**Platform 1 – Geological Resources**

**Combined brine-CO2 re-injection at geothermal power stations reduces carbon emissions and extends the lifespan of wells and infrastructure: a win-win for the environment and the generator**

**Alignment with the strategic intent of the Platform**

New Zealand’s commitment to a low-carbon future is facing significant challenges to ensure an affordable, secure, and sustainable supply of energy in the face of a rapidly changing climate. The nation’s geothermal power stations make a significant and increasing contribution to baseload electricity generation, but are not free from carbon emissions and the punitive cost of the carbon tax.

To mitigate the carbon emissions, geothermal electricity producers are shifting towards re-injecting CO2 back into the reservoir by mixing it with the expended geothermal brine. This process, called co-injection, can thereby transition geothermal generators from CO2 emitters to CO2 neutral.

This new approach offers a transformative solution for geothermal power production both in New Zealand and overseas. However, the long-term impact of CO2 co-injection on the performance of the geothermal reservoir remains unknown. Addressing this issue is crucial for understanding the continued performance and sustainability of the reservoir and has become a focal point of our ongoing research efforts.

**The need for SSIF investment**

Geothermal power plants utilise hot brines (saline solutions) extracted from the Earth's crust to generate electricity. These brines typically contain high concentrations of CO2 and other non-condensable gases. During the electricity generation process, these gases are separated from the brine and are released into the atmosphere, resulting in average emissions of ~122 grams of CO2 per kilowatt-hour of electricity generated.

Mineral scaling is another ongoing challenge for power plant operators. Amorphous silica is the most prevalent scaling mineral, forming along the flow path in both the production infrastructure (pipes and wells) and subsurface reservoir. To mitigate and slow the rate of silica precipitation, acid is injected into the geothermal brine. However, when this acidified fluid is re-injected into the subsurface, it reacts with the surrounding rock minerals, neutralising the acid and triggering rapid silica precipitation. This process can lead to the fouling of rock close to the re-injection wells, necessitating the drilling of new wells, thereby significantly increasing operational costs.

Maintaining an acidic pH of the fluid after re-injection could substantially slow or even prevent silica scaling, and so we tested the hypothesis that co-injection of high concentrations of CO2 could keep the pH low and prevent silica scaling.

**The research**

The Experimental Geochemistry Laboratory team at GNS developed a novel dual-stage autoclave method to simulate the interaction between CO2-charged geothermal brine and the reservoir rock. The concept is that re-injected CO2 forms carbonic acid when dissolved. This, in turn, will lower the pH of the combined re-injected brine and prevent silica scaling.

**Results**

A control experiment with greywacke (a major reservoir rock type in the Taupō Volcanic Zone) led to moderate silica scaling. When calcite was added in a second experiment, it produced consistently higher scaling, thus supporting the hypothesis that calcite in the re-injection rock causes enhanced silica scaling. In a third experiment, using greywacke and calcite, 2000 mg of CO2 per kg of brine were added to investigate the effect of CO2 co-injection. Silica scaling in this experiment was nearly zero, proving the concept that CO2 co-injection can mitigate this ongoing challenge for geothermal power operators.

The tests also revealed an important side effect of co-injecting high concentrations of CO2, the accelerated removal of calcite from the rock. This means that the CO2 is acting as a “cleaning agent” to remove the cause of rapid silica scaling.

**Collaboration and funding partners**

Building on several years of experimental work simulating the re-injection of geothermal brines into host reservoirs, the foundation of this project was set. These site-specific studies, funded by both domestic and international geothermal operators, led to the formulation of the novel concept of CO2 as a silica anti-scalant.

Encouraged by the promising results, two New Zealand geothermal power generators have requested further experimentation. The goal is to explore the effects of enhanced CO2 co-injection, potentially leading to more efficient and sustainable geothermal power production.

**Who it helps and how**

By using CO2 as a silica anti-scalant, power generators can mitigate the significant costs associated with injectivity declines in re-injection wells. This is truly a win-win situation where co-injection eliminates carbon emissions and the payment of carbon tax, while at the same time improving the efficiency of production operations and the sustainability of the geothermal reservoir. CO2 emissions captured from major external point-sources (e.g., industrial plants) could also be co-injected into geothermal reservoirs, providing a potential storage technology for captured CO2.