New generation sustainable binders – How they are made

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Geo40 Limited (Booth 12 Pavillion 1)

Geo40 is an innovative New Zealand company that was established in 2010 to develop technologies for the sustainable harvesting of minerals from geothermal water

Geothermal activity is natural and found around the world

Global geothermal hotspots

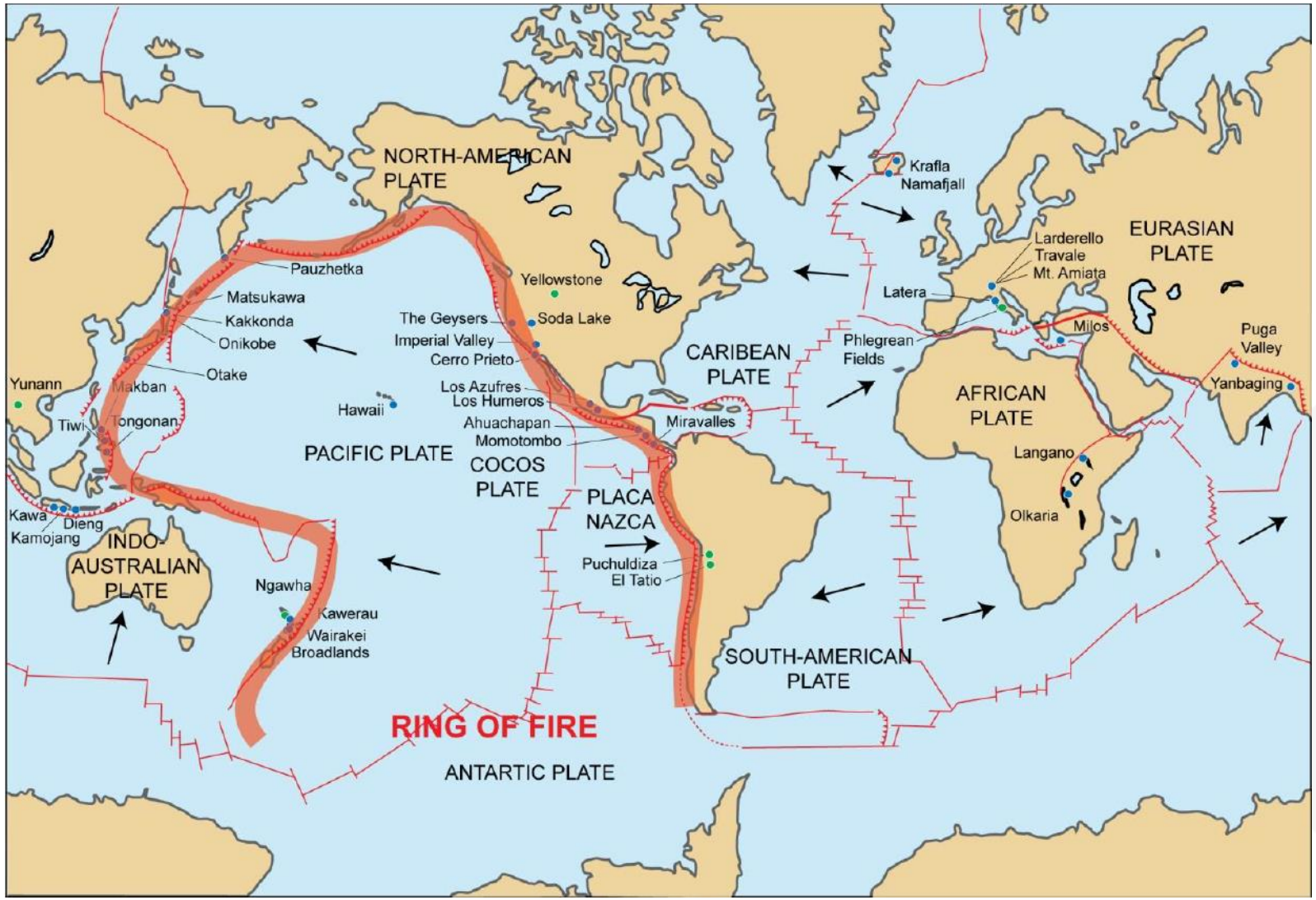
A geyser bubbling with hot geothermal water in Yellowstone National Park, USA

Traditional Japanese Onsen, Japan

Blue Lagoon in Iceland.

Silica terraces, Wairakei, New Zealand

Geothermal activity is natural and found around the world



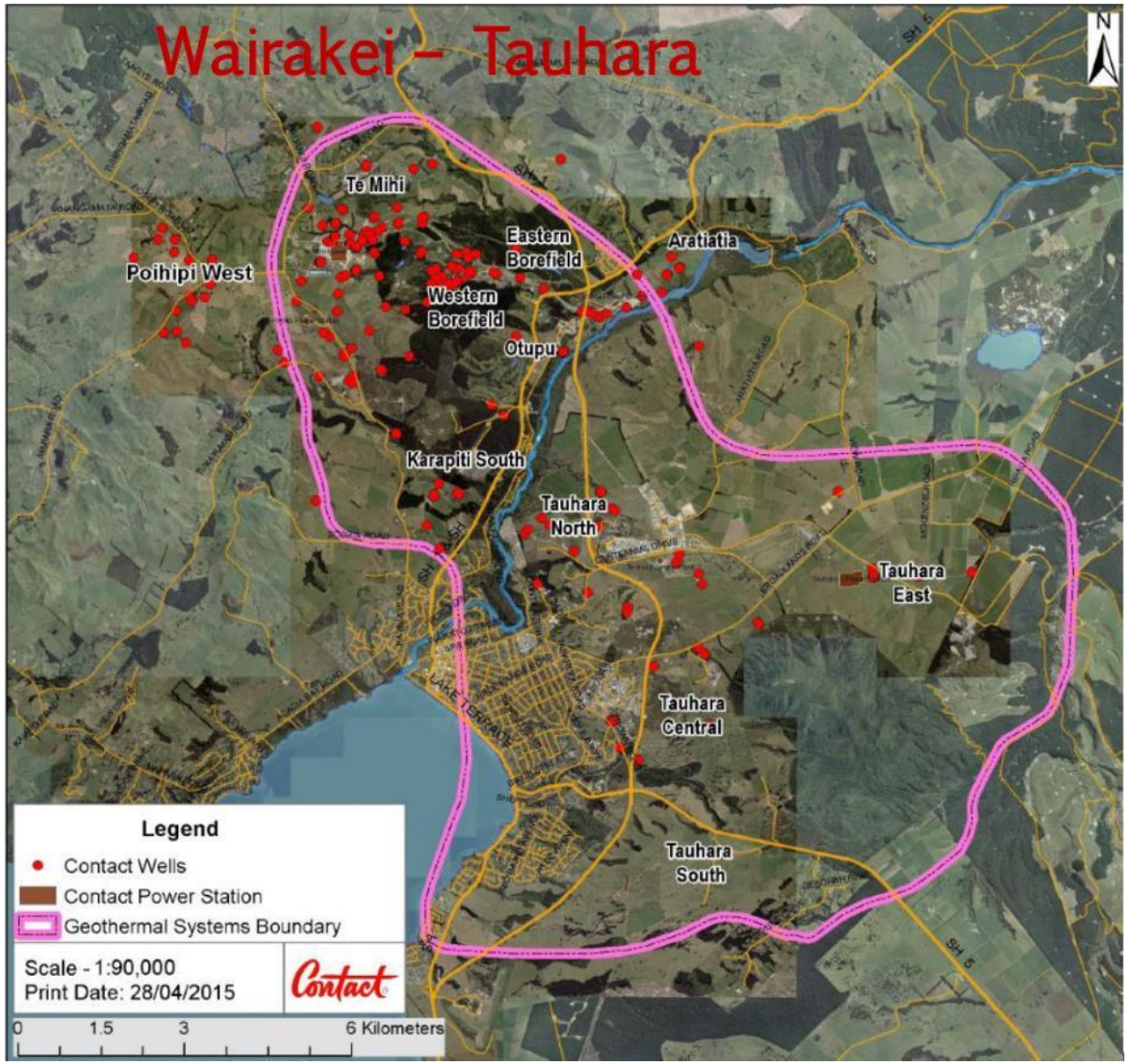
Global tectonic plates

Geothermal power generation - history

Early geothermal field development at Wairakei in New Zealand (circa 1950s)

- The world's first commercial geothermal power station was developed in 1911 in Larderellow, Italy
- New Zealand was the second country in the world to develop commercial power generation and commissioned the Wairakei Power Station in 1958
- This was the first plant in the world to use the flash steam process where super heated water is brought to the surface and the steam flashed off.

Geothermal power generation



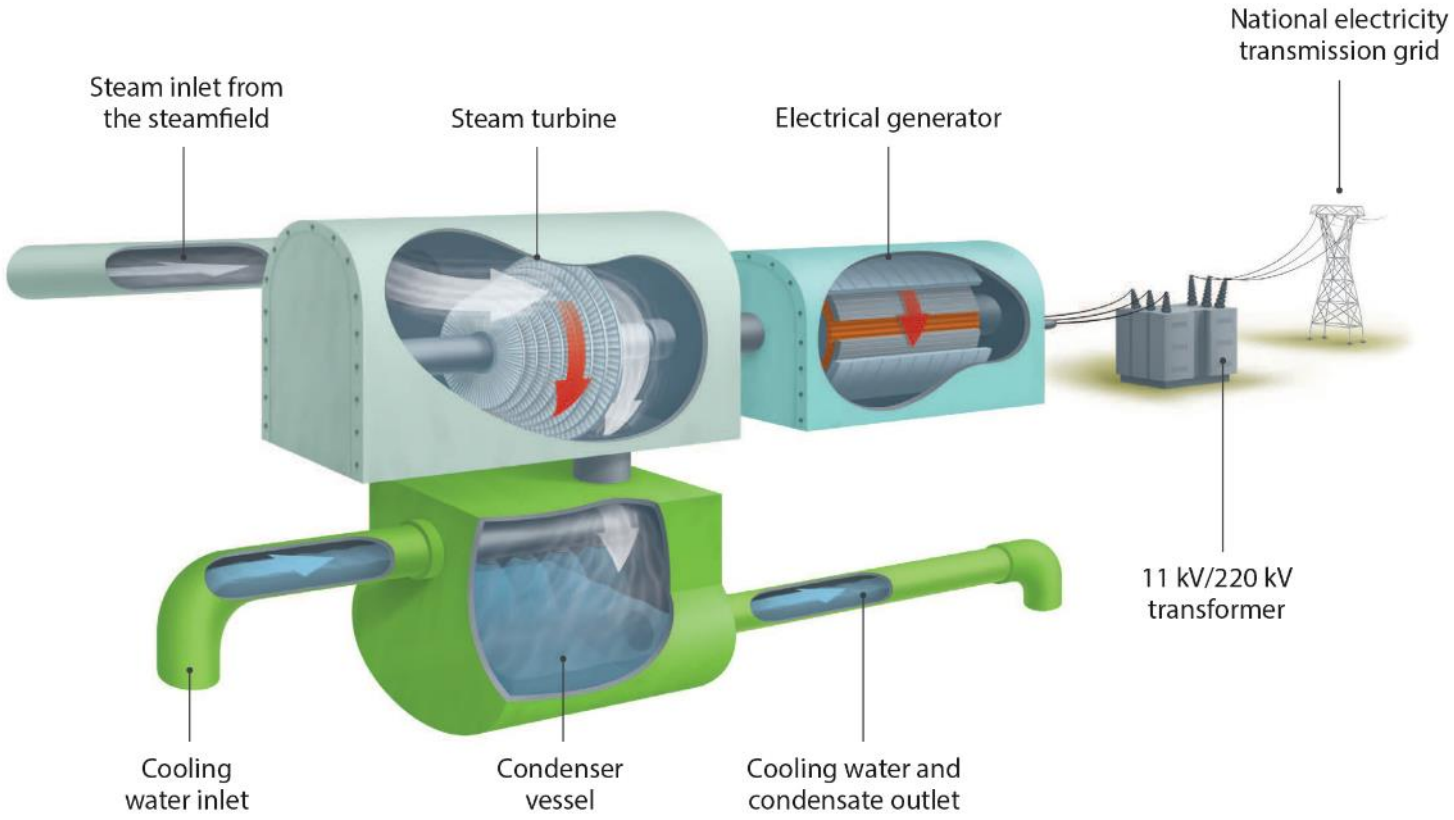
This map shows the extent of a typical geothermal field in New Zealand where there are four geothermal power stations generating in total 400MW of power

Geothermal power generation

Wairakei geothermal field, New Zealand

- The super heated water also contains minerals that have been dissolved by the water
- The most abundant mineral is dissolved silica. Other minerals such as lithium are also present in commercial quantities.
- At the surface the separated steam is piped to the power station.

Geothermal power generation



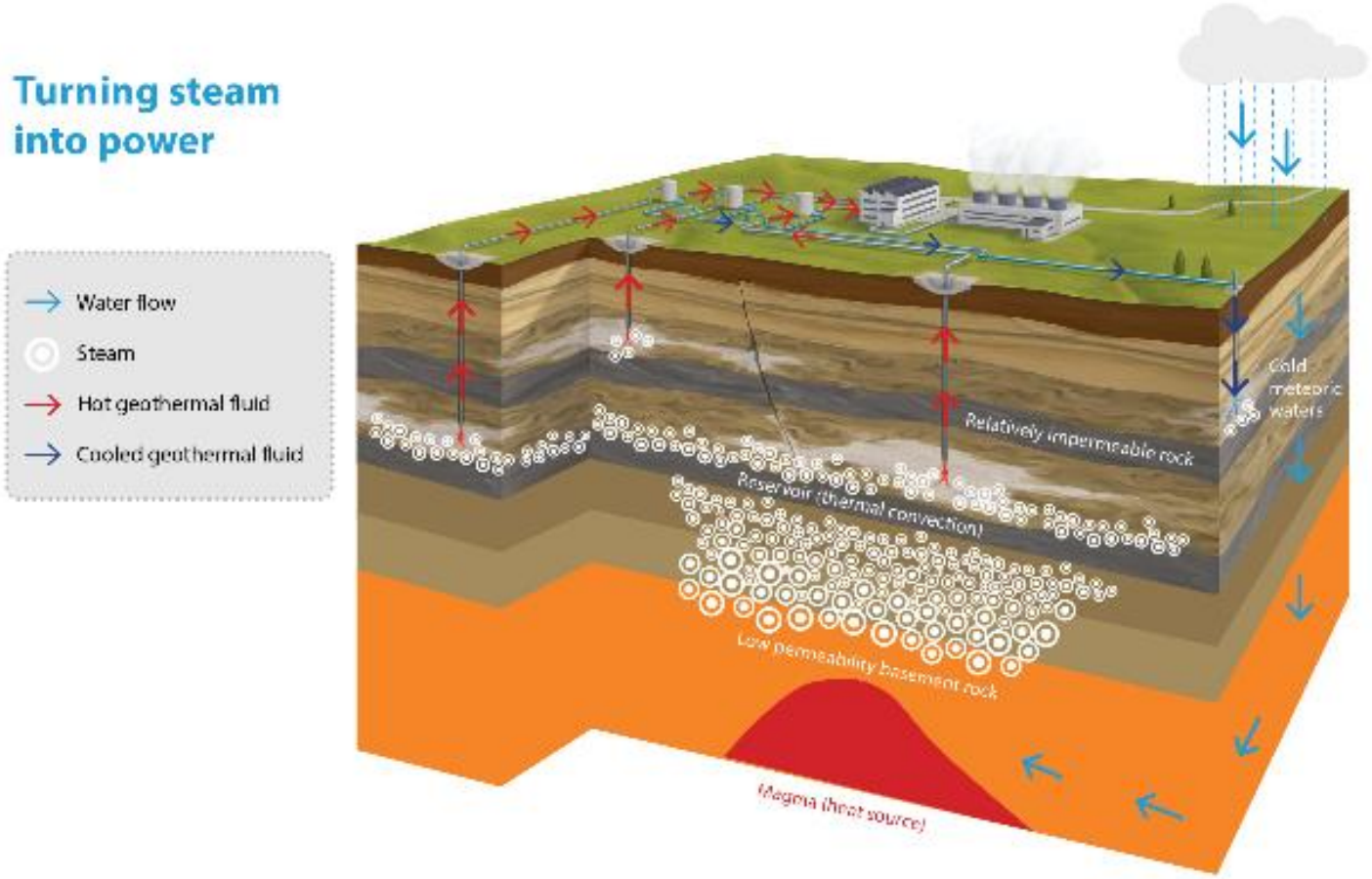
Typical geothermal steam turbine set-up

- At the power station, the separated steam is fed to steam turbines, where it is used to generate electricity.

Geothermal power generation

A 90MW steam turbine at Te Mihi Power Station, Wairakei, New Zealand

Geothermal power generation



Geothermal power station and field

- When the steam is separated from the super heated water, the volume of the water is reduced by approximately 30%, concentrating the silica and other minerals.
- Power generation is restricted due to the silica concentration getting close to its dissolved saturation point
- At this point, the hot water is pumped to the edge of the geothermal field and reinjected back into the reservoir

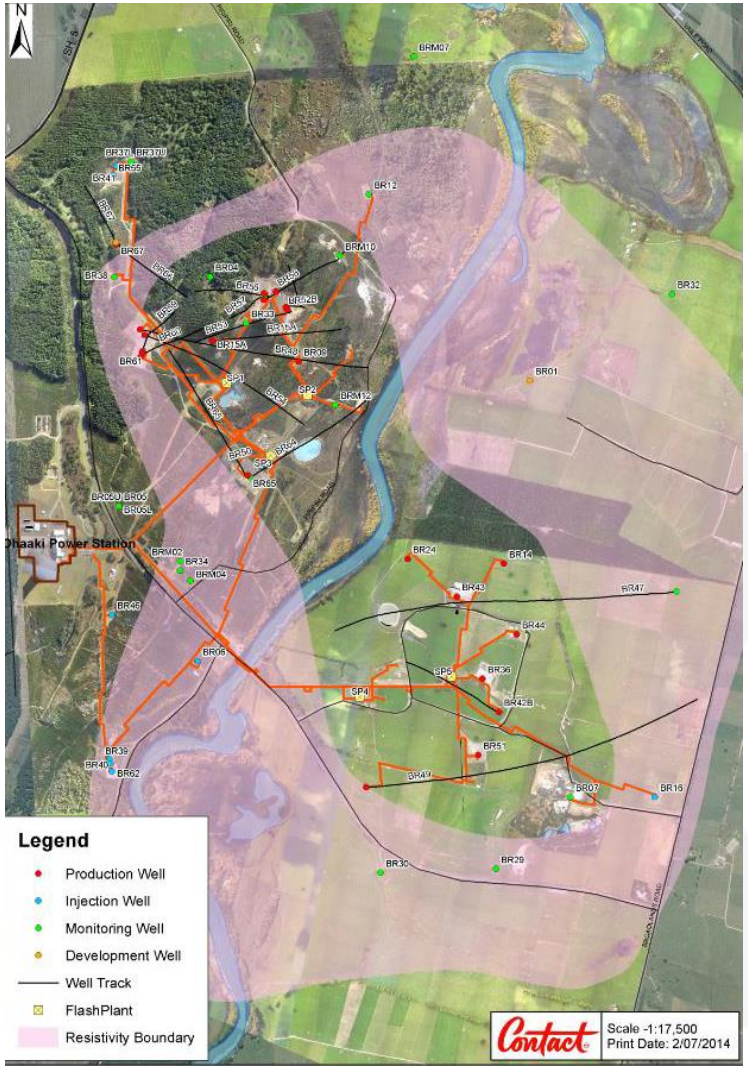
Silica scaling is a significant power plant maintenance cost

Scaling in 450mm (18 inch) pipe in Coso, California, USA

Scaling in 500mm (20 inch) pipe at Ohaaki, New Zealand

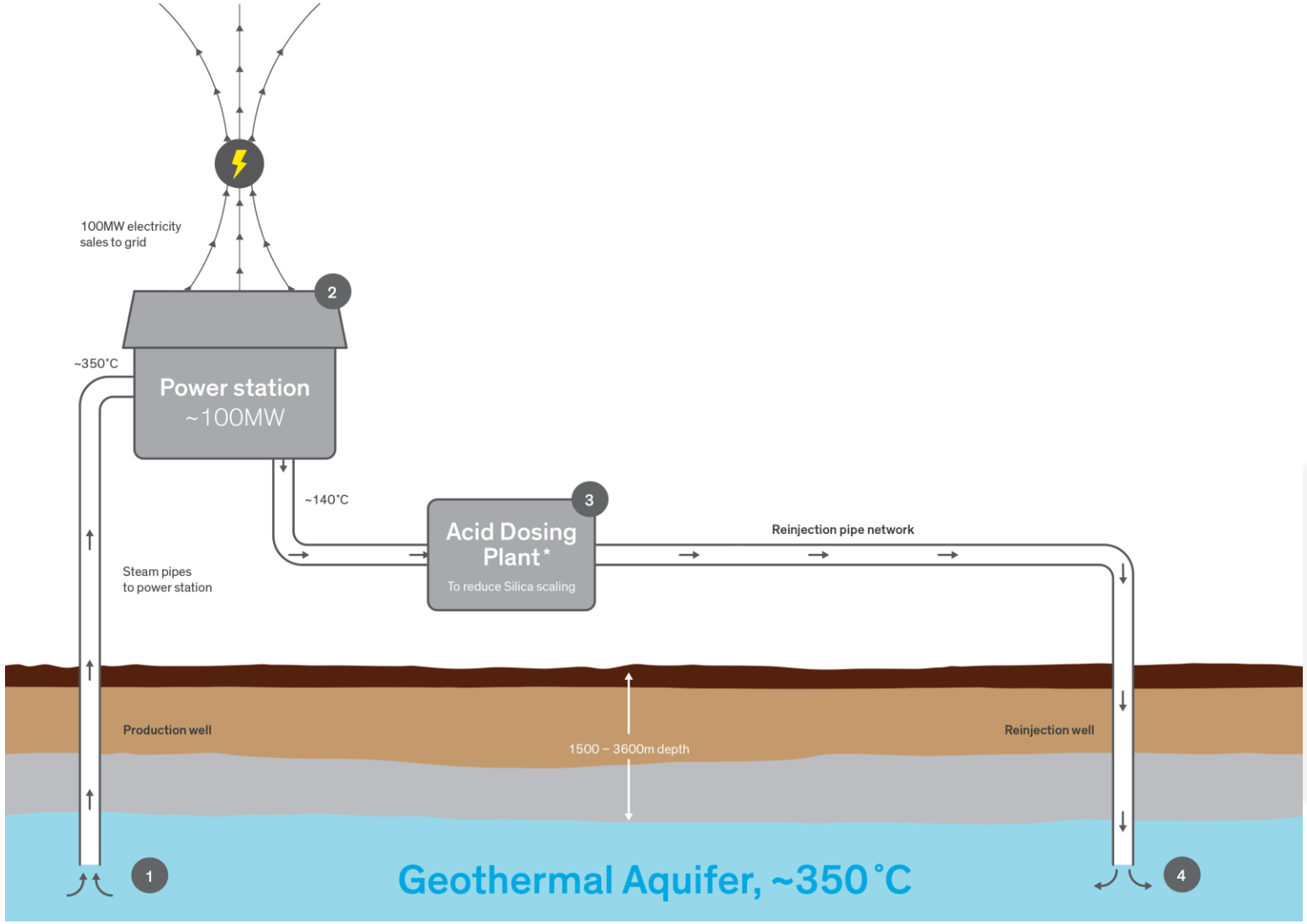
Reinjection pipeline

Reinjection pipe at Te Mihi Power Station, Wairakei, New Zealand

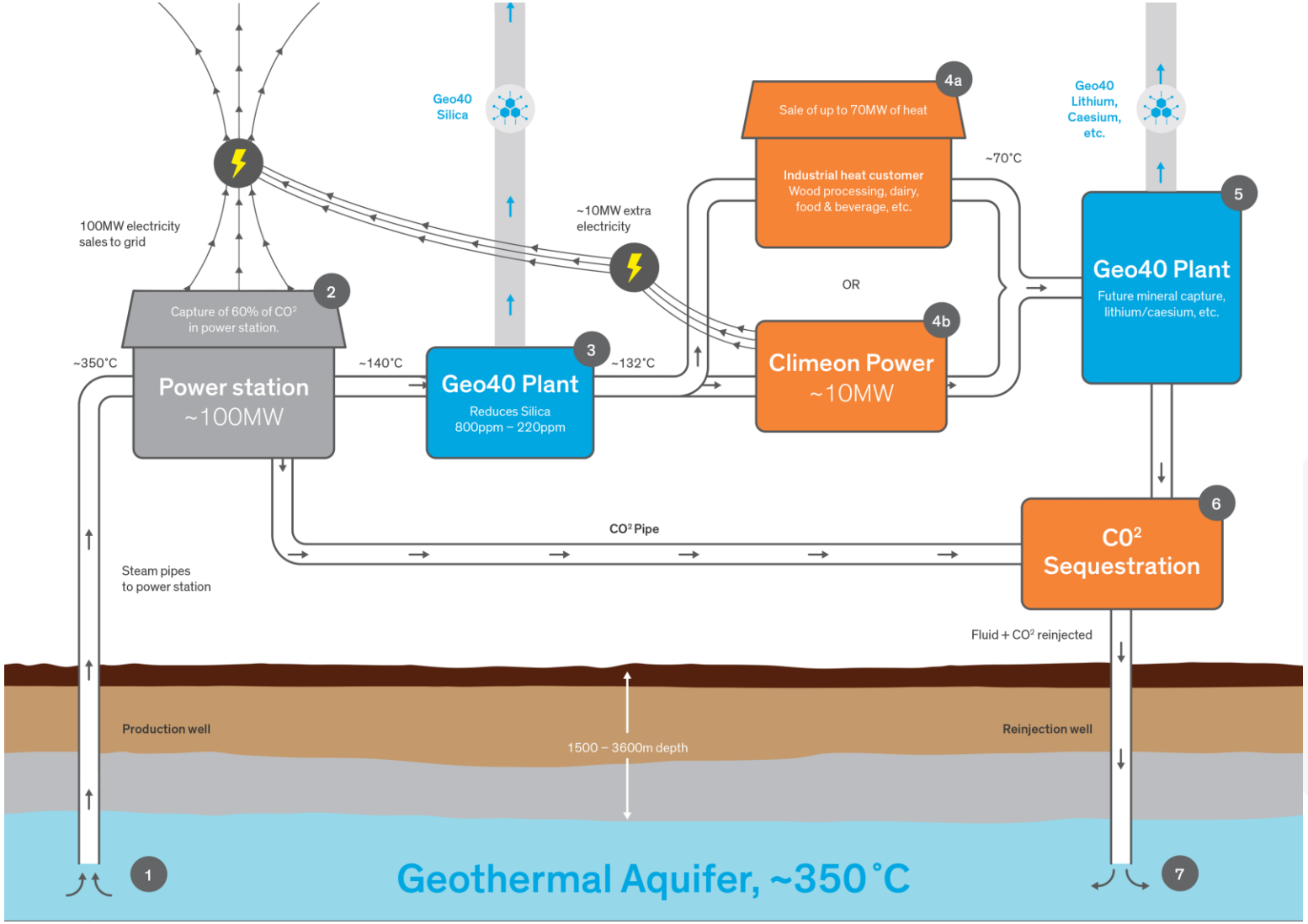


Distribution of production and reinjection wells, Ohaaki, New Zealand

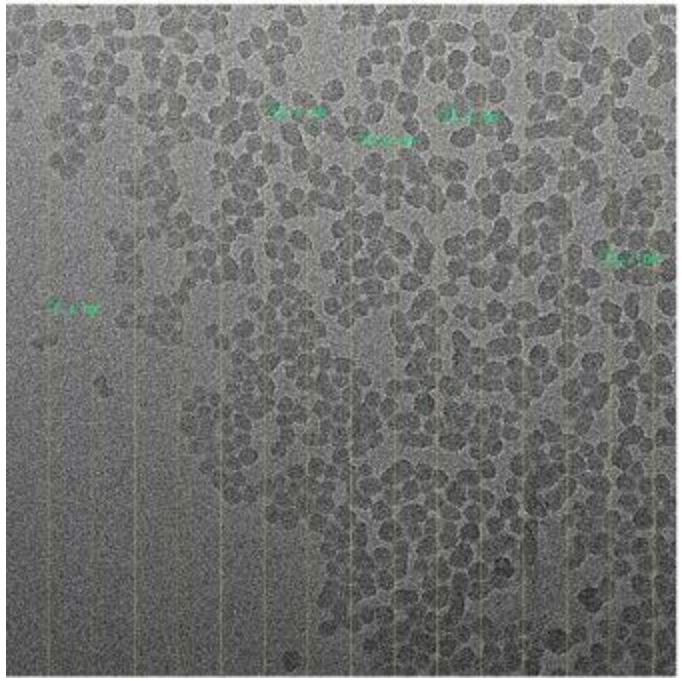
Geothermal power plant without Geo40 process



Geothermal power plant with Geo40 mineral extraction processes



Colloidal silica binders

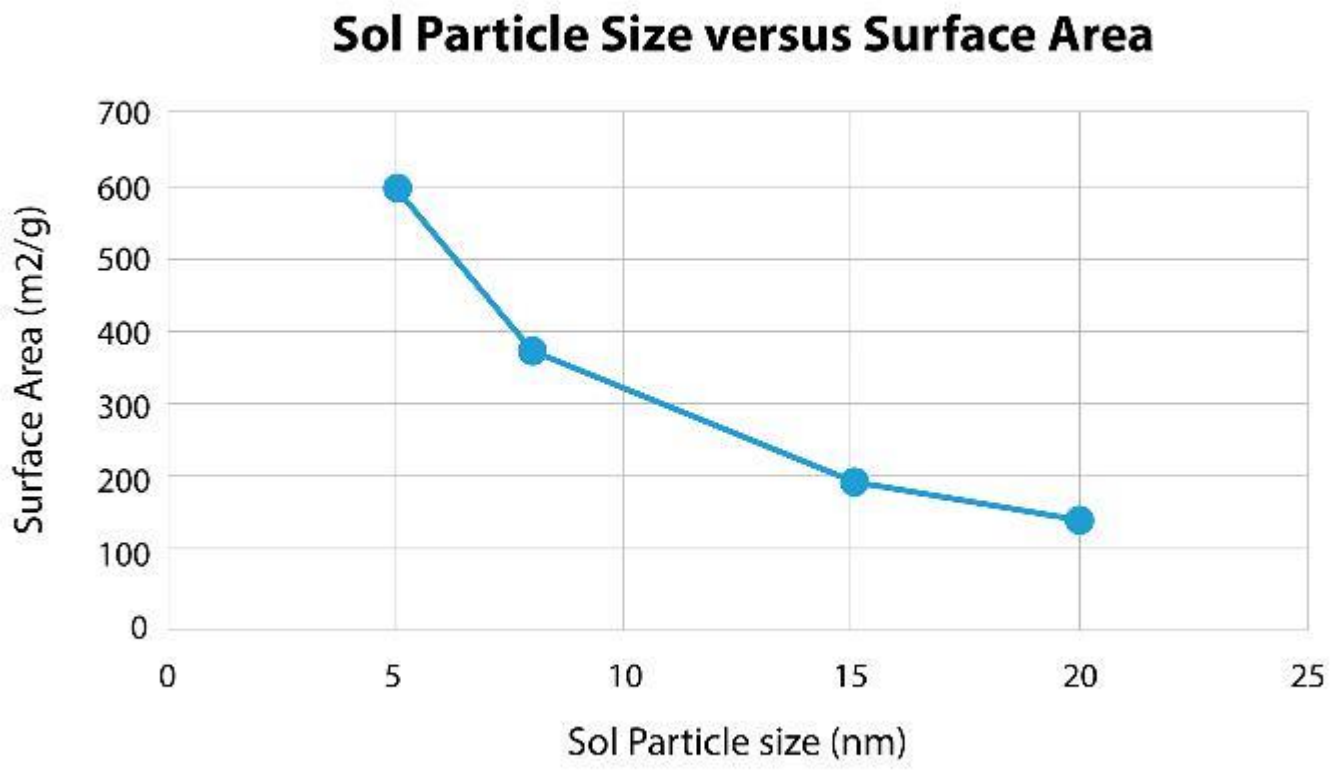


Transmission electron micrograph (TEM) of Geo40 10nm colloidal silica (sol)

Average particle size ranges for colloidal silica at 15% and 30% strength.

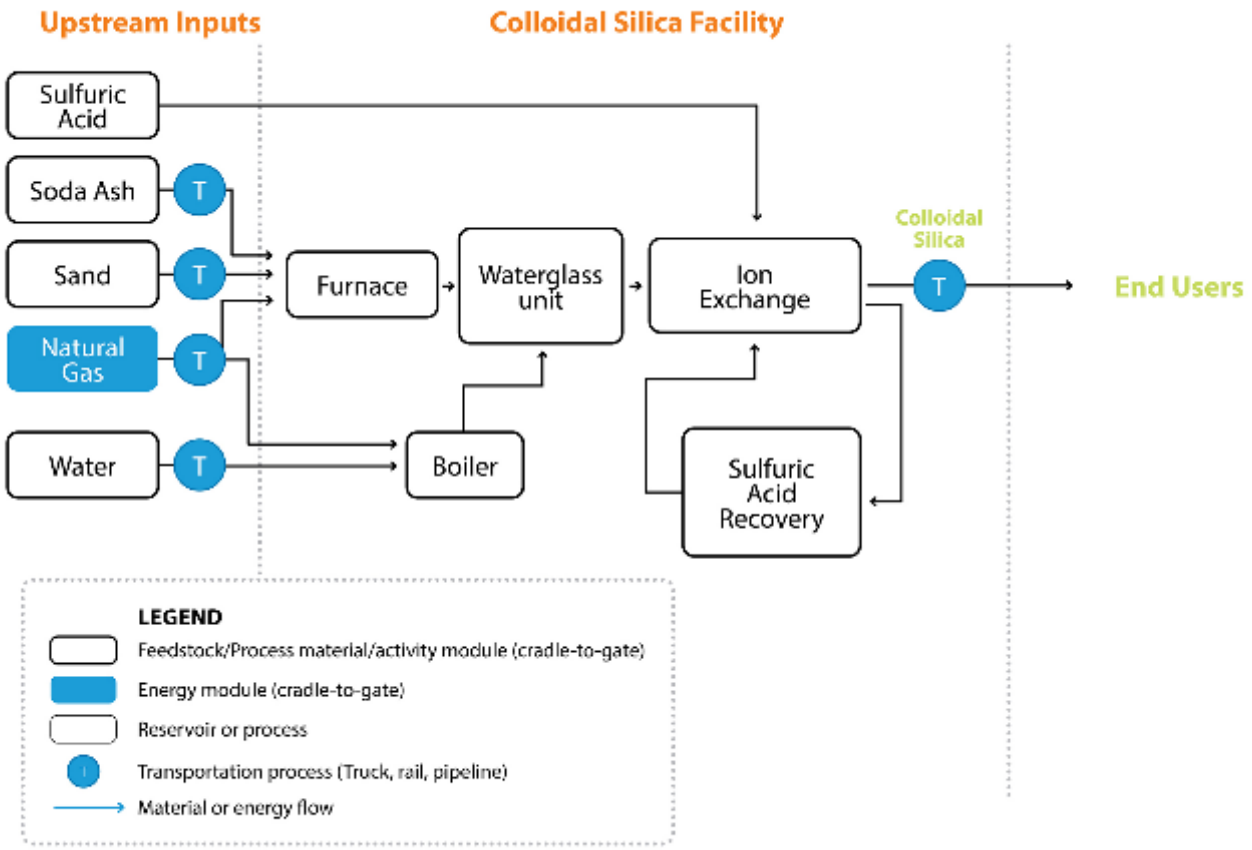
- Colloidal silica binders are sold under a range of brands for prime coat and back-up coats
- Some are sold pure, some come pre-formulated and some are modified but for all, it is the colloidal silica that is the key ingredient that provides the green and fired strength in the shell
- Typically binder systems consist of colloidal silica nano-particles of 8nm, 10nm and 14nm

Colloidal silica binders



- A human hair is approximately 100,000 nanometers in width
- Due to the very small size of the colloidal silica particles and their porosity, they have correspondingly very high surface areas
- 8.92 grams (0.3 ounce) of 5nm colloidal silica has a surface area of approximately 5,351m² or 6,400yrd² which is the size of an American football field, including the end zones
- It is the small particle size and relative surface area that gives colloidal silica its unique properties as a binder

Colloidal silica binders - How they are made



- The conventional process starts with quartz sand as the source of silica
- Temperatures of 1,600 °C (2,900 °F) are required to melt the quartz and react it with sodium to make waterglass
- The waterglass is then further heated in an autoclave to dissolve the silica and a combination of ion exchange and further heat and chemical addition are used to produce colloidal silica binders to various specifications

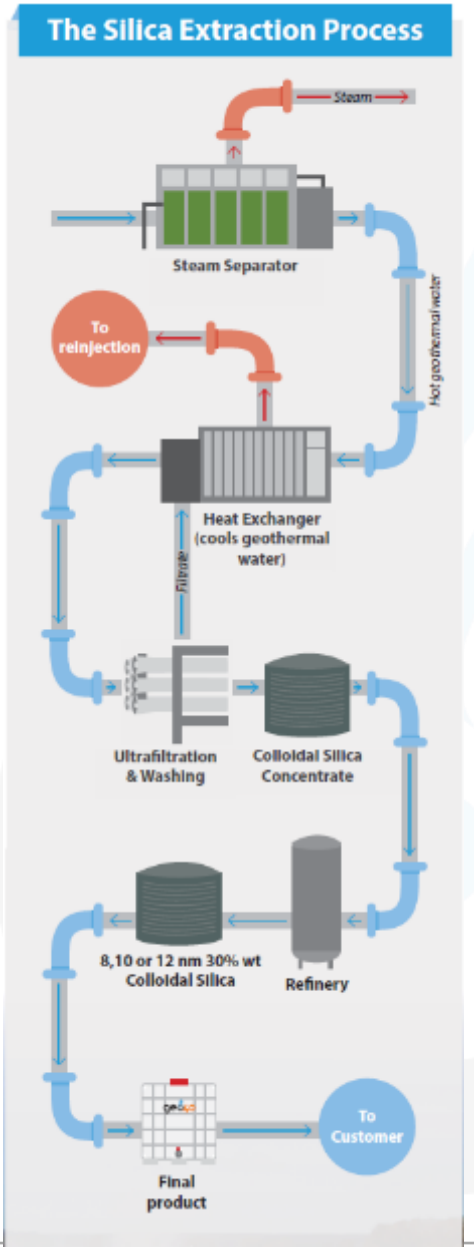
Colloidal silica binders - How they are made – Geo40 process

- Nature has done all the hard work in dissolving the silica, with no need for furnaces, autoclaves or ion exchange plants.

- The hot silica saturated water from the steam separator is cooled. During cooling, the silica forms a dilute solution of colloidal silica nano-particles. (In nature the cooled silica deposits as beautiful natural silica sculptures around geysers and hot pools).

- The pure silica nano-particles are concentrated using filtration, washed of trace minerals, and further concentrated to provide particles that are 5nm – 6nm in size. For some applications, this product is sold directly.

- For investment casting binders, the particles are grown, using renewable geothermal heat, to produce final products that are high quality, sustainable and cost competitive.



Geo40 process journey for new generation binders

- Started in 2010 to sustainably harvest minerals from geothermal fluid after the heat has been harvested by the geothermal power plant

- First large scale pilot plant commissioned in 2014. Pilot plant trials carried out on Wairakei, Kawerau and Ohaaki geothermal fields in New Zealand and Kakkonda geothermal field in Japan.

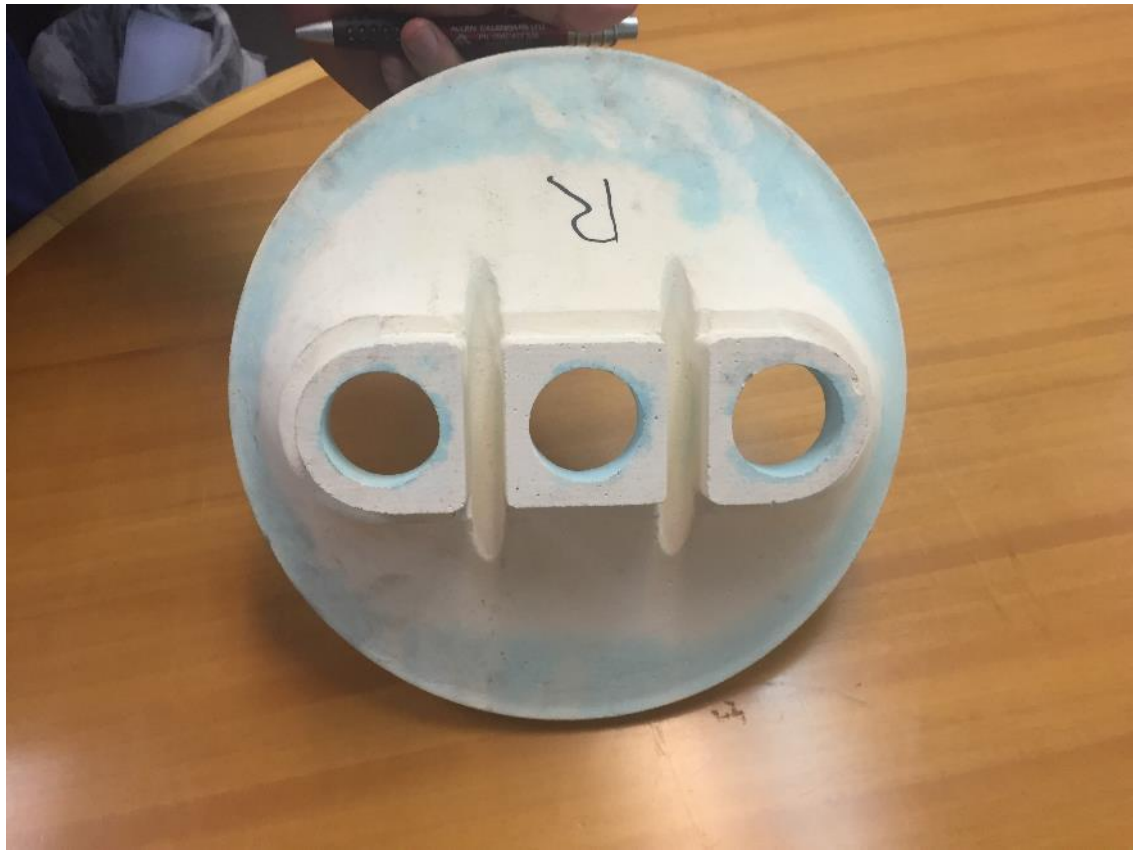
- First commercial plant in operation at Ohaaki geothermal field in New Zealand in in April 2018.

Pilot Plant, Wairakei, New Zealand

Ngawha Plant, Ohaaki, New Zealand.

New generation binders were extensively tested – investment casting

New generation binders were extensively tested – Ceramic castings



New generation binders were extensively tested – refractory fibre bonding

Geo40 process journey for new generation binders

Historic Maori whare (house) near the ngawha (hot spring)

Historic ngawha (hot spring) used for cooking and bathing

- During the development of the Ohaaki power station, hot water stopped flowing to an historic Maori hot spring
- Flow was restored using hot silica laden fluid from the power station which turned the hot spring from flowing clear to a milky white due to the silica coming out of solution

Geo40 process journey for new generation binders

Hot spring before Geo40 process, Ohaaki, New Zealand

Restored hot spring after Geo40 process, Ohaaki, New Zealand

Geo40 process journey for new generation binders

Hot spring outflow before Geo40 process, Ohaaki, New Zealand

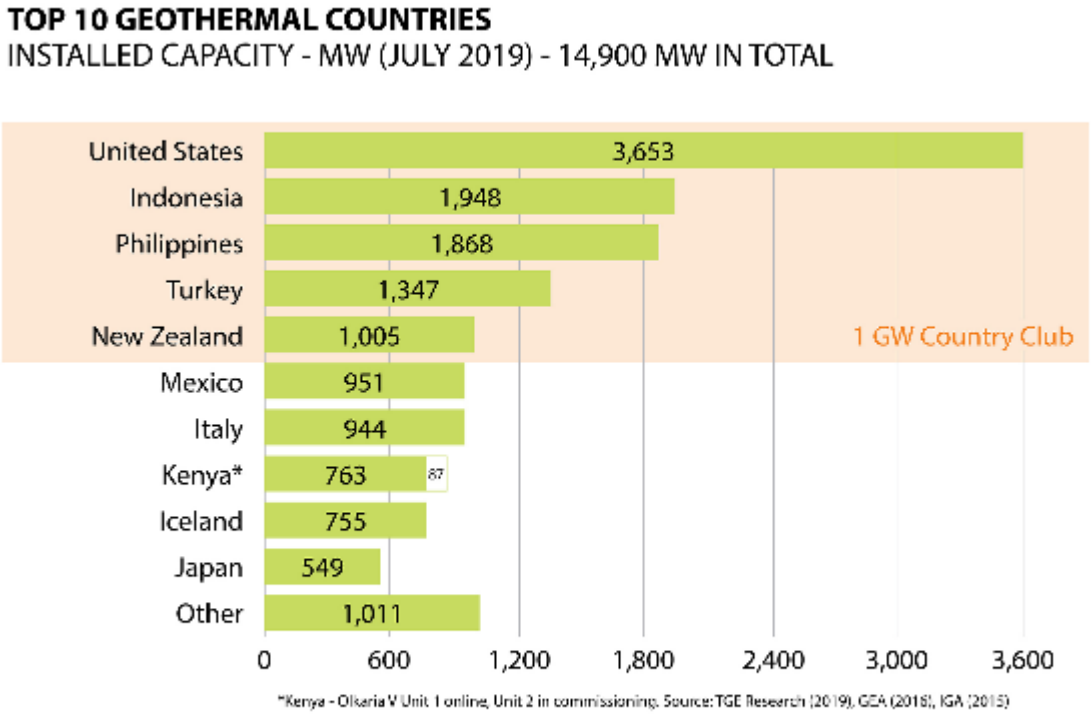
Restored hot spring outflow after Geo40 process, Ohaaki, New Zealand

Geo40 process journey for new generation binders

Hot spring outflow into the river before Geo40 process, Ohaaki, New Zealand

Hot spring outflow into the river after Geo40 process, Ohaaki, New Zealand

Geothermal power generation is global



Global Geothermal Power Generation Capacity - 29 July 2019 (source: ThinkGeoEnergy)

- Globally, geothermal power production is the fastest growing source of renewable base-load electricity
- Hot geothermal water is not only used to generate electricity but it is also used as a heat source for other applications such as heating glass houses and production of milk powder

Geo40 process journey for new generation binders

- The next large scale production plant using this new generation technology to produce colloidal silica products is due for completion in December 2020

- Further plants are planned around the world as demand increases

- In developing this process, Geo40 has been able to achieve what nature has been doing all along. Emulating nature's own processes and creating the next generation of sustainable, high quality silica products.

Geo40 Northern Plant , Ohaaki, NZ

Next-Generation Geothermal Innovation and Sustainably Harvested Products for a More Sustainable World

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