture while creating new shared, digital spaces.

Industrialisation. Globalisation. And now, digitalisation.

Social shifts become a “megatrend” when they create permanent change societally, economically, and technically – and not always for the better.

The big evolutionary changes society has made over the last 200 years have either been caused by or cemented in place through megatrends – and we’re in the midst of one now.

Going digital has passed, we’ve be thrown into a completely digital era.

CONNECTION AT A DISTANCE

We’re now able and in many places required to carry out our “day jobs” from a personal space or our home, rather than a company office location.

If we considered this to be solely a technical challenge to overcome, then the megatrend has done its job. It offers lots of benefits under the right conditions, from increased productivity to major cost savings.

Yet, we are all quickly discovering the truth that humans are social creatures, evolved to communicate, collaborate, and innovate through person-to-person contact.

Digital now must become more human.

“Humans work best as a collective, collaborative, and cohesive group. We solve problems and we innovate. The result is we evolve our thinking and actions.”

CREATING SHARED DIGITAL SPACES

Our cities have town squares, schools, and town halls. Our communities have meeting places and park benches. We even have dedicated social spaces in our homes: dining rooms, sitting areas, patios.

Humans have evolved through interaction within our communities. Our best ideas come from discussions and debates with one another.

A company culture is not dissimilar. If people feel isolated or disconnected digitally, it’s because they might not be able to access part of the collective thinking and decision-making they’d have in an office.

We are already seeing the consequences play out in our communities and workplaces where remote working has been in place for months. Seequent understands that remote working for our own team and our user community is here to stay.

NEXT GEN SOCIALISATION

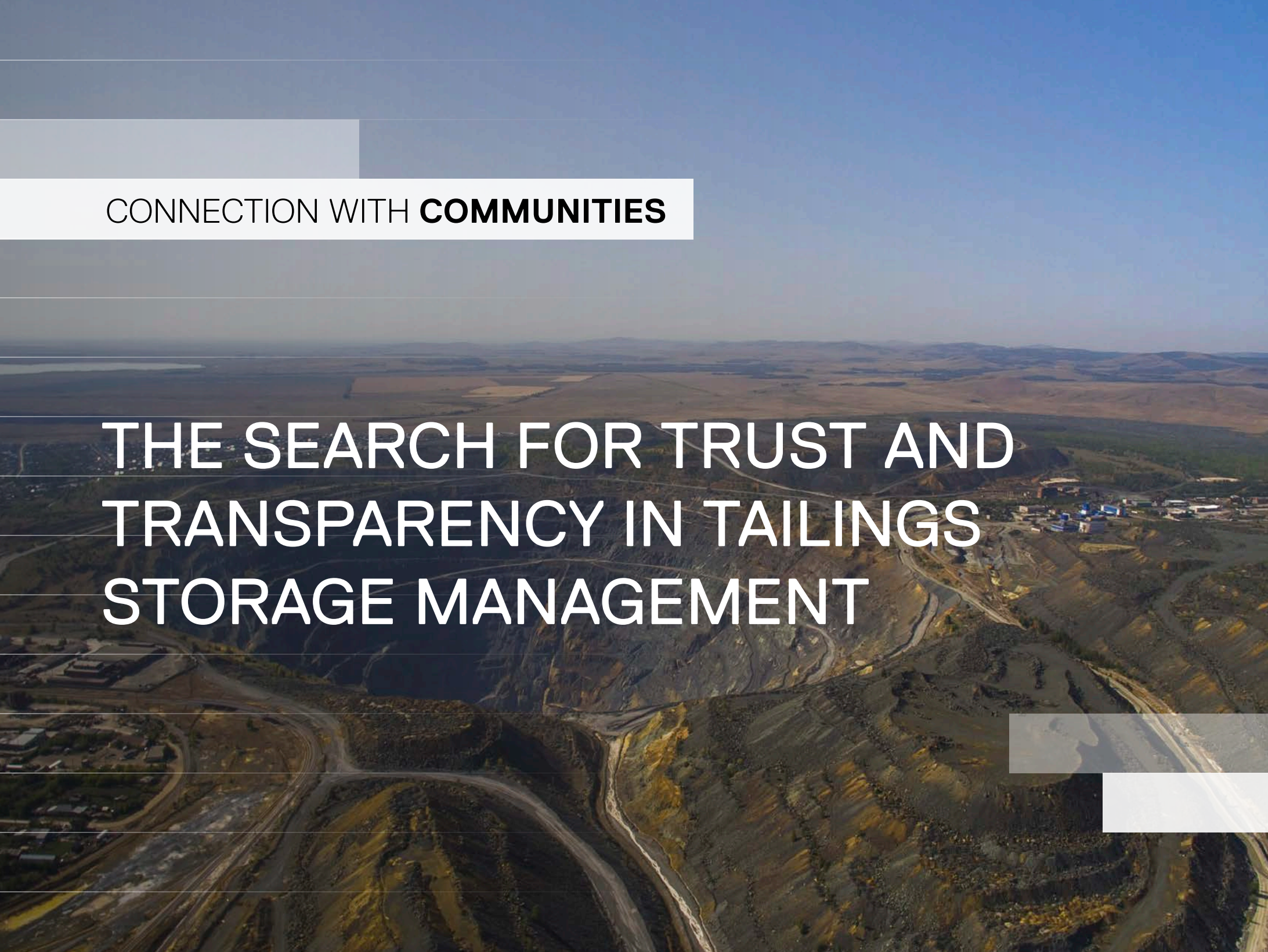
So, how can we address those social needs outside of the functional ones? How can companies create ways for teams to collaborate more – at a distance? Our latest products include ways to comment, share files, iterate, and plan from one single Cloud-based location.

New releases focus on connecting with open APIs and different products so that teams can learn from one another, and expertise can spread. We even hosted our annual conference, Lyceum, virtually so that people from across industries and around the world could learn from one another.

We will continue to use our technology to create, build, and support a culture of collaborative problem solving that meets our social human needs – and empowers us all to contribute to addressing the biggest challenges around earth, water, and energy.

CONNECTION WITH **COMMUNITIES**

THE SEARCH FOR TRUST AND TRANSPARENCY IN TAILINGS STORAGE MANAGEMENT



Pieter Neethling
Segment Director
Mining Production, Seequent.

At Seequent, we are innovating to enable the mining industry to transform the safety and sustainability of tailings storage facilities, build trust with local communities, and make major steps in fulfilling its corporate responsibilities.

Connection with communities and the social licence to operate have risen rapidly up the list of priorities facing the mining industry in the last few years, especially around tailings storage facilities (TSF). These are not areas the sector has been traditionally enthusiastic to embrace, but that's changing.

So in 2020, how is the mining industry responding to the challenges facing tailings facilities and the need for better management, transparency, and communication? In our recent Lyceum 2020 virtual conference, we asked three experts from the industry for their views – Caius Priscu of Anglo American, Dirk Van Zyl of the University of British Columbia, and Adriaan Meintjes of SRK Consulting.

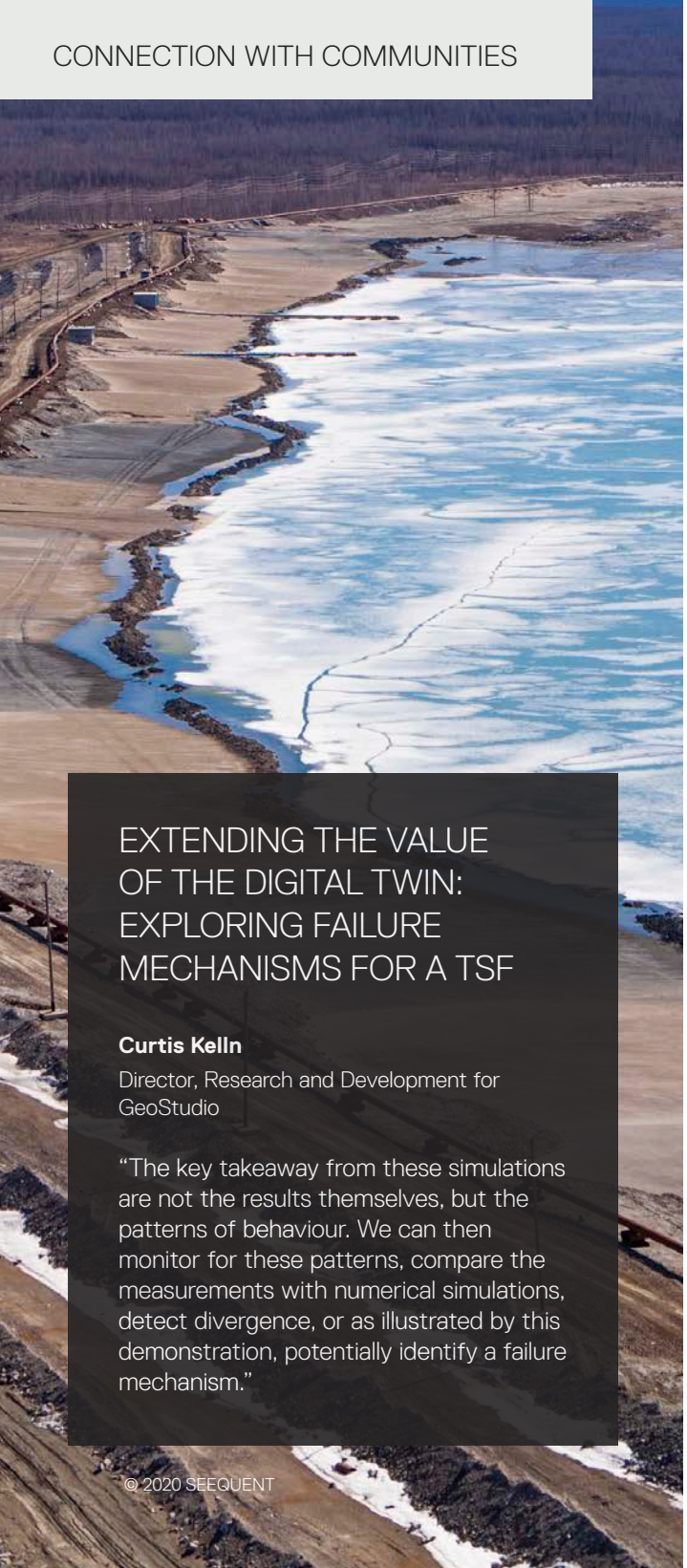
Here is just of a short extract of the insights they shared.

How is the industry reacting?

Caius Priscu:
In general, the mining industry is taking this extremely seriously. There have definitely been a few wake-up calls, if you want to call them that, that highlight how important these structures are. Tailings facilities are posing a potentially catastrophic risk for many if not all mining companies around the world. There is definitely a better understanding of the level of stewardship we need to implement for these facilities.

Dirk Van Zyl:
There is not the feeling of pushback that there might have been before. There really is an understanding that this is a serious subject. I think we are seeing big, big changes, more so than at any time in the last 50 years.

Watch the full Lyceum 2020 presentation:
Seequent.com/Lyceum



EXTENDING THE VALUE OF THE DIGITAL TWIN: EXPLORING FAILURE MECHANISMS FOR A TSF

Curtis Kelln

Director, Research and Development for GeoStudio

"The key takeaway from these simulations are not the results themselves, but the patterns of behaviour. We can then monitor for these patterns, compare the measurements with numerical simulations, detect divergence, or as illustrated by this demonstration, potentially identify a failure mechanism."

What are the changes you've seen?

Caius Priscu:

From my perspective, the biggest significant change has been an awareness of our profession and an awareness of our practice areas which have lifted the importance of having the right people with the right skills in the right roles, and I cannot emphasise that enough.

Dirk Van Zyl:

A more detailed evaluation of alternatives for sites and a clearer understanding of the consequences of failure. There is a difference in how companies have really taken this up and for smaller, junior companies there is still a maturity issue in terms of how they have worked around the tailings management piece. But I am very encouraged to see where we are right now.

How does the industry go forward to build trust with communities and making stronger connections with them?

Caius Priscu:

For the mining industry in general, the key word is going to be transparency, it's the number one topic on the table. From an Anglo American perspective, we already do quite a bit, sharing information with our local communities, having open doors to our offices, and site visits to our facilities from the local communities. Transparency and more formal reporting at a corporate level will become the norm.

Adriaan Meintjes:

Another dimension will be to ensure that everybody understands the topic. There is some education and training required to convert the understanding from a technical point of view more into layman's terms so everyone can understand equally well.

Dirk Van Zyl:

This idea of sharing information and helping people understand it so they can appreciate we are transparent is something engineers should take up as well, not just the communications departments within companies. This is another big challenge. Engineers are not very good at dealing at this level. We think, ok, some other guys in the company will take care of it!

What impact will the publication of the Global Industry Standards on tailings management have?

Caius Priscu:

The standard is very much welcome. I think it brings companies to a level playing field and it will help prevent catastrophic failures of these facilities in the future. But the devil is in the details. How well will it be implemented? Do we have the resources and the people to implement it? Are there enough specialists in the industry to implement this at a global scale?

Adriaan Meintjes:

Tailings have time dependent and load dependent properties and therefore you cannot do one set of tests and think you have defined the future. The implementation of the global standard needs to consider the scarcity of resource in the tailings business from clients to contractors to service providers and consultants – all the spheres of the tailings business. It has to be a comprehensive team and that needs significant consideration.

Dirk Van Zyl:

As we move forward it will be about integrating the engineering, the environmental, and the social elements. It is really bringing together that combination of all the professions. ”

What new challenges do the audits and reviews pose for consulting firms and mining companies in terms of transparency?

Caius Priscu:

There is a requirement for independent review boards or panels, but in the future we will soon be running out of independent reviewers because everybody is reviewing everybody else or the design of someone else! So that will be a big challenge.

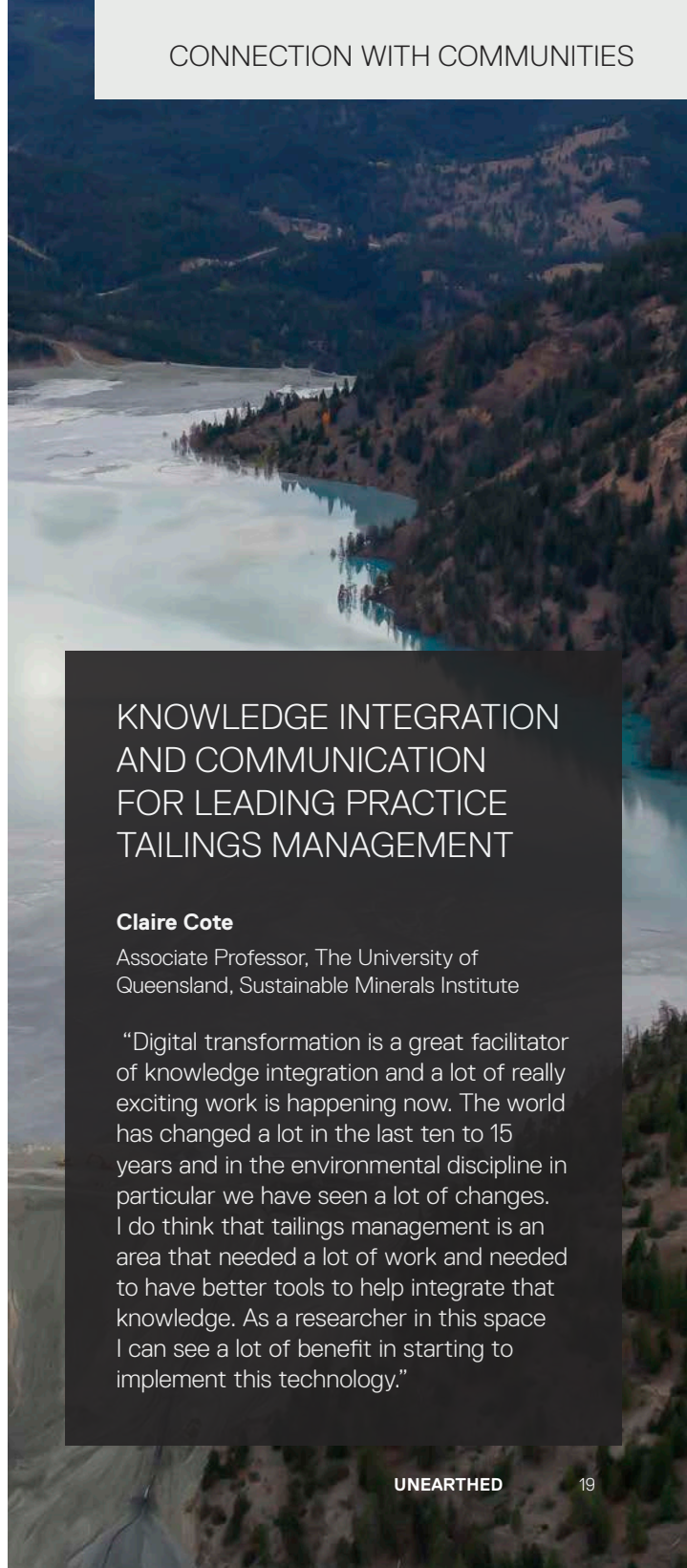
What I can also see coming is that I think we are going to see more intense collaboration between peers with regard to reviews – discussions between peers, supporting each other, informally exchanging ideas and knowledge of how we do things, both exchanges between mining companies and between various engineers of record.

Adriaan Meintjes:

One of the greatest benefits of the global standard is that it defines a consistent roadmap. On greenfield sites, the new way of doing tailings management according to the new standard will afford greater credibility on all parts. However, the biggest challenge relates to sites where there are legacy issues in terms of a lack of trust, and that will take considerable effort and time. But this is the best way forward: to undertake all communications in a transparent manner.

Dirk Van Zyl:

What we are seeing now really is tailings engineering becoming a career path and all mining companies will have to look at this very seriously. This is not something only for the consultants but something that will have to happen within the companies themselves. ”



KNOWLEDGE INTEGRATION AND COMMUNICATION FOR LEADING PRACTICE TAILINGS MANAGEMENT

Claire Cote

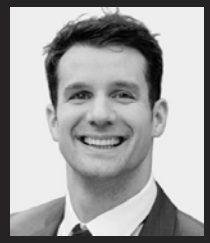
Associate Professor, The University of Queensland, Sustainable Minerals Institute

“Digital transformation is a great facilitator of knowledge integration and a lot of really exciting work is happening now. The world has changed a lot in the last ten to 15 years and in the environmental discipline in particular we have seen a lot of changes. I do think that tailings management is an area that needed a lot of work and needed to have better tools to help integrate that knowledge. As a researcher in this space I can see a lot of benefit in starting to implement this technology.”

CONNECTION WITH **STAKEHOLDERS**

5 WAYS CONNECTING WITH STAKEHOLDERS IS CRITICAL FOR CIVIL ENGINEERING PROJECTS

Peter Fair
Mott MacDonald



Tom Critchfield
Mott MacDonald

Complex projects involve many stakeholders who all need timely, accurate information to make project decisions and manage risk. Peter Fair and Tom Critchfield of Mott MacDonald have shared some insights about working on major infrastructure projects in the UK and Singapore.

1

Reducing risk and cost

Slow communication of geotechnical risk accounts for a large percentage of project delays, costing projects millions. Research from the National Audit Office in the UK has shown that delays of over a month on commercial projects are caused by ground risk at least 50% of the time.

2

Clear decisions trails

When a geological model supports integration with design, the resulting visual composite enables experts to identify data gaps and rapidly assess new project risks. On the North-South Corridor project in Singapore, Tom Critchfield notes that this visual integration was critical to helping the client understand the complexity and scope of the project and how the geology impacted design decisions.

3

Optimised designs

Well-communicated, accessible geological data helps design teams assess feasibility and optimise engineering decisions, potentially saving millions in construction costs. At a particularly difficult part of the HS2 high speed rail project in the UK, the geological data revealed some tricky areas around water levels and local abstraction wells. Peter Fair explained that early designs included complex deep cuttings to avoid these constraints, but as new geological data became available, the design engineers were able to develop a simpler solution at lower cost.

4

Getting the whole asset picture

Connected data supports better practices across the whole asset construction lifecycle, from initial geological models to the as-built result. On the HS2 project, Peter plans to incorporate data about extracted earthworks volumes, include photos of faults, add construction records such as testing and as-built information, and make all this available in the one model to the teams who will look after the asset in future.

5

Communication of change

Geological ground models keep changing as new data is collected and added. During the project construction phase, the validity of the data is continuously tested against reality. On a complex project like the Singapore corridor, which tunnels under residential and commercial buildings, ground monitoring of excavations is especially critical and enables experts like Tom to holistically assess the ground conditions and update the model accordingly. Where the reality differs from the expected conditions, Tom can communicate immediately to stakeholders, such as the geotechnical designers.

CONNECTION WITH **INDUSTRIES**

BRINGING GEOTHERMAL EXPERTISE TOGETHER

Technology supports our ability to connect across many disciplines. For those working in geothermal energy, the connection of expertise is critical to being able to advance and expand the industry. Hear what our Energy Lyceum panelists said:

For Ken Reidel of Star Energy in Indonesia this means allowing "multidisciplinary teams to look at the same information at the same time when they are making asset management decisions." He goes on to say this is not about combining data into one grand unified model, but allowing all users to have one window into all the properties the models have in common, where the workflow is more collaborative and less linear and iterative.

Better connection is realised when we share more datasets and interpretations across disciplines and sites. Other panelist Lara Owens spoke about stepping back from using only perfect physical models that are mathematically sound and connected to physics, and adding empirical models that also focus on processes and results, to enrich our thinking and interpretations.

Rosalind Archer, Director of the Geothermal Institute at the University of Auckland thinks we will see more machine learning used in how we view and interpret geothermal data. She goes on to acknowledge that "machine learning doesn't necessarily have the answer" but it can introduce new avenues of enquiry. For example, "If you put the machine interpretation in front of a human, it can prompt new and different thinking."

Jeff Caranto of the Energy Development Corporation in the Philippines takes a wider view, and feels that community knowledge, environmental and conservation data has to be included in the conceptual models as part of the project development. He goes on to say that as a model gets more complex with the addition of physical data, the "non-physical information gives important meaning and context" and that adding outside expertise will result in better project outcomes.

There are many ways geothermal experts are coming together to solve challenges across the industry. Technology plays a critical role by increasing our capacity to create and share data, but our ability to change thinking and innovate through connections is what underpins it all.

Marit Brommer, Executive Director of the International Geothermal Association and Katherine Young, Geothermal Program Manager at the US Renewable Energy Laboratory spoke with Clare Baxter of Seequent about their involvement with Women in Geothermal (WING) and about the future of the geothermal industry.

MARIT BROMMER

"The real value of geothermal is going to be in the energy transition space. It's going to take the integration of all renewable technologies working together to build smart cities and sustainable buildings, to reduce our carbon footprint and meet the terms of commitments like the green deal in Europe."

"You can do so much more beyond electricity. There are great baseload power suppliers, but there is opportunity to use the non-used part of the heat, for greenhouses, health and wellbeing, etc. And this entrepreneurial thinking and the development of associated technologies is just getting started and it's very exciting."

KATHERINE YOUNG

"Geothermal is a resource with a small visible footprint and this means we aren't like wind or solar where you can see the panels on your neighbour's roof or see the giant turbine. This low visibility is great in terms of our environmental profile, but not great for our commercial profile. We have to work together to show we are part of future energy solutions and use conversations about renewables to really promote geothermal potential."

"The Department of Energy in the US at sites like FORGE, are working on ways to have geothermal anywhere. Not just for large power supplies but for direct use for heating and agriculture and community farming, making it local and available. It's an exciting time to be part of the energy sector where we are making a transition from traditional energy sources to new ways of thinking about geothermal anywhere."

CONNECTION WITH **PARTNERS**

INTO THE FUTURE

At our recent Lyceum 2020 virtual conference, we were fortunate to have a number of our partners talk about the industry questions and challenges that most interest them and how data and connectivity will address these issues in coming years.

Here's some of the most intriguing points they made, and you can watch all the sessions here:

Seequent.com/Lyceum

"WE ARE IN A NEW ERA OF GEOTECHNICAL COLLABORATION..."

ROGER CHANDLER

Product Director Geotechnical Information Management at Bentley Systems.

...and Cloud computing has the power to change the way we do that. Most people look at Cloud computing as your memory, but when it becomes your brains and your memory, all sorts of cool things can happen. We can supply a single source of knowledge for your organisation and we can build up platforms that you can develop on, that other commercial applications can be connected into, that will give you a really powerful ecosystem to work with your data and work within your teams.

For example, in practice we have the option now to do real time monitoring and modelling as the driller or engineer is still on site. That means you don't have to wait for the engineer to get back, type his logs up for two weeks, and then produce your model. You've effectively got real time integration of site collected data into your Cloud environment, available to everybody.

And lots of people are already using this connected data environment. The latest statistics from our OpenGround Cloud platform show we have two and half thousand users, with over three quarters of a million boreholes logged and 25million feet of data.

“BY 2050 THERE WILL BE 10 BILLION PEOPLE ON THE PLANET...”

ERIC DESROCHE

Senior Strategy Manager Infrastructure, Autodesk.

...and 7 billion of them will be living in cities so we will need to make those cities smarter and more responsive to the needs of their residents.

Recently, Autodesk partnered with a firm called Statista to calculate how much work will be involved.

We’re going to have to build 13,000 buildings a day and enough roads and rail to wrap around the earth six times every year. That’s over 1.2million km of roads and rail needed for our global infrastructure each and every year between now and 2050. That’s just on the surface. Below the ground there’s also the need to build 2,600 km of utilities every day.

Demand for daily construction productivity requires immense spending and we come up short by 1 trillion dollars annually, but we can work smarter by implementing a BIM process.

So, how does technology play a role in this? Technology allows architects, engineers, and constructors to design and build better and smarter things. It is evolving the process of making so that the very act of designing and building is beginning to look a lot like the manufacturing industry.

In the future, work for our industry is going to be much more simulated. Humans are going to review designs and practise assembling construction projects in a virtual environment before stepping onto a job site.

We are also going to use computers to automate tedious and repetitive tasks. Software will explore design options for us, and we will select the options that best fit our criteria and human needs.

All of these changes, simulation, virtual reality, generative design and more, will help automate work in our industry and make us more productive and overcome the challenge of workforce scarcity.

“SHOULD EVERYONE BE ABLE TO DO A GEOSTATISTICAL MODEL...”

ALEXANDRE BOUCHER

Founder, Advanced Resources and Risk Technology, LLC

...or should that be left to the experts? In a perfect world, the only requirements for building a model should be to understand the geology. Unfortunately, that’s not the case today. I think we are expecting too much geostatistical knowledge from the users. When properly assisted by technology, users should not have to understand the nuts and bolts of our algorithms. The focus should be on when to use it and how to understand the results. We spend too many hours and even days manually fidgeting with parameters and results. Instead, we should spend that time critically assessing the output and thinking about the problem.

I choose to be a geostatistician. I love the mixture of mathematics, computers and earth science, but I also know that I am the exception and for geologists and engineers this is just a step towards a goal.”

“OUR SIMPLE GOAL IS A SINGLE SOURCE OF TRUTH...”

EMILY MULFORD

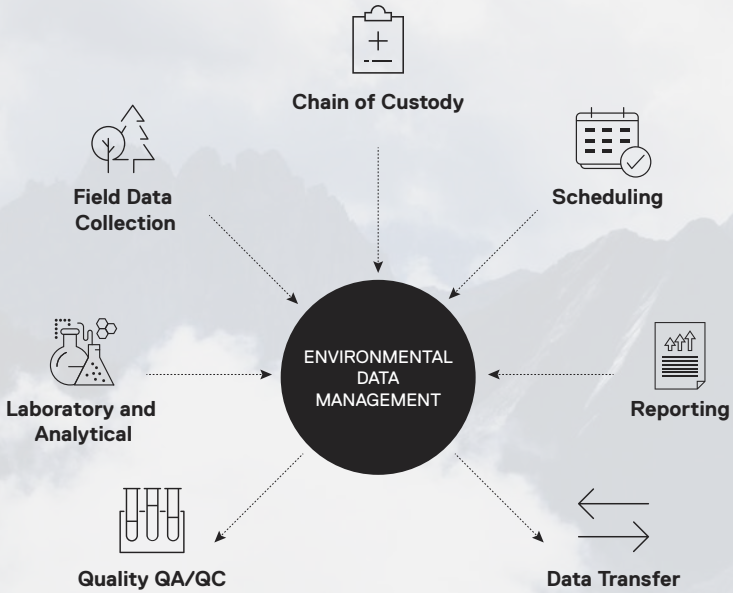
Director of Training and Marketing Communications, EarthSoft

...putting as much of our data as possible into one place. An Environmental Data Management System (EDMS) like EQuIS™ enables the management of many different types of data – environmental data, compliance data, operations and inspections data, and that list keeps growing.

But not only does data management have to deal with data types, it also deals with workflow.

There are many ways to get data into EDMS and we automate and digitalise all the workflows with EQuIS™ to minimise both human error and the time spent. The interesting thing here is that while some of these workflows have been automated and digitised for a long time – like reporting and data transfer - field data collection and chains of custody are two areas where we are seeing digitalisation transform that part of the workflow. Even within the last few years there have been significant drives to collect and even check the data for errors on a device in the field rather than using pen and paper and having to transcribe things back in the office.

And the ability to add electronic chains of custody into that workflow helps move us on from using only paper for that last remaining piece.



Data Management includes many workflows...
EQuIS™ automates them

CONNECTED BY: **NEURONS**

The typical human brain has 200 billion connected neurons. We think. The number is so vast that for years it was impossible to make an accurate estimate. In 2010, researchers at the Stanford University School of Medicine applied a state-of-the-art imaging system to brain-tissue samples and for the first time were able to rapidly and accurately locate and count the connections between nerve cells. Their conclusion was that our brains possess hundreds of trillions of synapses relaying the electrical impulses from one neuron to another. (Synapses secrete chemicals to cross the gap from one neuron to another, triggering electrical activity in the next in the line, and thus continuing the nervous signal.) There are 125 trillion synapses in the cerebral cortex alone. At the time of the study, the associated paper published in Neuron likened that to the number of stars in 1500 Milky Ways. Minute though neurons are, if you connected our body's supply of them in a straight line they would stretch for 1,000km. They pass signals at 250mph, and while we are developing in our mother's womb, we can grow them at the rate of 250,000 a minute.

CONNECTION WITH **TECHNOLOGY**

MAPPING THE GROUNDWATER SYSTEMS OF CALIFORNIA WITH AIRBORNE GEOPHYSICS

ROSEMARY KNIGHT

Department of Geophysics, Stanford University

"Groundwater makes up 97% of all liquid freshwater on the planet. It's essential both for people and healthy ecosystems and essential too that we figure out ways to measure, monitor and manage its quantity and quality.

"How do we get the information we need about these systems? One way is by drilling wells, but that only gives us information at the location of the wells themselves. We don't know what's happening between them or below them.

"So I have spent a lot of time thinking about how to use geophysical imaging to probe our groundwater systems, and for a number of years I've been using AEM – the Airborne Electromagnetic Method.

"What we're really mapping out is the electrical resistivity of the subsurface. What we want to do with that model is recover the information about what's truly down there and map out the spatial variations in the geological materials that are holding our groundwater.

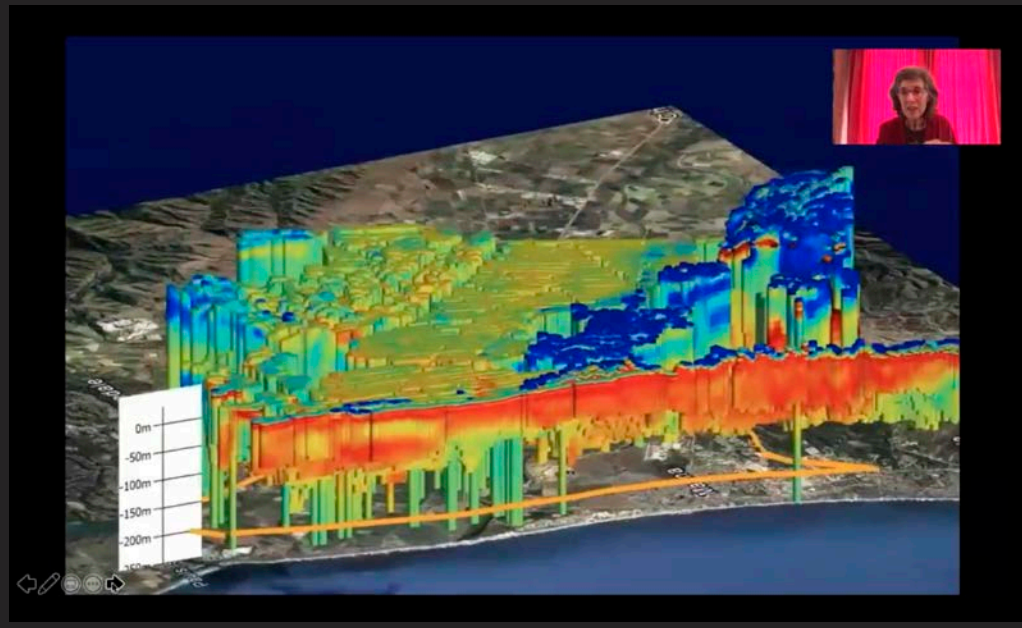
"We can also use the AEM to look at water quality issues, by mapping out salinity, because the electrical resistivity we're measuring is sensitive to that.

Mapping the threat of saltwater intrusion

"The study I'm going to describe is where we were looking at saltwater intrusion along the Monterey Coast. This is an area of California where extensive agriculture is heavily dependent on the pumping of groundwater, but when you're doing that right next to the Pacific Ocean, it draws seawater into the aquifers.

"This is not just a problem for California. Half the world's population lives within 60km of the coast and there is similar saltwater intrusion all over the world as these coastal aquifers are pumped to the extent that ocean water is drawn in.

"It's a problem for the ecosystem too. Some of the richest ecosystems on the planet are found within a kilometre



Red shows saltwater which has low resistivity, and blue indicates freshwater with higher resistivity.

of the coast, and the moment we have saltwater intrusion we are not only disturbing the human water supply, but the nutrient supply to these coastal ecosystems as well.

"For the groundwater managers trying to grapple with this problem, what they need to know is where is this saltwater/freshwater interface? We use AEM to answer that question because the existing well data just doesn't provide the spatial density really needed to understand what's happening here.

"What we arrived at was an absolutely phenomenal data set that shows saltwater all along the coast then moving inland in definitely a more complicated situation than you could ever resolve just by drilling wells. With this density of data you can start to see what's happening and what's controlling the saltwater intrusion. When the water managers in the area saw this they were absolutely amazed, it's a classic image of a saltwater intrusion wedge.

"We can also use AEM to explore groundwater quantity, not by detecting it directly but by mapping out the sediment types in the sub surface – where we have sands and gravels that hold and move large volumes of water, or clays that hold water but act as impediments to the flow so you can't pump the water out. So mapping what's down there in terms of the composition is an essential part of managing groundwater.

Knowing where to pump to avoid subsidence

"Another project was in the Central Valley of California - an agricultural area, but in terms of climate very close to a desert. Groundwater is being extensively pumped to support irrigation and we pulled together many varied data sets, all of which are part of understanding the delicate balance of groundwater quantity.

"Even though there is rain in the valley itself, it's the snowpack that accumulates over the winter that then melts in the spring and moves down into the valley that is really essential for supporting irrigation.

"The amount of water stored is quite variable between the southern part of the valley and the northern part. There's definitely more water in the north, and that means extensive pumping of groundwater in the south, which results in

subsidence. Parts of the ground have sunk 1.3 metres over 4 years.

“So we went in with our AEM to help groundwater managers understand what was controlling the quantity of groundwater, where it is in this area, and what can be done strategically about how and where to pump.

“By showing where there is a lot of clay rich material we could help groundwater managers think strategically about where to pump and how much to pump, because if you are extracting a lot of groundwater and there’s a lot of clays present, it’s the compaction of these clays that causes subsidence.

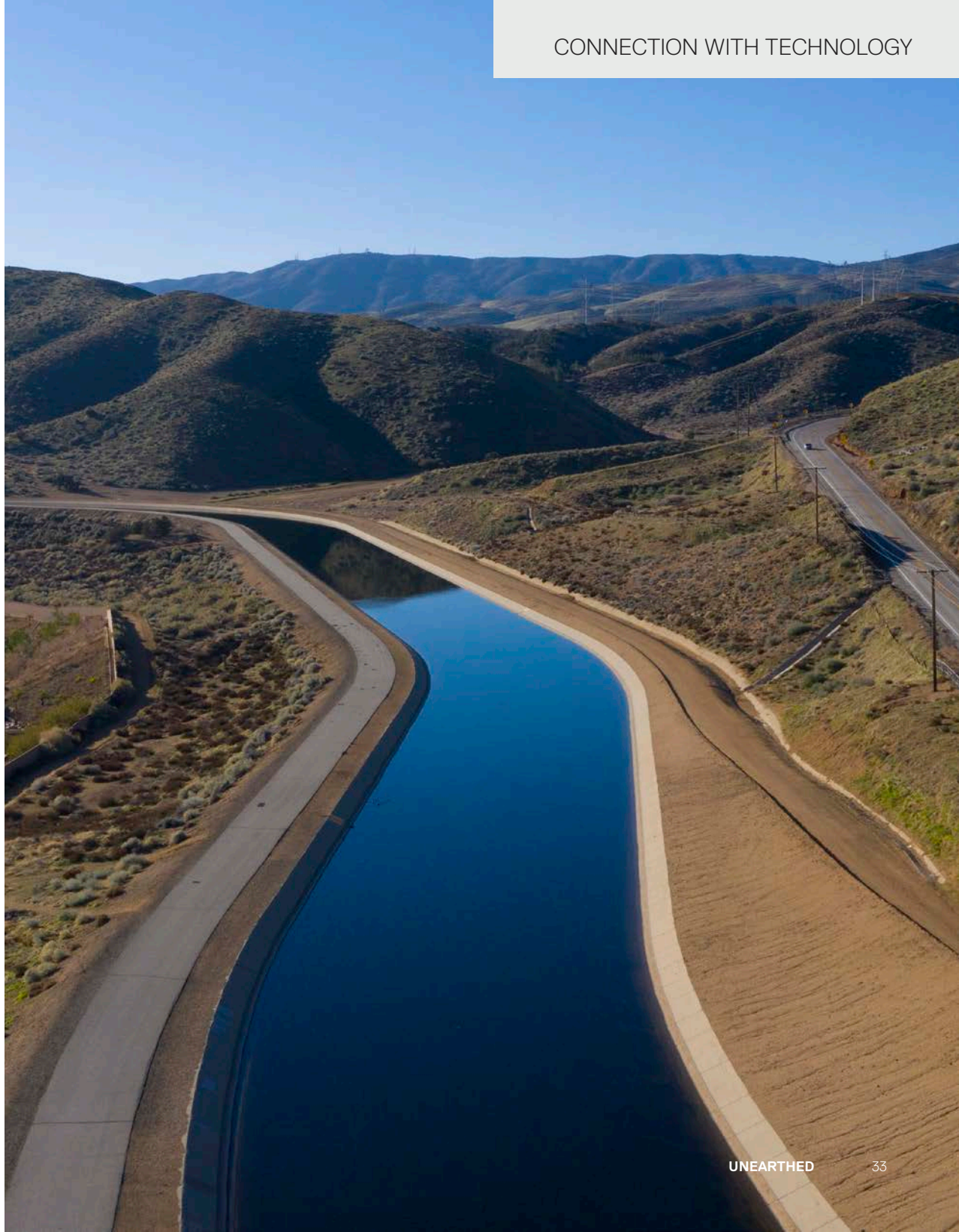
“It also enabled us to think strategically about opportunities to get water back into the subsurface, and we’re going to do some more work to understand how recharge from the Sierra Foothills is getting into the Central Valley.

A responsibility to manage groundwater sustainably

“Since 2014 and the Sustainable Groundwater Management Act, all groundwater in California has to be sustainably managed. Groundwater management plans are due in 2020 and 2022, so there is an urgent need for water agencies to figure out what is happening below the surface in terms of groundwater quality and quantity.

“The CA Department of Water Resources has committed $12million to conducting AEM surveys in the groundwater basins of California, but this is not just a California problem. Groundwater resources around the world are being challenged by climate change and population growth, and I believe those of us who have the knowledge to address these global problems should be doing so. It’s a responsibility to do what we can, and geophysics has an important role to play.”

Watch the full Lyceum 2020 presentation:
Seequent.com/Lyceum



WHY NOT DO IT BY DRONE?

For Rosemary Knight's projects, helicopters were employed for the airborne element of AEM. But increasingly drones are being used to map geology. They can match a number of the advantages helicopters offer over ground surveys – like access and density of data gathering – and come with notable cost savings. As self-titled 'GeoDRONEologist' Ronald Bell of International Geophysical Services notes: "I realised that what I was doing out in the field had been done the same way 50 years before and things hadn't advanced that much. I began to see there were a lot of things in terms of a mag service I could do better with a drone, and less costly than on the ground."

Typical use

I've done several projects where we've used drones to locate abandoned wells and legacy wells for the oil and gas industry, and many of those were in areas such as wetlands where it would have been difficult to locate them otherwise. In Colorado, we had a project where we had an idea where the wells were from public domain information but not enough to pinpoint them exactly. We went out and in four hours we found four wells that would have taken us two days to locate on the ground.

”

BENEFITS OF DRONE USE

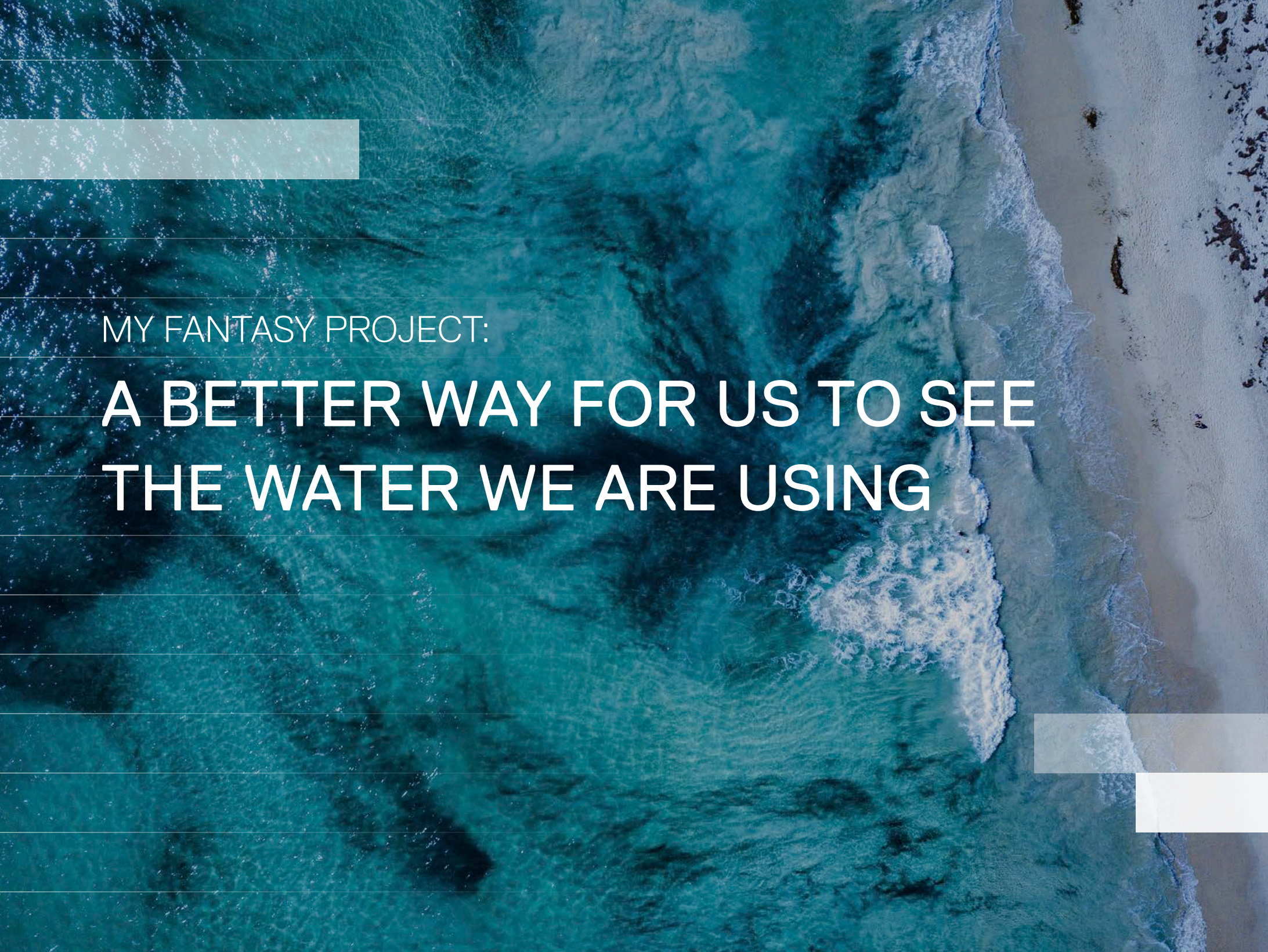
+ Obtains a bird's eye view	+ Enhanced signal strength as they fly closer to the surface	+ Enables temporal change detection. Projects can be flown a week or a month later and repeated one-for-one in scope so if something is missed on the first survey it can be caught on the second or third.
+ Can manage multiple data types including photogrammetry and magnetometry	+ Cheaper than a helicopter or putting a person on the ground	
+ Easier to access difficult areas such as wetlands and difficult terrains	+ Less risky for field staff	+ Near real time results
+ Improved spatial density	+ Reduced danger of property damage	

DISADVANTAGES

- Drones struggle with bad weather and vertical structures (They're no friend of trees...)	- Flights are short duration and payloads small (typically less than 5kg)	- Regulations can often place a limit on maximum flight altitude, forbid use near people, require a certified unmanned aircraft pilot, and allow daytime operations only.

EMERGING TECHNOLOGY

! Ability to fly at a constant altitude above ground level	! Correcting for roll, pitch, and yaw motion noise	! Multiple sensors/data for one mission
! Real time correction for sensor altitude noise	! Inclusion of sense and avoid technology (eg forestry and inside buildings)	! BVLOS... Beyond Visual Line of Sight



MY FANTASY PROJECT:

A BETTER WAY FOR US TO SEE THE WATER WE ARE USING

Julia Oliveira
Senior Technical Leader

Convincing the public to use less water will be vital to avoiding water shortages in the future, but are facts, figures and meter readings really the best way of communicating that to them? Could a more graphic approach inspire a greater global responsibility around the water we use?

Why this idea fascinates me

Water is a big problem in Chile where I live, but where I grew up in Brazil, I never had to think about it. We had rains across the year. They relieved the heat at the end of the day in the summer and there was a short dry season in the winter, but everything was balanced. Arriving in Chile, I had to learn to live without that rain and saw all the problems of desertification of the land. There are many reasons behind that, but I think the biggest is that people are not educated or informed about how they should use water. It's not easy enough for them to understand how scarce water truly is and what their usage of it means.

So what inspires me is the idea of transparent information about water status for the public and how that can influence and improve our reuse of water. If you know and value the water you use – and technology makes it really use for you to understand – I believe we will all be more prepared to save it, reuse it, and share knowledge with others.

How could it work

With sensors we can measure the change of water levels in rivers, lakes, underground, and pluviometry levels every day. All this data in numbers has meaning for only a few of us specialists, but as a powerful geological and hydrogeological model, open on the Internet, it can speak more than 1000 words. Such clear and striking graphics would help the public understand different challenges related to water.

Such models can be updated, showing the changes during a year, different seasons, where this water is coming from, and how much water we have for usage.

Every day the average person in North America uses 88 gallons (333 Litres) of water. Imagine being able to measure that using IoT, then showing it as a graphic that would generate more transparency around when we need to save water. Or, how waste water – 1.6 gallons (6 Litres) in flushing a toilet, 8 Gallons (30 Litres) for a four-minute shower – could be reused for growing forests, landscaping, irrigation of agriculture crops, and even to recharge aquifers.

What does it offer?

I believe that such a project to drive water transparency would benefit everyone, from a single person to mining, big or small industries, and agriculture. True clarity on how much natural water we have in one year would reinforce a sense that water is limited, and it's important to think and care about.

The knowledge that when I switch on my shower, the water level is going down, or that this year we had no rain can be communicated much more powerfully through images than numbers. And it's a solution not just for arid areas but for all environments.

The role played by connectivity

Connectivity is the key to improving communication around water. We need comparison and tracking of different scenarios to understand the changes and what should we do.

Having 3D models of geology and hydrogeology, being able to track with IoT and sensors the usage of water and transforming that into data that can be visualized and understood by every member of the public could transform how we feel about our water and the personal responsibility we take for it.

To plan a sustainable future, it´s necessary to understand the yesterday and the today. Tracking the data in a platform that can share the knowledge in a comprehensive way will help to avoid different challenges in the future and make better decisions about water scarcity and water quality.

CONNECTED BY: **SATELLITE**

Telstar 19V is the most massive communications satellite ever commissioned, weighing 7,076kg and created to boost connections and serve growing markets in the North Atlantic, Canada, Caribbean, and South America. It was launched from Cape Canaveral in July 2018, atop a Falcon 9 rocket, and sits in a 35,800km high, geostationary orbit providing Ka-band (26.5-40GHz) and Ku-band (12-18GHz – typically used for satellite TV) coverage. Its two solar arrays should keep it running for around 15 years.

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Our virtual Lyceum 2020 conference brought together thousands of professionals across mining, civil, environmental, and energy industries to help shape the future of geoscience technology.

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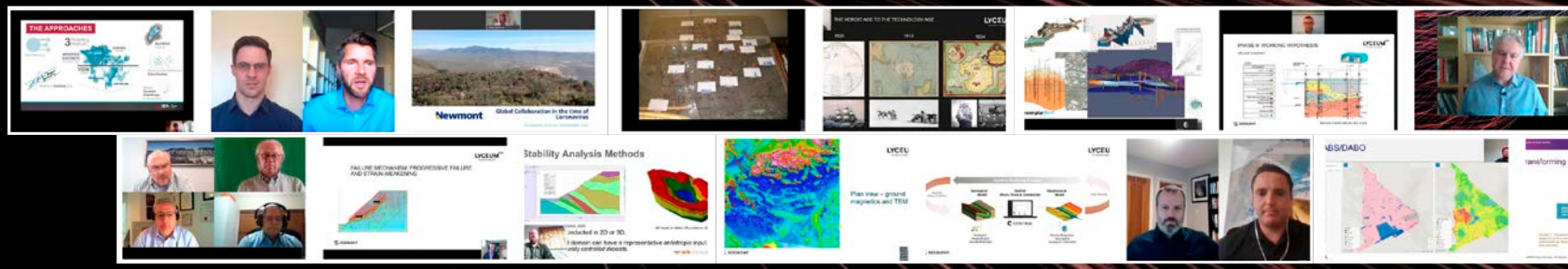
Managing Director, Microsoft's
Worldwide Energy Industry Practice



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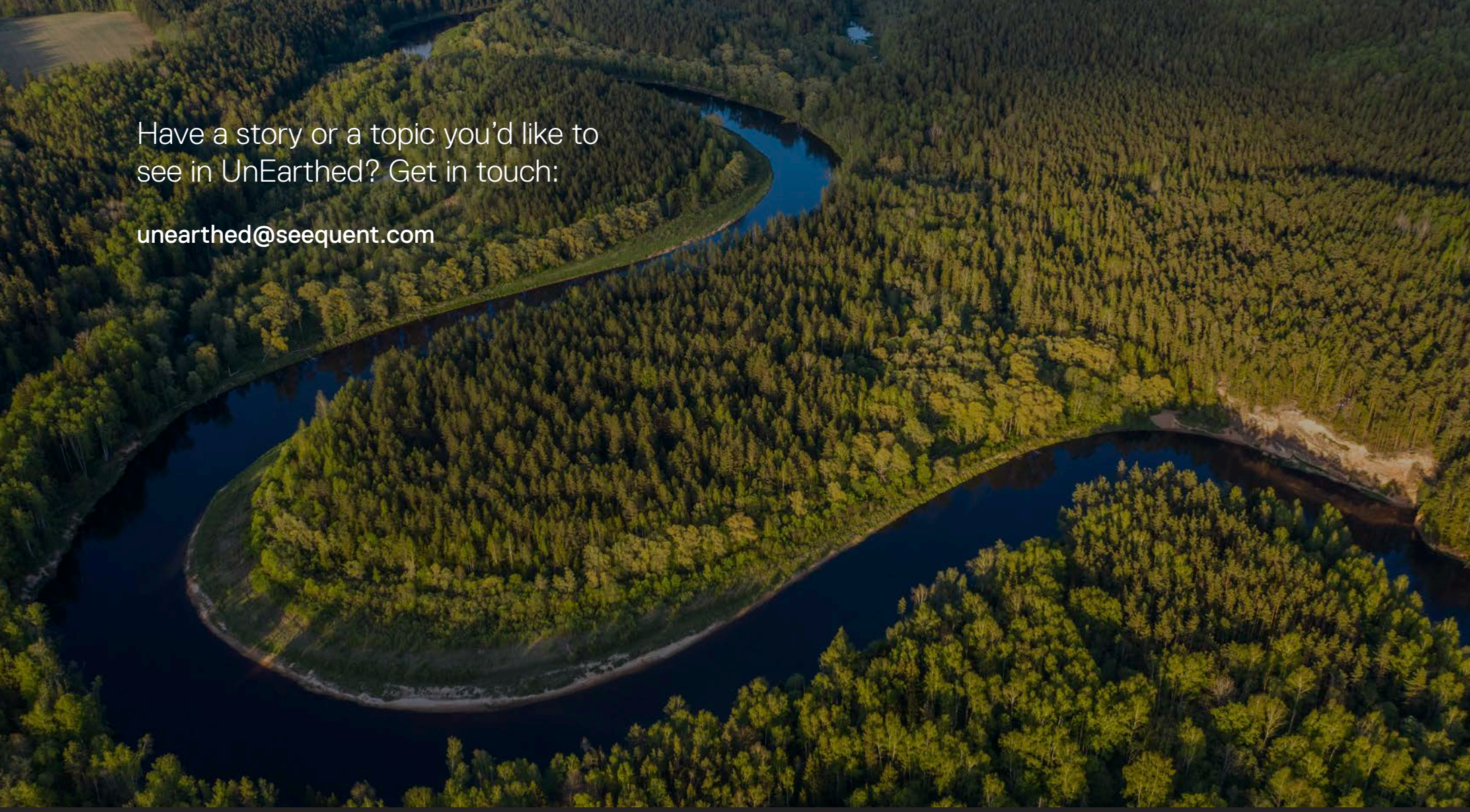

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unearthed@seequent.com

FROM COMPLEXITY TO CLARITY

Seequent software empowers geo-professionals, decision-makers, and communities to uncover solutions that benefit people and the planet.

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