



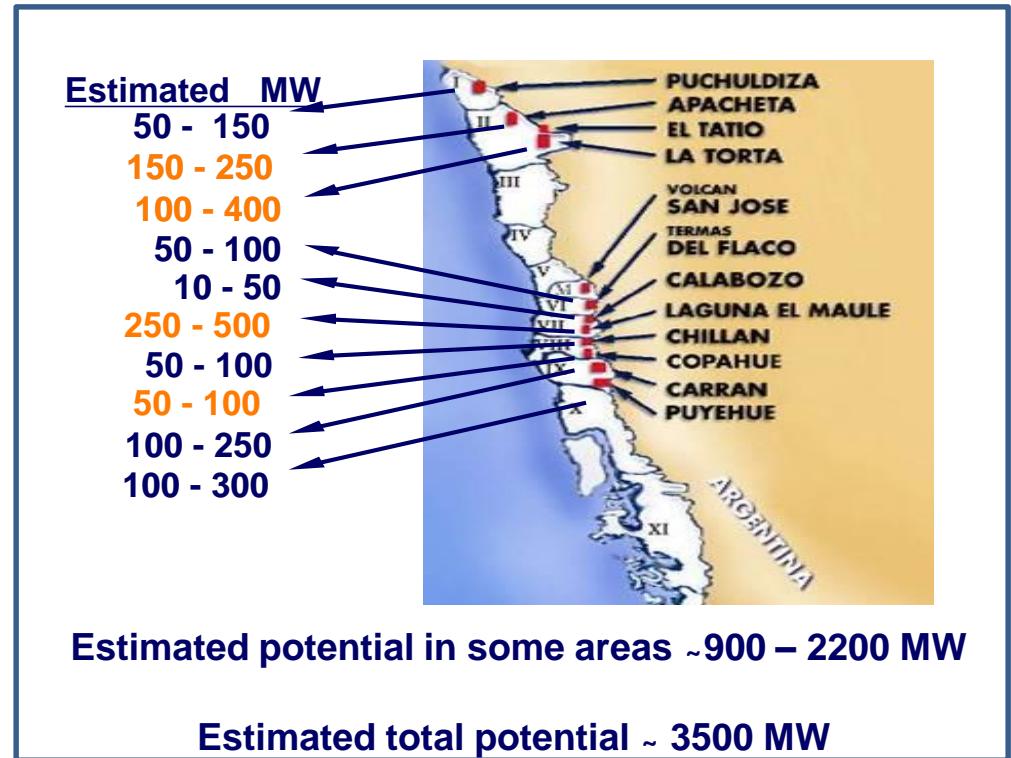
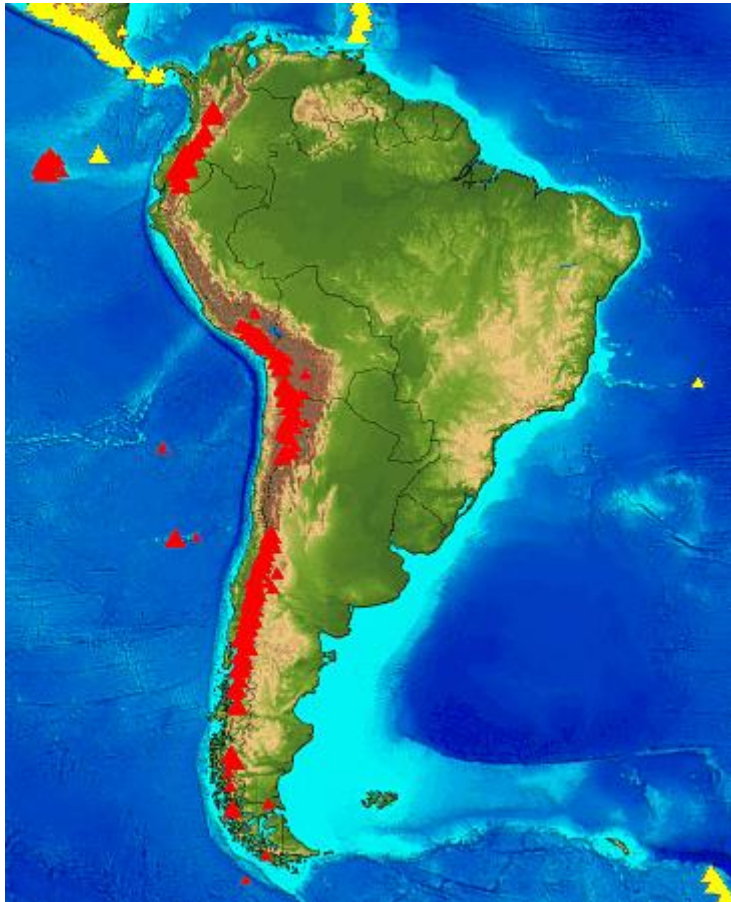
# Cerro Pabellón geothermal plant: a success story

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**GEOLAC**

Santiago - Chile – July 17, 2019

# Geothermal resources in Chile



# GDN company context

## Joint Venture EGP-Enap



**Geotermica del Norte (GDN)** is a Joint Venture between **Enel Green Power** and **Enap** for the development of geothermal resources in Chile

At present Enel owns **84.6 %** and ENAP **15.4 %** of GDN

84.6% 15.4%

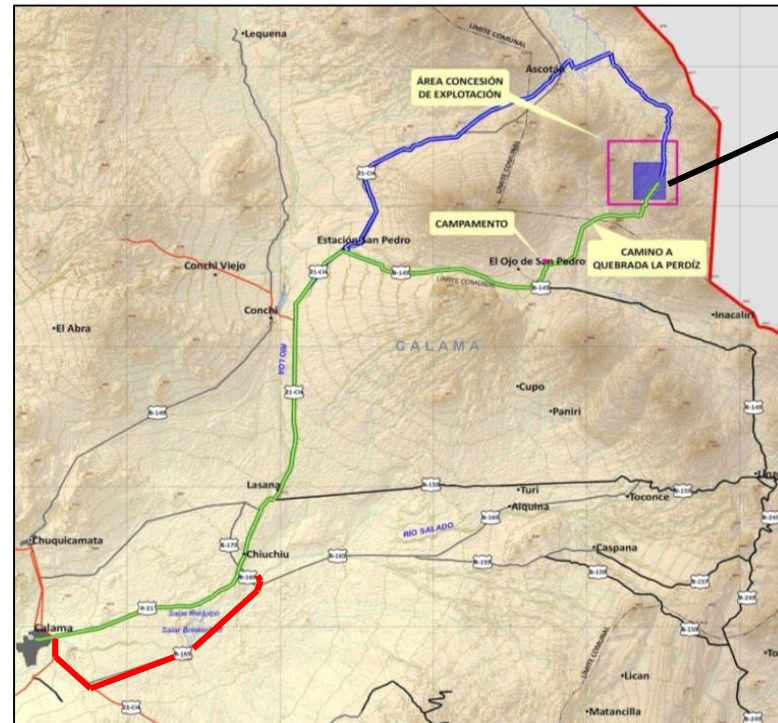


**Geotermica  
del Norte S.A.**

**Cerro Pabellón project**

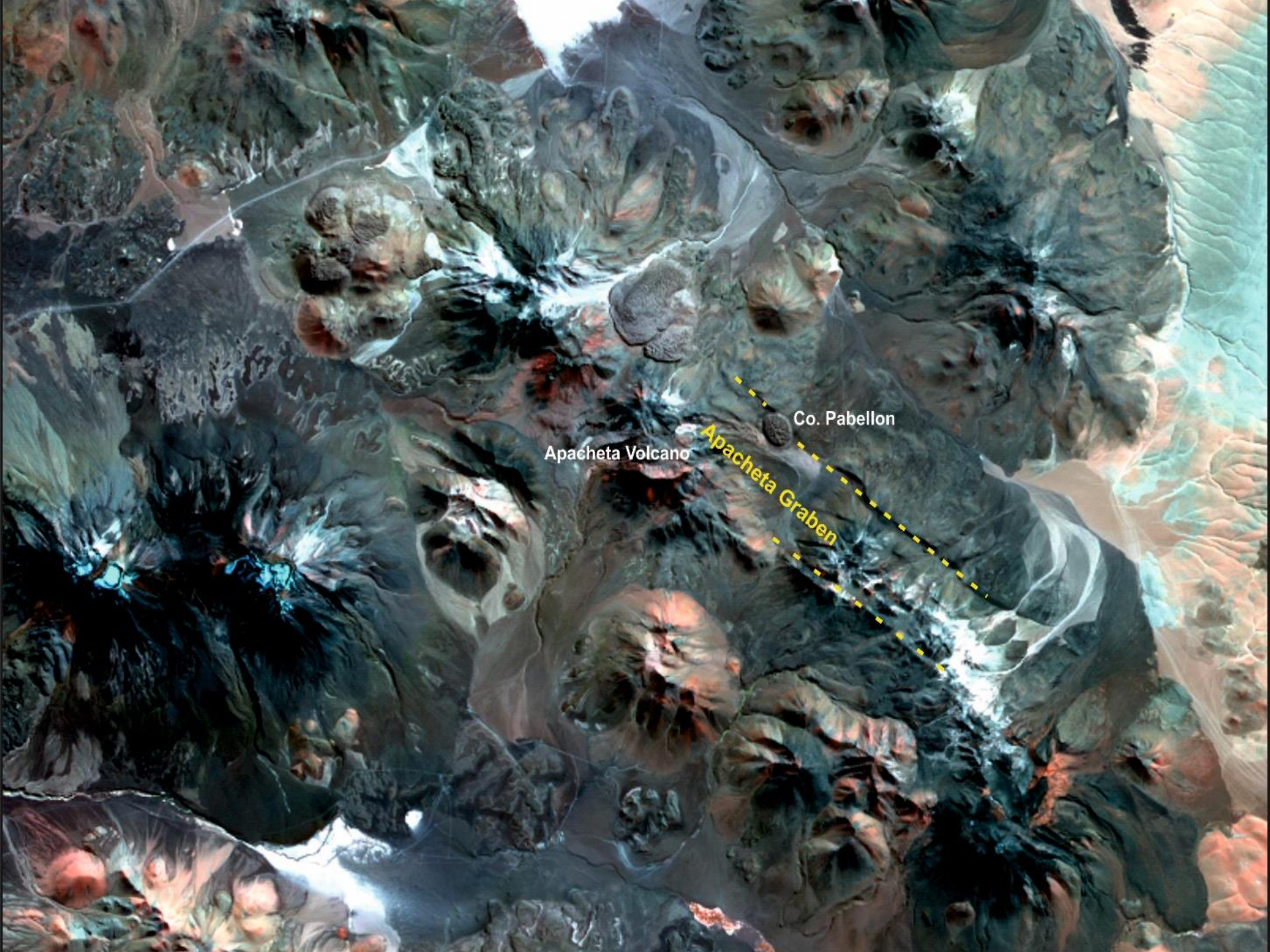
# Location of Cerro Pabellón project

The project is located in the Desert of Atacama, at about 100 km NE of Calama and at an elevation of 4500 m



Location and main roads





Apacheta Volcano

Co. Pabellon

Apacheta Graben

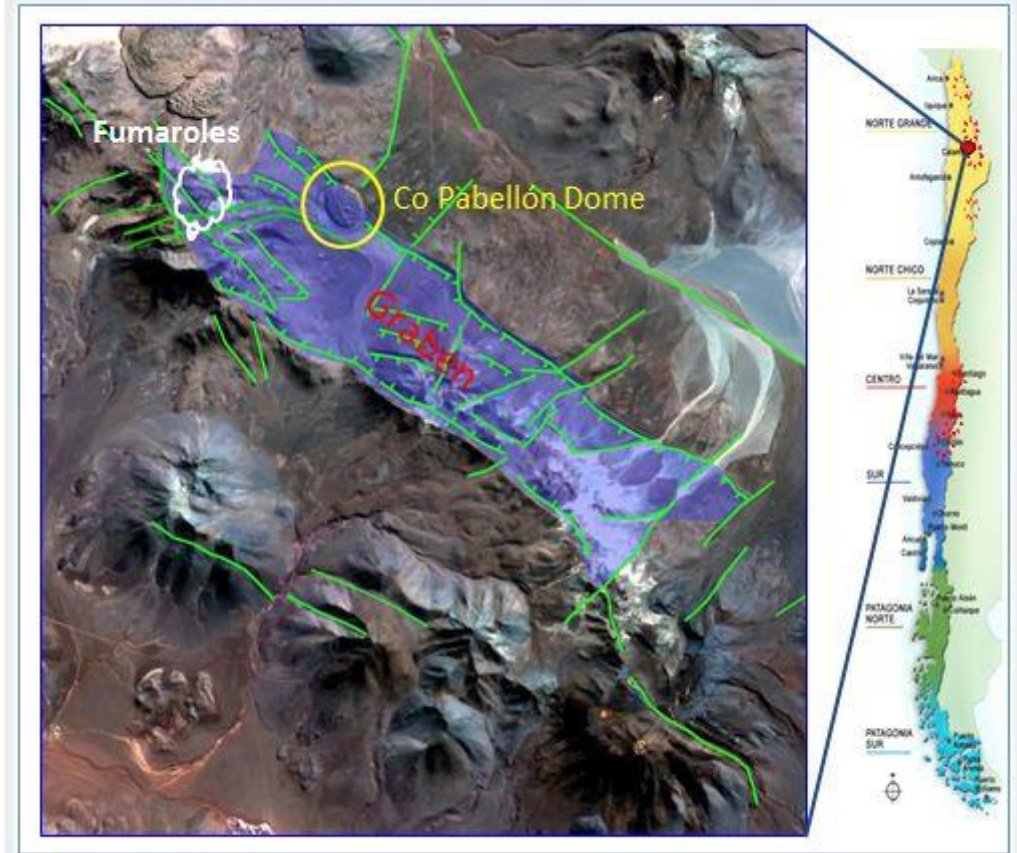


# Cerro Pabellón: geo-scientific framework

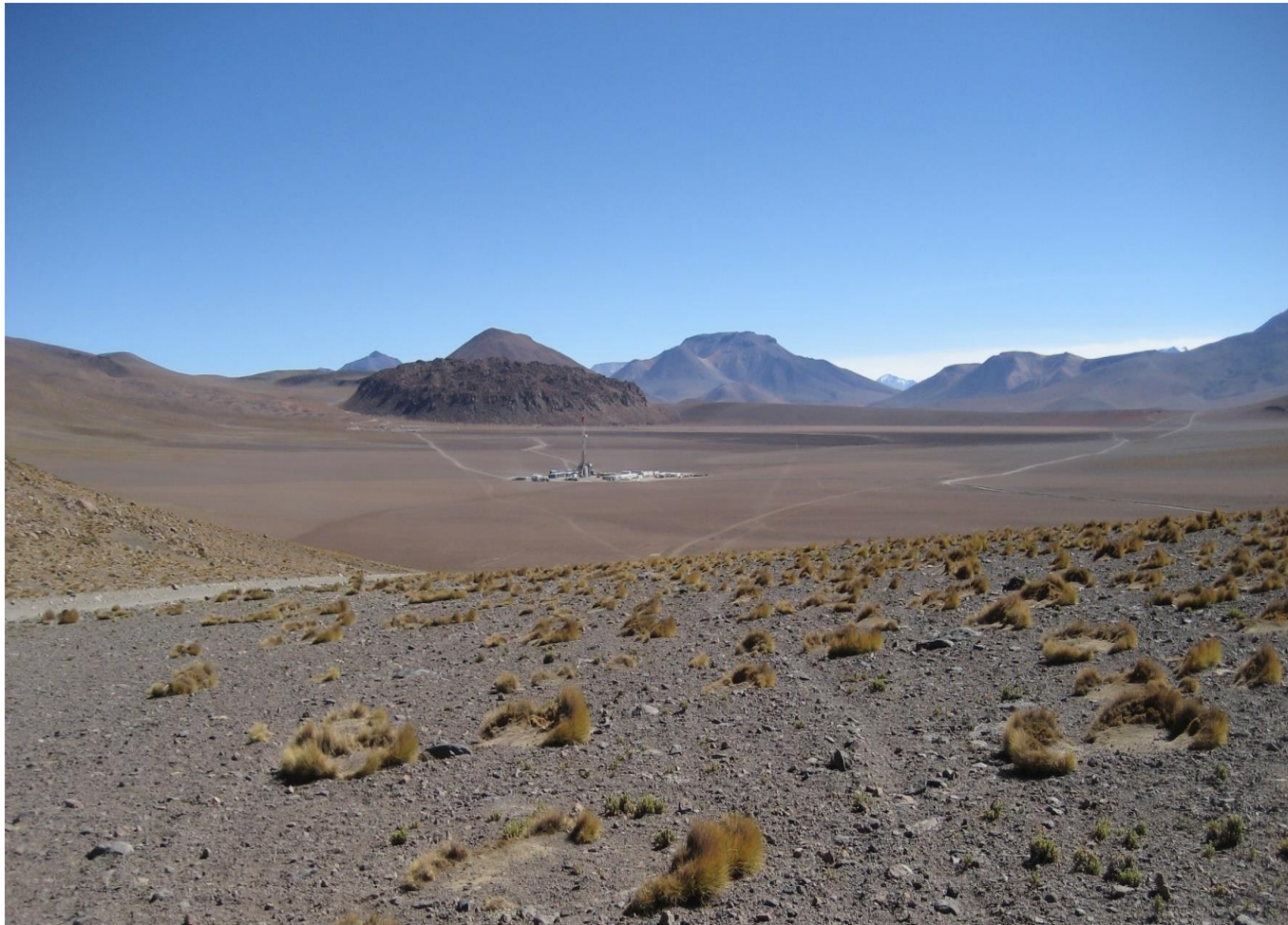
## Attractive features of the Pampa Apacheta Area

The **Pampa Apacheta Area** attracted the GDN interest for a series of peculiar geo-scientific features:

- ✓ A large and very well defined "**Extensional Graben Structure**".
- ✓ The **recent acid volcanism** testified by the characteristic 50k years old "*Cerro Pabellón Lava Dome*".
- ✓ The presence of 2 **over-heated fumaroles** on the top of the local volcanic ridge.
- ✓ The **high temperatures values at shallow depths**, found by CODELCO during fresh water exploration in this sector.



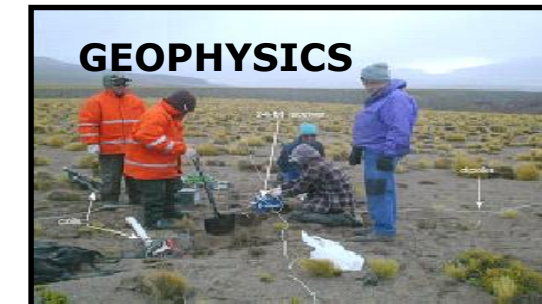
# Cerro Pabellón: area of the project



# Surface exploration activities

The **surface exploration** of the Cerro Pabellón area was carried out between 2006 and 2007 and consisted in:

- **Geological** studies by *remote sensors* and 3 distinct *stratigraphy, volcanic and structural* field surveys.
- **Geophysical** studies of Magnetotelluric (110 sites), Gravity (200 sites) and Magnetic Field (200 km<sup>2</sup> covered by airplane).
- **Geochemical** sampling, analysis and interpretation of local thermal manifestations and bibliographic recompilation.
- N° 1 **slim hole** was drilled in 2007, confirming the presence of a very interesting thermal anomaly with temperature of around **215°C** at only **512 meters**.

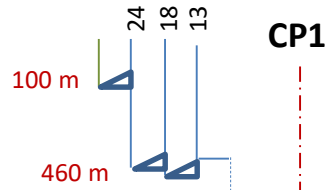




## Location of the 4 deep exploratory wells



# Well CP-1: technical profile & static T-P Log

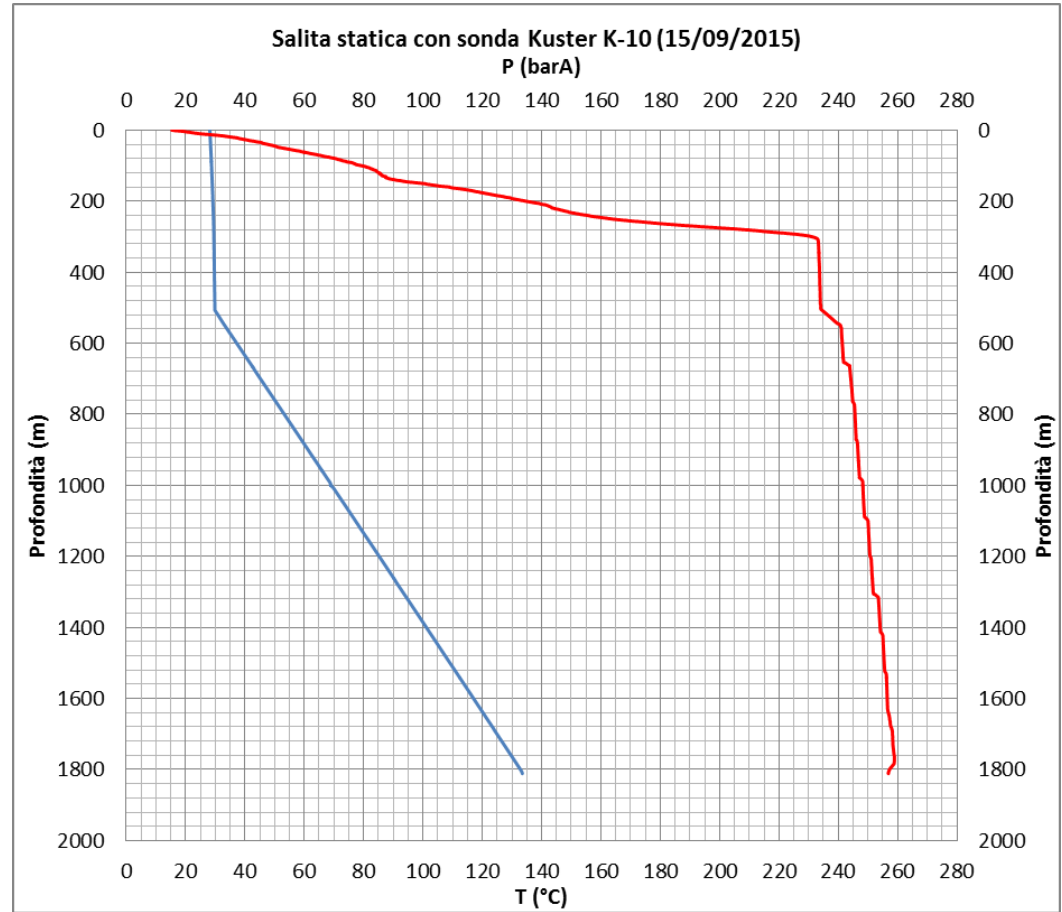


9 5/8 (SLOTTED LINER)

Bottom Hole 1815 m

Inj. Index = 9 m<sup>3</sup>/h/bar

Main fracture 1760 m →



## Well CP-1: production test



Reservoir Temperature  $\sim 260^{\circ} \text{C}$

Flow-rate  $\sim 300 \text{ t/h}$  @ 8 bar WHP





# Cerro Pabellón development program

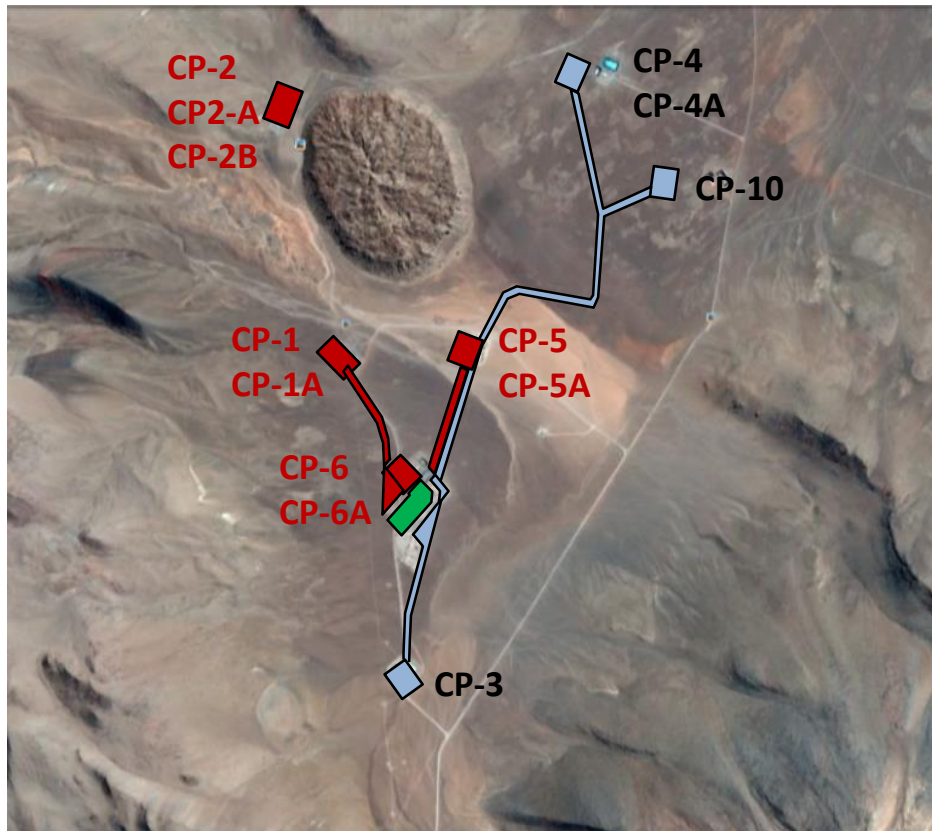
- Accordingly to the positive results of the exploratory wells a resource assessment was carried out and a development program was implemented, including:
  - The drilling of additional wells for production and reinjection purposes
  - The construction of:
    - ✓ 48 MW power plant
    - ✓ Gathering system
    - ✓ 80 km transmission line 220 kV
    - ✓ Camp for 700 people located at 3850 m elevation, at a distance of 25 km from the project area
- Considering the characteristics of the project area a high enthalpy binary plant (HE-ORC) with 2 x 24 MW units was selected



**The first 24 MW unit was put in operation on March 31, 2017  
and the second unit on June 12, 2017**

# Cerro Pabellón

## Project Lay-out and Drilling activity



### ❑ 6 Production Wells

- ❑ CP-1 (exploration)
- ❑ CP-5, CP-5A, CP-1A, CP-6 , CP-6A

### ❑ 48 MW Geothermal Power Plant

- ❑ 24+24 MW gross *High Entalpy Binary*

### ❑ 4 Injection Wells

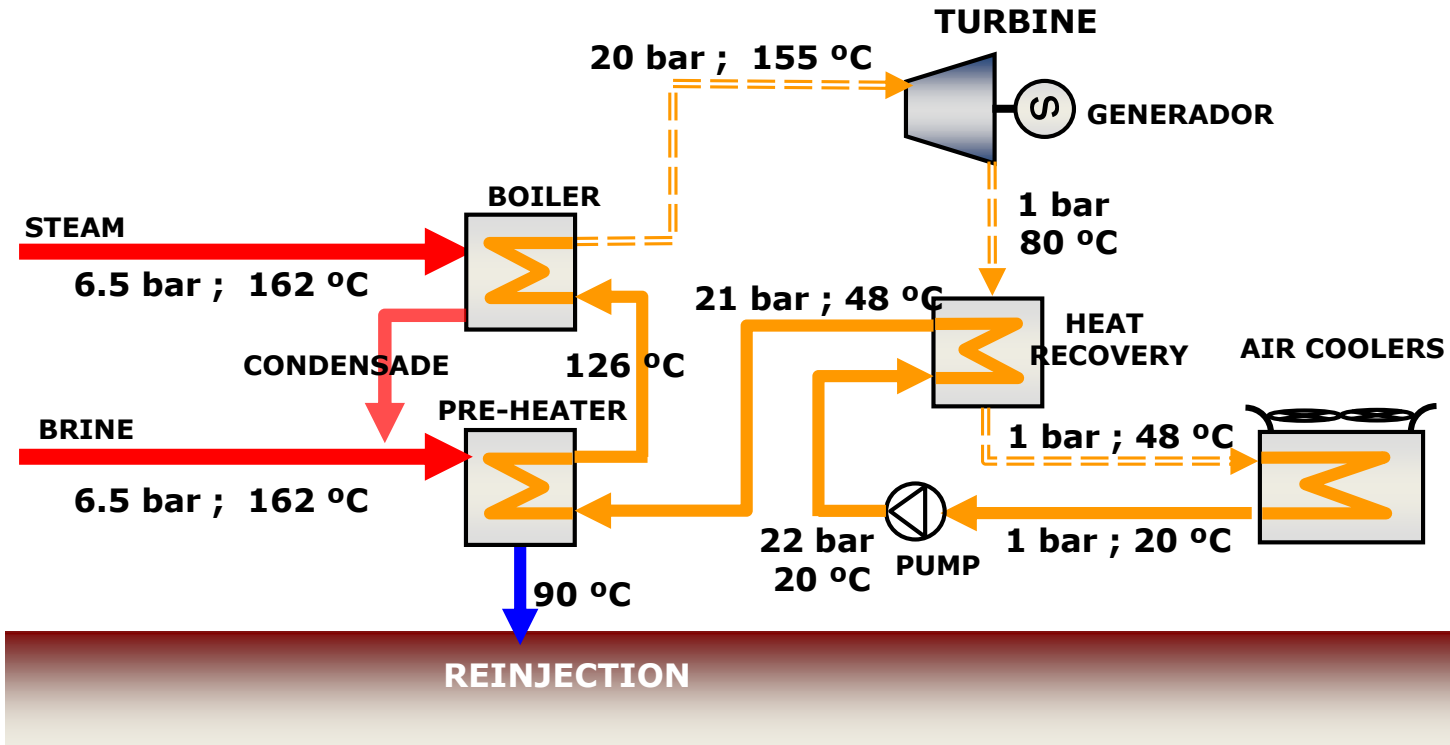
- ❑ CP-3, CP-4 (exploration phase)
- ❑ CP-4A, CP-10

### ❑ 2 Bake-up Production Wells

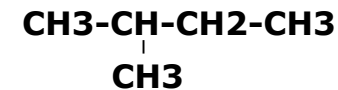
- ❑ CP-2A, CP-2B

Out of the 13 drilled wells only CP-2 is considered not usable for the plant operation

# Flow diagram of the Binary Unit



**ISOPENTANE,  $T_{eb.} = 28 \text{ °C} @ 1 \text{ bar}$**





# HV Transmission line lay-out



**Rated capacity 100 MVA – 220 kV single circuit  
218 Towers - Total length: 80 km**

# The Cerro Pabellón project



**The first geothermal plant in Chile and South America**



# The Cerro Pabellón project





# The Cerro Pabellón project

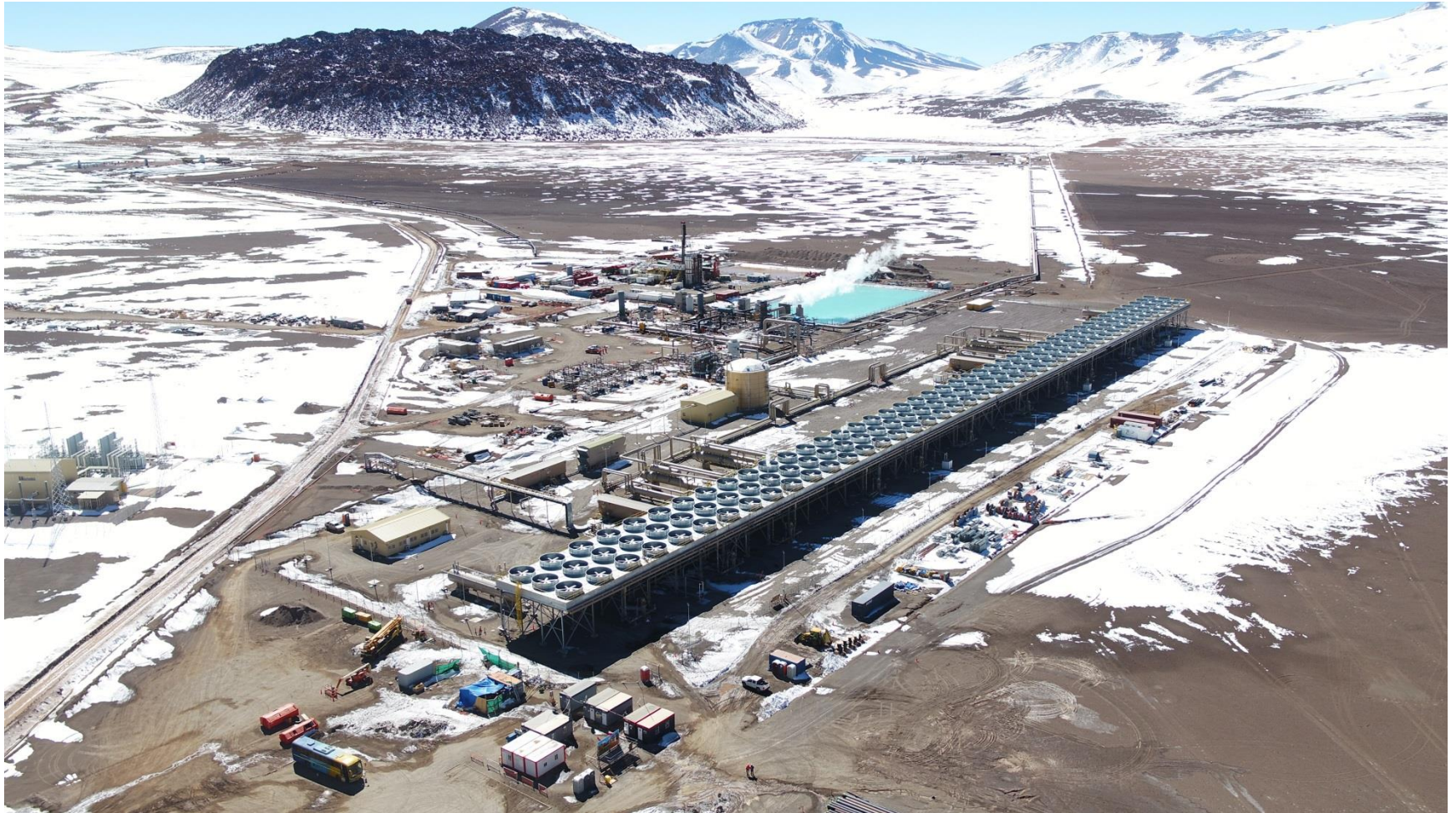


# The Cerro Pabellón project





# The Cerro Pabellón project





# Cerro Pabellón Third Unit

Already approved the construction of an additional **33 MW** unit that will benefit for CapEX reduction thanks to all infrastructures already built up and to the availability of geothermal fluid.

- The expansion of the geothermal project does not require any drilling activity.
- The new unit will lean on the existing gathering system with the additional pipeline for connecting the CP2 well pad (+2 wells).
- 100% integration with existing mechanical, electrical, monitoring and control systems





## CSV – Creating Share Value

In the area of the project there are **6 Indigenous Communities:**  
Ollague, Estacion San Pedro, Cupo, Toconce, Taira y Conchi Viejo

- **Socialization process** together with Ministry of Energy – Division Participation y Dialogue
  - Project description
  - Programs aimed at education, energy, tourism and economic developments
- Constitution of **6 new small companies**, managed by women of the Ollague community that provided several services to the project: cleaning, laundry, transport of personnel, food supply, others.
- **Tourism development program** of the Alto el Loa territory
- **Electrification program**



# Innovation and Sustainability in the Camp “INNOVABILITY”

## Pilot plant for a sustainable electricity generation

A pilot plant 100% free of CO2 emissions, commercial size, composed of a 125 kW PV plant and of a storage system based on Hydrogen and Lithium batteries was installed in the camp. The energy produced 24/7 basis covered the energy needs of waste-water purification plant and of other equipment (utilities).

## Camp Carbon Foot print: CO2 neutralization

To reduce the Camp’s ecological footprint, in addition to our engagement in reducing water consumption with a treatment plant and in recycling the waste, we achieved the complete neutralization of the CO2 footprint. For this initiative we received an award from the Ministry of Environment:

**“Sello de Excelencia en la gestión de gases de efecto invernadero”** Cerro Pabellon was the First Project in Chile to receive this award



# Cerro Pabellón Geothermal Project

## Camp Carbon Footprint: CO2 neutralization



MINISTERIO DE MEDIO  
AMBIENTE

1° EMPRESA EN GESTIONAR  
CON EXCELENCIA LOS GEI





## Cerro Pabellón

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Cerro Pabellón is not a simple geothermal plant, but it was and still is an example of sustainability and technological innovation in all various aspects

# Cerro Pabellón

