

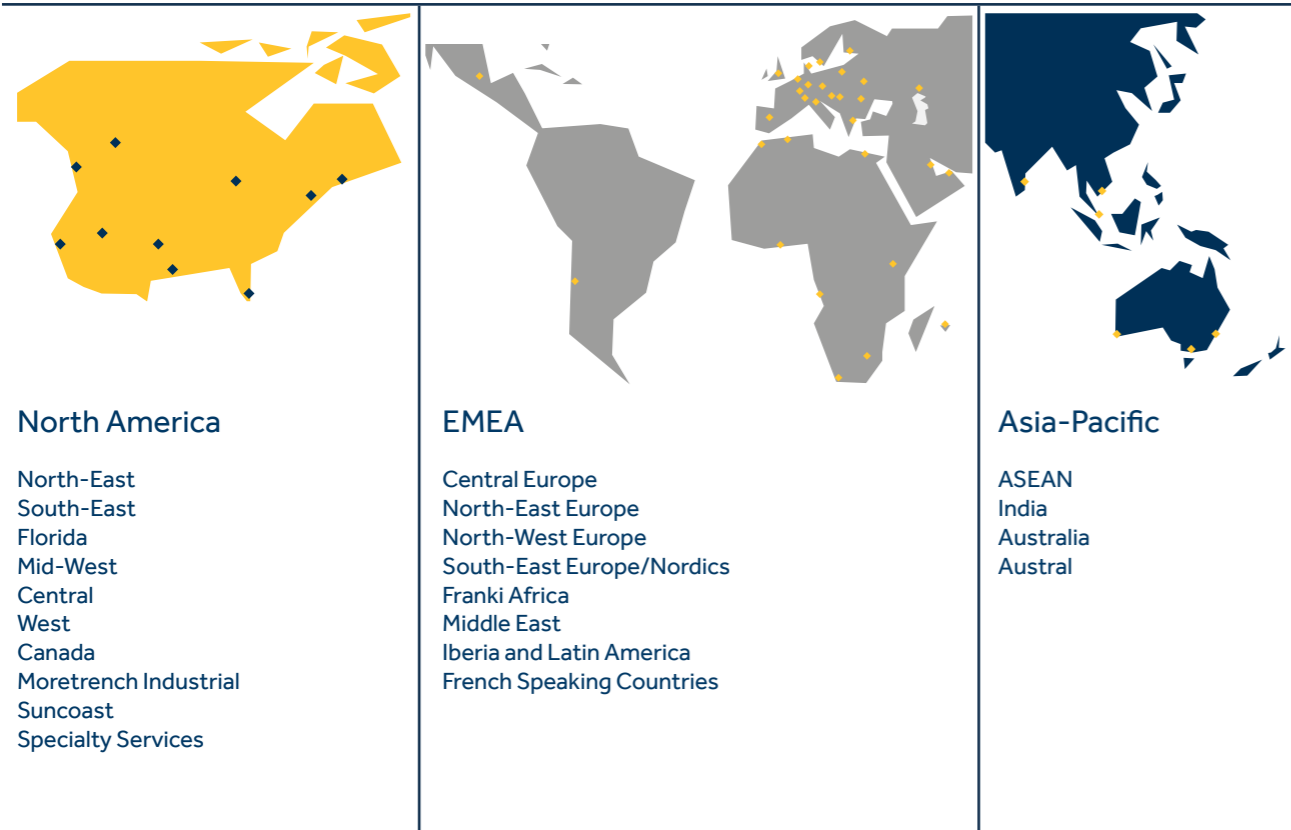


Mining

- Foundations and increasing bearing capacity
- Increasing tailing dam storage capacity
- Tailing dam ground and surface water protection
- Tailing dam stabilisation
- Liquefaction prevention
- Slope stabilisation

Keller Group plc - Who we are

Every day, people around the world live, work and play on ground prepared by Keller, the number one geotechnical specialist contractor worldwide.



Solutions specialist

Used alone or in combination, our techniques solve a wide range of geotechnical challenges across the entire construction sector – from industrial, commercial and housing projects to infrastructure construction for dams, tunnels, transportation and water treatment, as well as projects to address environmental challenges.

Global strength and local focus

We are unique in that we combine global strength and knowledge with our local presence and focus. Our knowledge of local markets and ground conditions means we're ideally placed to understand and respond to a particular local

engineering challenge. Our global knowledge base then allows us to tap into a wealth of experience, and the brightest minds in the industry, to find the optimum solution. With 10,000 employees and operations across six continents, we have the people, expertise, experience and financial stability to respond quickly, get the job done and see it through safely.

By connecting global resources and local knowledge, we can tackle some of the largest and most demanding projects around the world but the everyday work we do is just as important and, in total, we handle an unrivalled 7,000 projects every year.



Helping create infrastructure that improves the world's communities

- Ground improvement
- Grouting
- Heavy foundations
- Earth retention
- Instrumentation and monitoring



Mining

Keller has the expertise to provide complex and advanced foundation and ground improvement solutions for the mining industry, even in remote locations where many of these projects are found. We have extensive experience in managing the complicated logistics involved, and work to industry-leading health, safety, environmental, and quality standards.

Challenges we can solve

Our extensive geotechnical expertise accumulated over years enables us to provide cost-efficient solutions and respond flexibly to a variety of challenging situations and conditions.

We use advanced technologies that allow the execution of highly complex works, such as stone columns, wet and dry soil mixing, rigid inclusions, various types of piles, barrettes, diaphragm walls, nails, anchors and sophisticated types of grouting.

We take special care to keep disruption to a minimum, selecting technology and equipment to ensure operations can continue during the works.

Health and safety

We believe no one should be harmed as a result of any work we do and our ultimate goal is zero incidents.

Health and safety is a priority for Keller and we have a proven track record of one of the lowest accident frequency rates in our industry. The commitment of leaders and employees to our Think Safe programme has earned us awards and recognition from industry bodies as well as our clients.

Our commitment to sustainability

At Keller, we are committed to better understand our contribution to sustainable development and work collaboratively with our customers and stakeholders to reduce potential impacts.

We offer:

- Soil remediation and prevention of contamination: cost-effective and environmentally-beneficial soil remediation solutions to reduce contaminants to levels which are suitable for use without environmental risks or danger to health.
- New materials and design solutions to reduce carbon: lower carbon products to help clients reduce the carbon footprint of their projects, as well as carbon measurement and offsetting.
- Equipment to reduce spoil and materials: innovative solutions to help clients reduce and/or reuse spoil generated from some ground improvement techniques, like piling and grouting, saving the cost of removal from site and disposal.

Project examples

Ground improvement Kittilä Gold Mine Lapland, Finland

Operated by Agnico Eagle, the Kittilä gold mine is in northern Finland within the Arctic circle. As the tailings dams were reaching their capacity, the sides needed raising to ensure production could continue. This work increased the load on the soft deposits already contained within the dam so Keller was called on to stabilise the ground.

Working with Agnico's geotechnical team, we initially carried out trials using wick drains, also known as PVDs, alongside a soil mixing solution; dry soil mixing was ultimately selected for the job. As the treatment had to take place inside the tailings dam, but be installed from the top of the embankment, careful planning was required.

Keller implemented dry soil mixing 18.5m deep to stabilise the soft soil. The work spanned two years with more than 2km of the dam treated, whilst gold production continued.

Ground improvement San Rafael Mine Antauta, Peru

San Rafael mine, owned by Minsur, in Antauta, Peru is one of the main producers of tin in the world. It's located in a mountainous area, 4,500 metres above sea level.

The dyke at the mine is gradually being heightened to bring it up to a safer level, and measures put in place to ensure it can withstand the effects of an earthquake. Keller was brought in to carry out ground improvement.

We mitigated the potential for liquefaction of the tailings located under the dyke through large-diameter jet grout columns, allowing for an increased bearing capacity and seismic strength. The target of the soil improvement programme was to reach a shear strength of at least 500 kPa for the volume of soil treated.

Maintenance and repair

Rio Tinto jetty refurbishment Dampier, Australia

This jetty needed complete refurbishment in highly restrictive conditions: the client needed the jetty to remain in operation throughout the works. Austral Construction, a Keller company in Australia, developed innovative methods to execute and ultimately reconstruct the jetty. Austral earned Rio Tinto Chief Executive's Best Global Contractor Award – 2016 for its performance on this project.



Project examples

Deep foundations Mopani Synclinorium Concentrator Zambia

Mopani Copper Mines (MCM) is an integrated copper and cobalt producer located on the copper belt of Zambia. MCM operations currently consist of four underground mines and a concentrator in Kitwe (Nkana Mine), and a smelter and refinery in Mufulira. The Mopani Synclinorium project was an initiative to increase the lifespan of the Nkana mine by 25 years and boost concentrate output.

The geotechnical works for this project included 1,448 Franki pre-drilled driven cast in-situ piles, each 410mm to 610mm diameter and up to 12m long.



Ground improvement La Parrilla Mine Cáceres, Spain

La Parrilla Mine, owned by W Resources, is a tungsten and tin mine development in Spain, around 250km north of Seville.

Keller executed a ground improvement treatment installing stone columns underneath a new tailings dam to be built at the mine. This dyke was built in four phases reaching a maximum height of 24m in the final phase, measured from the foundation to the top.

The new dyke is between two existing dykes and founded on a mud base made of clay and silt of soft to a very soft consistency with some sand. During phase one, we carried out ground improvement over an area of 7,800 m². This improved, reinforced and homogenised the geomechanical characteristics of the ground, and sped up the consolidation process to guarantee the general stability of the dyke.



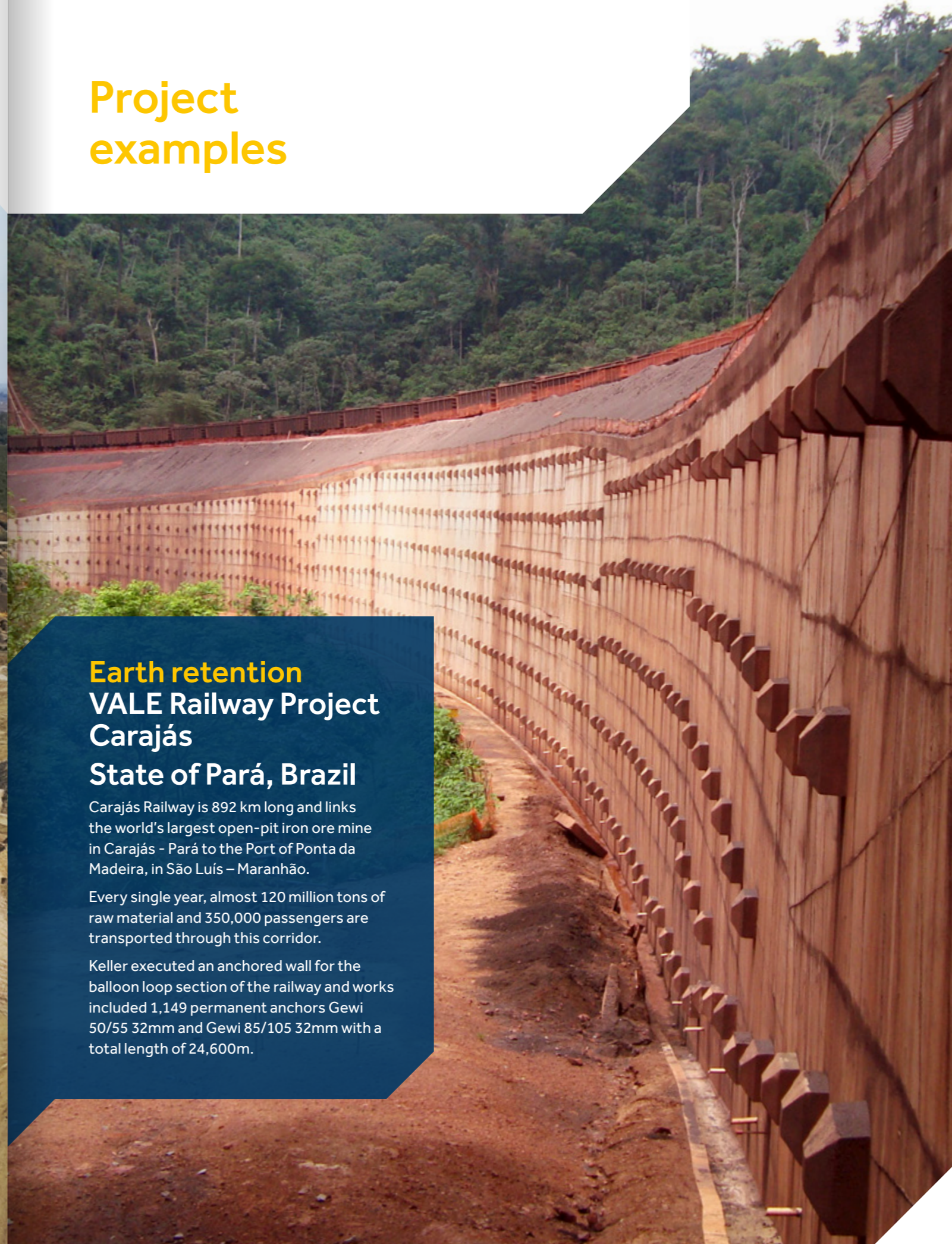
Project examples

Earth retention VALE Railway Project Carajás State of Pará, Brazil

Carajás Railway is 892 km long and links the world's largest open-pit iron ore mine in Carajás - Pará to the Port of Ponta da Madeira, in São Luís - Maranhão.

Every single year, almost 120 million tons of raw material and 350,000 passengers are transported through this corridor.

Keller executed an anchored wall for the balloon loop section of the railway and works included 1,149 permanent anchors Gewi 50/55 32mm and Gewi 85/105 32mm with a total length of 24,600m.



Groundwater control Basal Aquifer Trials Fort Hills, Canada

Keller completed a large scale pilot test demonstrating that artificially frozen ground could form an impermeable groundwater barrier in the basal aquifer to prevent the inflow of saline sand into the large open-pit oil sands mine. A total of 85 refrigeration pipes were drilled and installed to 150m (492ft) and connected to four high capacity mobile refrigeration plants. This highly successful project confirmed that specialised refrigeration pipes and fibre optic instrumentation could be used to advance ground freezing technology on large mining projects under adverse environmental conditions.

Project examples



Earth retention Nkomati Mine Mpumalanga, South Africa

Nkomati Mine is owned by a partnership between African Rainbow Minerals Limited and Norilsk Nickel Africa. Producing nickel, it is 300km east of Johannesburg in South Africa.

Keller's work included the design and construction of a retaining wall to support the highly variable soft decomposed layers above the bedrock. The objective was to allow the mine to sit at the steepest possible angle to achieve maximum ore extraction, as close to the property boundary as possible, without affecting current operations.

The retaining wall increased the area of the open cast mine allowing mining of the richer ore closer to the property boundary. This anchored contiguous pile wall is one of the largest executed in South Africa with a plant length of 330 linear meters and a maximum excavation height of 28m.



Project examples

Ground improvement Heap Leach Drainage Safford, USA

This copper mine in Safford, Arizona uses an ore extraction process called heap leaching. Engineers needed to limit the application rate of the extraction solution to maintain slope stabilities. This resulted in a reduced recovery rate of the leachate solution. Over time preferred flow paths developed within the ore pile, reducing the volume of ore exposed to the leaching solution.

The site also had pockets of ore that had decomposed from gravelly to clayey materials. The low permeability of these materials trapped the leachate solution in the pile, resulting in perching/slow percolation and reduced mine production.

Wick drains were installed across the 244-acre site significantly improving leachate circulation throughout the degraded layers of ore deposits.



Ground improvement Vale Malaysia Iron Ore Facility Lumut, Malaysia

Vale, a world leader in iron ore mining and distribution, planned to build a distribution facility in Lumut, Malaysia, with a capacity to handle 200 million tonnes of iron ore a year. Keller was awarded a design and build contract for the foundation of the iron ore facility.

The main challenge was to design a treatment solution to support a 19m high iron ore stockpile and foundation system for the stacker/reclaimer. The contract milestones were critical. Given the loads, the soft soils were expected to exhibit significant settlement and deformation.

The stockpile and stacker/reclaimer berm were treated using stone columns. Spacing varied between the columns based on the soil conditions in each zone. The berm was supported by bored piles. To assist Vale with stacking and surcharging the stockpile, we adopted a staged loading programme. Instrumentation monitoring then allowed close observation of the loading and soil reactions.

Project examples





Deep foundations Transmission Towers Wilpinjong, Australia

Wilpinjong Mine needed to relocate a large overhead powerline and install a number of new pylons. The pylons were located on a previously backfilled open cast mine pit which required a specialist foundation solution.

Keller designed permanently cased piles at 610mm diameter, which were installed to extremely tight tolerances through rock fill to depths of 40m to meet the pylon dimensions.

Project examples



Grouting Holcim Quarry Hagerstown, USA

This drilling and grouting contract involved installing a grout curtain between the quarry and a nearby stream at the existing operating surface mine at Holcim's quarry.

The job consisted of cleaning out the existing piezometer wells, drilling new grout holes, and pumping a low mobility grout into the formation to block water flow and increase flow lines. Eight holes were cleaned out and 20 new holes were drilled to maximum depths of 318ft. Over 1,200 cubic yards of low mobility grout was pumped.



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