

# NEW ZEALAND SUPPORTING CAPABILITY FOR GEOTHERMAL DRILLING IN EAST AFRICA

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## ABSTRACT

A niche area where New Zealand expertise excels is developing and delivering successful drilling programs both for exploration and exploitation. This expertise has been sought after in many countries around the world, including east Africa, where commitment to geothermal development goes back to the late 1970s.

This current project “East Africa Drilling Support” is provided by the African Geothermal Facility (AGF) which is a partnership programme between the Ministry of Foreign Affairs and Trade (MFAT) and the Africa Union (AU). The goal of this project is building human and institutional capacity focused on technical knowledge and good decision making, not just delivering technical or commercial knowledge to the projects. This is not only critical for the sustained successful execution of the Aluto geothermal project and for the planning of future drilling in Djibouti and Tanzania, but also long-term sustainability and effectiveness of the Partner organisations.

The key short-term outcome for this project are for the Partners and their drilling teams, to grow in confidence to manage drilling programs and display an increased understanding and competence in project management. An essential component has been the engagement from the wider teams within the Partner organisations, in particular the inputs and data from the various geoscience disciplines on which the drilling exploration programmes are built. The aim being to look critically at their concept models, consider alternatives and range of outcomes and thus optimising exploration drilling success. This is in conjunction with specific drilling activities such as well design, drilling risk, drilling contracts and drilling management to name a few.

The long-term outcome is successful implementation of the Partner’s respective geothermal projects and thus new low-carbon electricity generation in their countries. The technical support and capacity development within this project is intended to help them on this journey of self-reliance but also continue to cement the ongoing relationship and value New Zealand has had in the region for 50 years.

## 1. INTRODUCTION

The story of New Zealand’s energy industry would be incomplete without considering the reach it has globally, particularly in the geothermal sector. New Zealand has had a significant impact in developing the global geothermal industry. The direct reduction of carbon emissions by international geothermal projects we have enabled is equal in magnitude to all of New Zealand’s net carbon dioxide emissions (about 12 MT/year). East Africa is one of the key regions that our industry has been supporting for 50 years and a good example of how our export technology has been applied.

The African Geothermal Facility (AGF) is a partnership programme between the Ministry of Foreign Affairs and Trade (MFAT) and the Africa Union (AU). The AGF was established in late 2017 and provides technical assistance, advice, professional development and, more importantly, capacity building to support geothermal sector development across 11 eligible east African counties, with the aim of making small targeted interventions to help facilitate, unlock and catalyse geothermal development where it can.

The AGF identifies areas of technical assistance required through consultation with partners in the region and the New Zealand geothermal industry. The programme manager is based in Addis Ababa, Ethiopia and works closely with the African Union (AU) and other donors to prioritise work that can accelerate or unblock delays to progress geothermal exploration and development.

A range of support projects are in delivery, under the AGF. This paper explores a current project being delivered by Jacobs, in collaboration with Contact Energy that provides technical support and capacity building to drilling programmes in Ethiopia, Djibouti and Tanzania.

## 2. THE LAST 50 YEARS IN EAST AFRICA

While still crafting the early skills for exploration, drilling and development of geothermal, the New Zealand geothermal pioneers began supporting development assistance projects in Asia, Latin America and Africa. The New Zealand geothermal systems were “wet” compared to the dry steam producing systems developed in the early part of the 20th century in the USA and Italy. Our researchers developed the skills for dealing with the steam-water mixtures produced at Wairakei, which proved key to unlocking the global geothermal potential. Private enterprise also saw an opportunity to sell specialist skills developed locally, onto an international stage, and use the core specialist technology as a vehicle to sell other services such as construction, engineering, and capacity development. This early work evolved into a mix of government-supported and private sector activity from New Zealand in a growing international geothermal industry.

By the 1970s, New Zealand had become a global leader in geothermal technology. The United Nations Development Program (UNDP) looked to our government agencies (Ministry of Works and DSIR) for technical leadership with its geothermal exploration and drilling campaigns in Chile and Kenya. Ministry of Works drilling engineer, Neville Dench, was assigned to Kenya in the early 1970s to lead the fledgling geothermal drilling programme at Olkaria. This was to be the beginnings of a 50-year involvement by New Zealand in geothermal development at Olkaria and in the East Africa region.

While British and Icelandic consultants engineered the first Olkaria I, 45 MW, power plant using wells drilled by Neville Dench's team, New Zealand company GENZL delivered successive contracts for ongoing drilling and steam field design in the 1980s. GENZL, which was established by McConnel Dowell, Ceramco, Worley Consultants and Tonkin and Taylor as a vehicle for exporting New Zealand skills, managed the drilling for much of the Olkaria II plant and designed and managed the construction of extensive piping for connecting additional wells to Olkaria I. They also had the overall management and technical design and supervision contract for exploration drilling of the new Eburru project near Olkaria from 1988 to 1991. They later helped private developer Ormat with its first 48 MW development at Olkaria.

New Zealand consultant SKM (now Jacobs) won the owner's engineer role (including total steam field design) for building the Olkaria II power plant in 2 stages (76 MW and 38 MW) during the 1990s through to 2010 and had a similar role (including transmission line) for the Olkaria IAU and Olkaria IV plants (2 x 140 MW) commissioned in 2014 and 2015. MTL, based in Auckland and other New Zealand engineering providers, are currently finalising designs for an additional steam field, feeding a further 70 + 165 MW of new generating plant in Olkaria.

These decades of work have seen Olkaria develop into one of the three most significant geothermal developments in the world, with over 700 MW installed by Kengen, the state-owned developer/operator, and 140 MW by Ormat, a private power developer. Olkaria is now meeting about 45% of Kenya's power demand for the 35 million people connected to the electricity grid. At the same time, we have seen that geothermal has been displacing fossil fuels in the country, which has limited further hydro potential and only a few wind power sites to meet the growing demand for clean power. While awaiting the major construction phase at Olkaria, several heavy fuel oil power plants were constructed, and some of these have now been dismantled.

There was a similar beginning for geothermal exploration in Ethiopia, with several prospect areas being identified in the Rift Valley and explored by UNDP teams in the 1970s. The Aluto project was selected for drilling that began in 1980, with GENZL managing the drilling and well testing. GENZL went on to be owner's engineer for the 7.3 MW power plant that was eventually completed in 1998.

Alongside this direct technical engagement, capacity development, primarily from Auckland University's Geothermal Institute, has contributed to the ongoing development and self-sufficiency of the geothermal industry in the region. Ninety-six students from the region, comprising about 15% of the total cohort over the first 25 years of the Institute's operation, came from the region for the year-long geothermal diploma course. The relationships and trust developed by students with the New Zealand industry played an essential role in enabling the more resounding support that the New Zealand industry could provide.

An example of broader and diverse engagement growing from this trust was a recent exchange with Kenya regarding community involvement in geothermal projects. Contact Energy (as a developer) and the Tauhara North No2 Trust (as kaitiaki of geothermal resource) made several visits to Kenya and hosted Kenyan's to New Zealand to share our learnings on community engagement and involvement in geothermal projects. This seems to have helped ease some land issues at Olkaria. Such approaches have the potential to be enabling for many projects we see globally.

Just prior to the AGF being established, the New Zealand aid programme was supporting detailed surface exploration of geothermal resources on the Comoros Island in association with Jacobs and supported by GNS. This included support preparing GRMF applications for the surface studies and exploration drilling, detailed 3G surveys, infrastructure assessment, comparative renewable energy study and assisting local experts for ESIA. The Comoros geothermal project is currently seeking further funding for exploration drilling

### **3. TECHNICAL SUPPORT AND CAPACITY BUILDING FOR DRILLING ACTIVITIES**

The objective of this project – East Africa Drilling Support – is to strengthen the Project Partners' organisational and human capacity to successfully undertake the resumption of geothermal development drilling in Ethiopia; and the resumption of exploration drilling in Djibouti, and the support of exploration drilling in Tanzania.

The Partners and their drilling projects are:

- Office Djiboutien de Développement d'Énergie Géothermique (ODDEG) – Gale-le-Koma, Djibouti
- Tanzania Geothermal Development Company, (TGDC) - Kiejo Mbaka, Tanzania
- Ethiopian Electricity Power (EEP) – Aluto, Ethiopia

A summary of the three partners and their drilling projects follows.

#### **3.1 Djibouti**

The Government of Djibouti has expressed a desire to generate 250 MWe of geothermal power in the next 10 years. (Kayad Moussa et al., 2018). The Office Djiboutien de Développement d'Énergie Géothermique (ODDEG) was formed in 2014 to fast-track

geothermal development, but there is a need for clarity and alignment around the roles and responsibilities within the geothermal development framework.

Djibouti has been pursuing an exploration program in the Fialé caldera in the Lake Assal region. The Fiale project is managed by a project management unit under the authority of Electricity of Djibouti (EDD). It is financed by the World Bank, the African Bank for Development, OPIC, French Agency for Development, GEF and ESMAF. Exploration drilling commenced in mid-2018 and was planned to assess the geothermal capacity of the site with four directional wells to a vertical depth of 2,500 m. Results have not been fully reported but apparently were less favourable than hoped with high salinity and lower permeability than predicted in a reservoir of fractured volcanic rocks where the water temperature is estimated at 300 °C. The future of this project is uncertain, but it may not be able to support the planned 50 MW of development.

Gale-Le-Koma geothermal project was originally explored in 1987. After a long period of project hiatus, USD60million (with USD27million from Kuwait Development Fund) has been accumulated to finance eight production wells and two reinjection wells for planned 15 MW power plant development. The NZ-AGF support is for the drilling of three wells at this location.

In addition to Asal-Fiale and Gale-Le-Koma projects, ODDEG has also planned to drill for numerous other projects. In 2020, a well drilling program of temperature gradient holes and slim hole drilling for PK20-Ambado was designed, with a number of different areas planned for exploration drilling in the future.

The immediate need for ODDEG is support for the initial preparation for exploration drilling at Gale-Le-Koma, providing training and ongoing guidance in planning the drilling campaign, best international standards and proactive in project management, bidding, contracting, procurement and project financial structuring.

### **3.2 Ethiopia**

The government sector geothermal exploration work to date has been carried out by the Geological Survey of Ethiopia (GSE) and has benefited from a number of technical cooperation programs. The most recent technical assistance and funding are from Icelandic International Development Agency, United Nations Environment, French Development Agency, the World Bank and Japan International Cooperation Agency. Ethiopia Electric Power (EEP) is the sole public developer of energy, including geothermal. In recent years IPP's have also become involved in geothermal exploration and development. (Solomon Kebede 2020).

The government is involved in drilling 4 areas (Aluto, and three areas at Tendaho) and is in the process of appointing drilling contractors and procuring two deep drilling rigs. France's development assistance programme is supporting the drilling at Tendaho. Although GSE has been involved in drilling in the past, and have rigs for shallow drilling, they have limited capacity for servicing major drilling operations.

The private sector is building up to be ready for when the new law and its regulations are in place. The Tulu Moye project, which plans to build a 50 MW plant in the first phase by 2023, is currently drilling its third exploration well (Aug21). In early April 2020, the Corbetti geothermal project has also signed a new Power Purchase Agreement (PPA) and Implementation Agreement (IA) with the Government of Ethiopia (GoE) and Ethiopian Electric Power (EEP).

The Government is considering a major restructuring programme of the public sector (\$1.5 B World Bank support) that will also affect geothermal. EEP may be broken into smaller entities (to compete and have some private ownership), and parts of The Ministry of Water, Irrigation and Energy (MoWIE) and GSE will be merged into one of the "baby EEPs" that is responsible for geothermal (Integrated exploration, development and operation - Energy Development Commission (EDC)). This will require considerable capacity building because there is limited geothermal development and operational capacity within the combined organisation presently.

The new Ethiopian Energy Agency (EEA) has a directorate responsible for geothermal resource licensing, with 33 staff, including 10 technical staff. This agency is responsible for granting and monitoring compliance of geothermal exploration and development licences. Due to the government salary structure, the agency cannot entice talent from EEP or the private sector, so it has to draw on staff from water and minerals regulatory areas. So these staff are new to geothermal and have limited geothermal experience.

New regulations for geothermal have been drafted (based on examples elsewhere), but staff will need assistance and training. A data management system is being considered (support from USAID). There is also an overlay of data management provided from the EAGER program of technical support provided by Britain, finishing in 2019.

EEP has procured two drillings rigs and have contracted Kerui Petroleum and KenGen to operate the rigs to drill the first two wells of an eight well program at the Aluto geothermal project with a planned power plant of 35 MW initially. The goal of EEP is to have a fully formed, self-sufficient drilling and maintenance team within two years. The first well was spudded at Aluto at the end of May 2021.

### **3.3 Tanzania**

The Government of Tanzania formed a dedicated geothermal company called Tanzania Geothermal Development Company Ltd (TGDC). The Government, through TGDC, has already developed a Strategic and Business Plan that will guide the company business decisions, processes and growth for a horizon of 25 years. The country's target is to generate 200 MW from geothermal by the year 2025 (Power System Master Plan 2016 Update), which is supported by TGDC 25 years Strategic Plan (2017). TGDC has made reasonable progress with early surface exploration, assisted by the EAGER programme and its technical advisors. They have

identified four initial projects that will help in achieving the 2025 target (200 MW), namely Ngozi, Songwe, Kiejo-Mbaka and Luhohi. All four prospects are apparently ready for drilling to confirm the resources (Shakiru Kajugus et al., 2020). TGDC plans to buy a slim hole drilling rig that is already in the country. Local capacity building is essential with key areas in developing organisational and institutional capacity in geosciences, engineering, compliance, project management, drilling and direct use (Kato Kabaka 2018).

The resources tend to be lower temperature and structure controlled and many are likely to need geothermal pumping for production. TGDC needs assistance with geothermal drilling, which is an activity new to this country. Funding is uncertain with not much international assistance. Three slim hole wells will be drilled at Ngozi prospect first (not yet started), then three slim hole wells at the Kiejo-Mbaka prospect will be drilled, likely in 2022. The estimated resource temperature at Kiejo-Mbaka is 140°C.

Several initiatives to develop direct use projects have been undertaken, such as conducting regional and specific direct uses surveys. Site specific surveys have been conducted in Ngozi, Songwe Luhohi, Ibadakuli, Kiejo-Mbaka and Kisaki. The identified opportunities encompass agricultural, industrial and recreational uses, including tourism.

Similar to the needs to ODDEG in Djibouti, TGDC is seeking help with building up capacity for managing a drilling campaign, the procurement and operation of a government-owned slim hole drilling rig, and best international practice and standards for drilling.

#### **4. ADAPTING TO A NEW WAY OF DOING THINGS**

The goal of this project is building human and institutional capacity focused on technical knowledge and good decision making, not just delivering technical or commercial knowledge to the projects. This is not only critical for the sustained successful execution of the Aluto geothermal project and for the planning of future drilling in Djibouti and Tanzania, but also long-term sustainability and effectiveness of the partner organisations.

Capacity development is vital – by training, ‘learning by doing’ and mentoring support – and needs to be appropriate for the partners’ needs and chosen development pathways. The desired outcomes in both the short and medium-term will be geothermal professionals within the partner organisations who will have improved skills and knowledge and government entities with improved practices and decision processes relating to geothermal development, particularly in relation to the design and implementation of exploration drilling programs.

However, with the impacts of Covid-19 around the world, and associated travel restrictions, our traditional methods of technical support, capacity development, and ongoing mentoring of counterparts demanded a rethink and different approach. While we know that working alongside the partners can be hugely productive and beneficial, at Jacobs we also have a long record and culture of engaging with clients remotely and providing ‘real-time’ support and advice on active drilling projects. In 2020, the change to global remote working in our industry had been surprisingly rapid and effective. It has been driven by need, but many aspects will be here to stay because they have worked so well. For this project, we have also leveraged the value of using much more interactive technology, videoconferencing and shared digital workspaces for accessing materials.

Utilising our in-house Digital Transformation team, we developed a delivery and content management system that is accessible and adaptable to the partner’s needs but provides a more enduring delivery of this NZ Aid investment that will last beyond the immediate programme. It is intended to also allow much better cross-fertilisation of learning and ideas between the stakeholders, something that we have found is important within all of our MFAT geothermal programmes.

##### **4.1 Online Platform**

We developed an online platform within Microsoft Teams® that we have called DrillDown, which offers a variety of communication methods to offset the loss of direct co-working and allow mentoring to continue longer than was envisaged with just on-site time. There are other advantages in the areas of improved access to training/learning materials, document templates and methodologies for the use of the projects and for greater visibility of all deliverables created throughout the program (while retaining confidentiality for each stakeholder’s program). Adopting this type of approach has allowed us to just “get on” with the job and not waiting for the Covid-19 situation to improve.

Drilldown is intended to be a Learning Centre for all the partners, with the main host being the underlying SharePoint site. The main landing page (Figure 1) guides users towards the training materials best suited for the well delivery process stage they are in. Also, if they are unsure of which stage they are after, there are document libraries that are able to be searched and filtered to display relevant training materials. The Well Delivery Process contains an overview of each stage of the drilling program. Further information can be found by following the links on the Well Delivery Process home page, which will then show presentations, video streams, templates and guidelines for each topic. The Partner’s Survey is currently open and accessible from the main page, so the learning material available in DrillDown will be tailored to match what the participants request. The Short Video Library contains pre-recorded lectures on a variety of topics, including features of a geothermal well, types of geothermal wells, well design, well delivery process, NZ Standards, preparation for drilling, wellhead design, drilling production wells, drilling rigs and health and safety considerations.

Individual Teams sites for each Partner are intended to be used as a delivery and content management system. These sites aim to be engaging for the Partners, allowing them to chat, ask questions and receive feedback from Jacobs and Contact Energy staff, especially as drilling programs kick-off and progress. The file-sharing space is collaborative. Partners can upload documents for review and see where Jacobs or Contact Energy staff have written up feedback and comments to their reports and other documents.

## 5. PROGRESS AND CHALLENGES

This project has been running from the beginning of 2021 and has both been challenging and rewarding. The biggest challenge is relationship building with the Partners of whom we have never met before. In contrast to our ongoing projects in Indonesia and the Caribbean, we have built long-standing, close professional and collegial relationships with Partners founded on many visits to these regions, and often with lengthy stays in-country. However, like many in this new COVID world, we have to adapt and build on the trust that has evolved between NZ and the Partner countries from our many years of involvement in geothermal development in East Africa. Our approach must be collaborative and supportive whilst being flexible and very responsive when the need arises.

Each of the Partners is at different stages of their geothermal programs and have a range of expertise within their organisations. While many within the teams are relatively young and inexperienced, many have had training at geothermal schools around the world and are eager to learn. There are other agencies providing support to these programs (particularly in Ethiopia and Djibouti), so our inputs are targeted in specific areas where there are gaps. The flexible nature of the this particular AGF project is crucial in this respect.

All three Partners have the desire to build strong drilling teams, which includes owning and maintaining their own drilling rigs. Both EEP and ODDEG have purchased rigs and TGDC are in the process of purchasing one. This is a common theme in the region that follows the geothermal development models of KenGen and GDC who own their own rigs. This ownership of rigs is not something Jacobs nor Contact Energy would normally advocate for typical developers, and particularly not for the first wells of a new drilling campaign with inexperienced teams. However, independence and self reliance are important for all the Partners who also feel this is the most cost-effective way to drill wells in the region in the longer term. At this point Jacobs and Contact can advise on good industry practice and standards, trouble-shoot whilst the initial wells are being drilled, and provide support and guidance on drilling contracts, tendering and procurement for future campaigns. We have provided many training materials on these topics and supplemented this with live Q&A sessions with each Partner (Figure 2 as an example). The challenge now is for them to take these learnings and incorporate them into their drilling activities whilst also conveying their expectations to their drilling contractors. We want to empower them to have the confidence and knowledge, as owners of these developments, to make informed decisions and be able to direct their contractors effectively and successfully.

For the Partners who have not yet commenced drilling, it has given us an opportunity to review their conceptual models and drilling objectives and strategies, and subsequent drilling programmes. In most instances, surface exploration work has been carried out by external consultants but the Partners have expressed a need for further understanding of uncertainties in their conceptual models, and if any additional survey work or reinterpretation of data can be carried out prior to finalising their drilling plans. The goal here is to have all disciplines within their geoscience and also drilling teams working together and understanding the validity or gaps within the various inputs to their models.

A challenge that is common across all Partners is variable or poor access to the internet, including poor bandwidth and lack of suitable hardware. So whilst there is an abundance of training materials available unless the personnel are head-office based, they can have issues accessing these materials. Likewise, with live Q&A sessions, cameras are rarely on, and participants often drop out then have to rejoin. There is no immediate fix to this, but we have encouraged all teams to use the chat function on Teams to elicit a quick response from our NZ team and work to ensure that every question is felt to be a valid and important one.

## 6. CONCLUSIONS

The key short-term outcome for this project are for the Partners, and in particular, their drilling teams, to grow in confidence to manage drilling programs and display an increased understanding and competence in project management. What has been essential over the last months is engagement from the wider teams within the partner organisations, in particular the inputs and data from the various geoscience disciplines on which the drilling exploration programmes are built. The aim of this is for them to look critically at their concept models, think about alternatives (eg. best and worst case scenarios), probability of discovery and thus optimising exploration drilling success. This is in conjunction with specific drilling activities such as well design, drilling risk, drilling contracts and drilling management to name a few.

Remote capacity development and learning are challenging, and nothing can beat face-to-face support, however throughout 2021 we have adapted and felt more comfortable with alternate methods of supporting our Partners. This is evident as our interactions grow more frequent and individuals grow confidence to contribute to discussions, ask questions, challenge each other and begin to question previously held assumptions.

The long-term outcome is successful implementation of the Partner's respective geothermal projects and thus new low-carbon electricity generation in their countries. The technical support and capacity development within this project is intended to help them on this journey of self-reliance but also continue to cement the ongoing relationship and value New Zealand has had in the region for 50 years.

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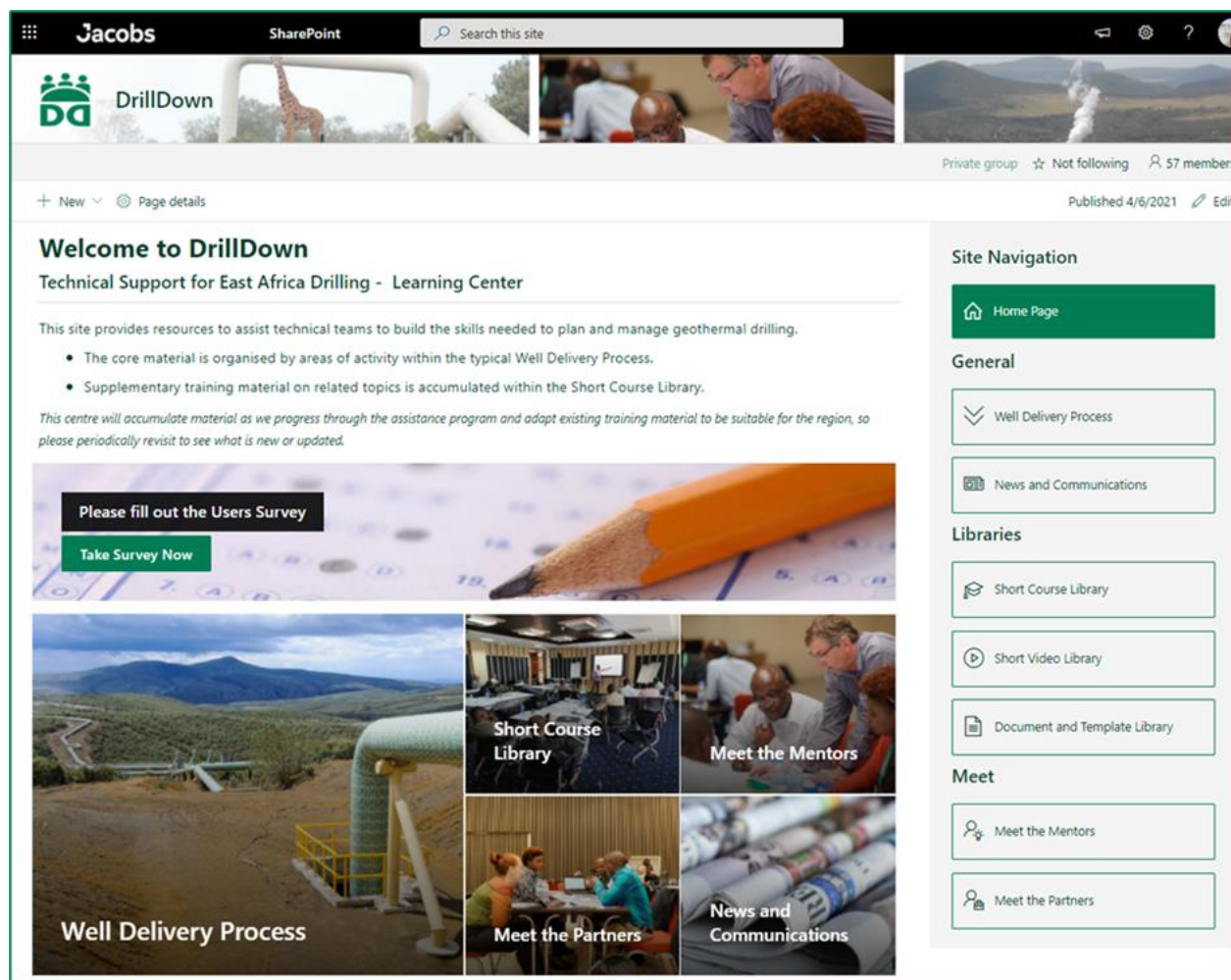
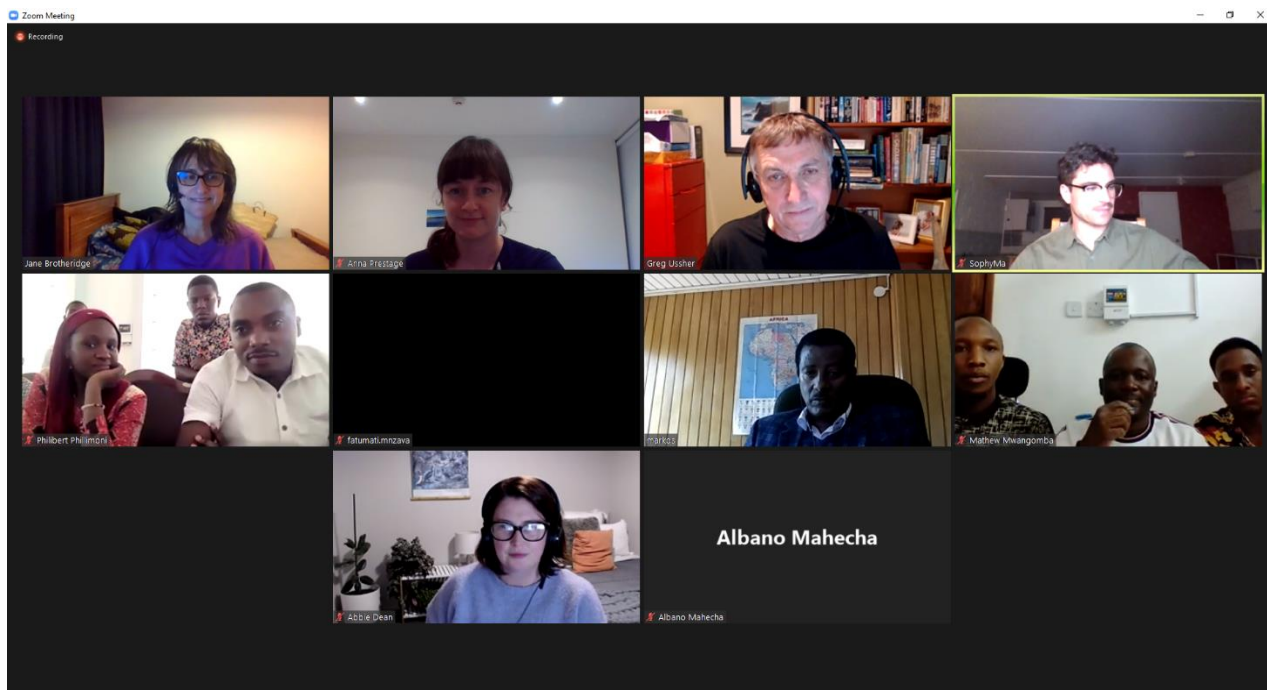


Figure 1 DrillDown main page



**Figure 2** Example of Q&A session with TGDC