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Present Status of the Copahue Geothermal Project

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ABSTRACT

Since 1974, the exploration project for Copahue geothermal field has been developed, taking into account the observed reservoir parameters, the development of this type of energy in the rest of the world, and the economic situation in the country. In 1988 a 670 kWe binary cycle pilot plant was installed in the field.

A technical-economic feasibility study was concluded in 1992. By that time, the global political and economic scenario had undergone a profound shift, in Argentina as elsewhere. Within this new model, radical changes were made to existing regulations, including the privatization of the electric energy production, transport and distribution sectors throughout the country. In 1996-97, Neuquén Province launched a district heating project for Copahue village.

Because of the changes on the economic and political scene, there was a renewal of interest and encouragement in developing the Neuquén geothermal project.

1. INTRODUCTION

The Copahue geothermal field is located on the western border of Argentina with Chile, in the Province of Neuquén, at approximately 37°S, 71°W. It is in the Andes, at an altitude ranging between 1600 and 2900 meters, in the Copahue-Caviahue semi-elliptical valley, which runs NS for about 15 km and EW for 20 km.

The valley is a volcanic caldera that formed during the effusive evolution of this complex, which began about 4.3 million years ago, during the Pliocene (Linares et al., 1999); the last phase of this evolution, which began about 1 million years ago, in the Upper Pleistocene, created the present-day Copahue volcano.

The Copahue eruptive complex characterized (and gave its name) to a system of volcanic complexes known collectively as the "Zócalo Volcánico de Copahue" (Copahue volcanic basement) (Ramos, 1978), which covers a surface area of about 10,000 km^2 in the central-western part of Neuquén Province. East of this area there are sediments of the Mesozoic Neuquén Basin, characterized by hydrocarbon deposits. The majority of the oil and gas produced in Argentina comes from Neuquén Province.

The bottom of the valley dips ENE, from an altitude of 1700 – 1800 m in the west to about 1500 m in the northeast. Bordering the valley, at an elevation of over 2000 m, is a flat-peak mountain chain; Copahue volcano, in the western part of the valley, is an exception, with an altitude of 2977 m.

Copahue volcano is covered by glaciers and snow packs. Glaciers covered the area and eroded the surface in Pleistocene time. Glacial striae can be found all over the central part of the volcano, in places on the bottom of the caldera, and in the valleys surrounding it. The glacial influence can also be seen in the U shape of these valleys. Lake Caviahue (Figure 1), the biggest lake in the region, was also formed by glaciers. There are many streams and lagoons that owe their origins to the particular topographic features of the region, and to intense precipitations.

Annual precipitation in the area is around 2000 mm, most of it coming from snowfalls in winter. The snowy season lasts approximately from May to November.

Figure 1: Aerial view of Lake Agrio or Caviahue in winter

This region is famous for its thermal springs. There are eight sites, known as the Termas de Copahue, Las Máquinas, Las Maquinitas, El Anfiteatro, West of COP-2, Crater Lagoon, Volcano Water Spring and Chancho Co (which is located in Chile). Some of them are used for balneotherapy, with facilities for this purpose at Termas de Copahue and Las Máquinas. The water of the Volcano Spring is also used for balneotherapy in Termas de Copahue and in Caviahue.

There are two villages in the area, Caviahue and Termas de Copahue, whose main activity is tourism. Caviahue has a population of about 500 throughout the year and was created in April 1986. Copahue village, on the other hand, does not have a permanent population, because of weather conditions during winter. From June to September, no one lives in the village except security guards. The area has been famous throughout history, the native peoples using the thermal springs for their beneficial properties. There are records of the utilization of these springs for therapeutic purposes dating back to the beginning of the last century .

The geographical characteristics of the region of Copahue, its landscape, with streams, waterfalls and the characteristics Araucarias forests; the six-month skiing season, and the other adventure sports available, along with the thermal resources described above, have made this region increasingly attractive as a tourist spot over the last few years. There are accordingly projects for hotels and tourist facilities that would increase the current availability of 1200 beds to more than 3000 in about three years.

Figure 2: Stream "Arroyo Agrio" with the waterfall "Cascada del Basalto", near Caviahue village.

2. HISTORY OF THE GEOTHERMAL PROJECT

Exploration of the Copahue geothermal field began in 1974, and was developed in different stages, the first of which consisted of geological, geochemical, and gravity surveys, as well as gradient wells. In 1976 work began on drilling the first deep exploration well (COP-1). The second stage of the project began in 1980, with new studies of the geology, the geochemistry of the fluids, and geophysics (with vertical electrical soundings-VES). In 1981 well COP-1 was technically modified and completed (1414 m depth). The well data were satisfactory, and the borehole produced superheated steam.

In 1986, the second well, COP-2 (1240 m depth), also produced superheated steam. In 1988 a binary-cycle pilot plant was installed on the COP-1 site, with a capacity of 0.67 MWe. In that same year, work began on a technical - economic feasibility study, with the cooperation of the Japan International Cooperation Agency (JICA-EPEN, 1992).

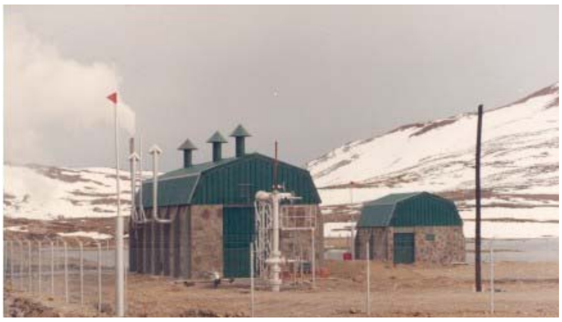

Figure 3: The Power Plant located at the COP - 1

This study included the drilling of well COP-3, to a depth of 1067 m, which again produced superheated steam. It was estimated that the well could produce about 60 t/h of steam, and the final report provided encouraging indications for the installation of a 30 MWe geothermal power plant. At Figure 8, we can see a Columnar Section of this three first wells drilled at Copahue. At that time, the political and economical scenario underwent some profound modifications in Argentina, following on similar changes on an international level. This led to the privatization of electric energy production, transport and distribution throughout Argentina.

In 1997-98, Neuquén Province implemented a district-heating project in the village of Copahue, using geothermal vapor to heat the streets, and the supply of steam to heat buildings in the village. This system consists in a pipe imbedded in concrete plates. The coils transport the geothermal steam, which condensate transmiting its temperature to the environment. By this way, the temperature is transferred by conduction, convection and radiation.

In some tests carried out, were obtained that with environment temperatures from 0 to –15°C, and winds of 65 km/h; the temperature of two test plates, maintained over 5°C, without snow covering them; even in this area, the amount of snow were over 4.5 m of depth. The steam feeding to the pipe system were constant with a pressure of about 0.2 Mpa and a temperature of 121°C. The maximun consumption of vapor were 50 Kg/h/plate.

The total length of the heating system is 1880 m, with plates of 7.5 and 6.5 m of width and a thickness of 0.20 m. The steam consumption rate is about 37 kg/h/plate; and the tube heaters are made by carbon steel, type ASTM A 106 Gr B.

The system is feed by two wells, COP-2 and COP-4; and the steam is transported by a pipe of 2396 m of length.

Figure 4: A street in Copahue village showing the geothermal heating system.

From the measurements carried out in the four wells drilled in this field, we obtained the following reservoir parameters:

- Well COP-1: static temperature = 250°C
  static pressure = 4.0 MPa
  flow rate = 12 – 15 t/h (1.0 – 1.4 MPa)
- Well COP-2: static temperature = 235°C
  static pressure = 3.5 MPa
  flow rate = 6 t/h (0.6 MPa)
- Well COP-3: static temperature = 240°C
  static pressure = 4.0 MPa
  flow-rate: 50 – 60 t/h (1.0 MPa) (calc.)
- Well COP-4: static temperature = 235°C
  static pressure = 4.0 MPa
  flow rate = 50 t/h (1.0 MPa)

Studies on rock samples from the wells also revealed some interesting data with implications for the reservoir, including the presence of alteration minerals such as Ca - zeolites, stilbite, laumontite and wairakite, accompanied by epidote, prehnite, garnet, chlorite and tremolite, which occur within a temperature range of 200°C - 300°C (Mas et al., 1995). This information was also confirmed by the study of the fluid inclusions (Mas et al., 1993), which found filling temperatures from 240 to 280°C in the quartz coexisting with wairakite.

Figure 5: COP-4 well and the steam pipeline, with Copahue volcano in the background.

From other studies, it was determined that there is a strong structural control over the geothermal reservoir (Mas et al., 2000)¸ which was confirmed during drilling. These data and the results of the geophysical and geochemical surveys indicate the presence of high-temperature geothermal resources below the depths drilled so far.

There is a fault system that affected this volcanic complex; which main direction is N55W and their associated are N55E, EW and N40W.

The geothermal reservoir is placed predominantly in zones of secondary permeability, in calcalkaline lavas and piroclastic rocks of Las Mellizas Formation, and is constituted in the known levels by overheated steam.

Between the studies mentioned above, there is a Heat Flow Distribution Map, which was performed with the data obtained from 12 wells drilled for this purpose, with depths that ranged from 50 to 200 meters.

This map shows the distribution of this parameter in an area of about 100 Km^2, with values over the world rate of 60 $mW.m^{-2}$. This data allows to consider that the thermal anomaly is important, with peaks values six times over the world rate.

The comparative analysis of the heat flow distribution with the tectonic scheme of this area, shows the correlation that exists between the axe of the elongated area of the higher values of heat flow, with the main structural lineament of this zone, recognized by traditional methods as geology and remote sensors evaluation. The heat flow distribution map also shows that there is a zone of potential interest near the village of Caviahue. These assumptions have all to be confirmed.

3. PRESENT STATUS

After the change of economic and political conditions encouragement was given to implementing the Neuquén Geothermal Project. EPEN (Ente Provincial de Energía del Neuquén), the company responsible for supplying energy to most of Neuquén Province, has thus started work to put the geothermal power plant in operation again. The plant had previously been abandoned because of operational problems. EPEN is also re-launching the project to install a higher-capacity power plant that would provide the energy needed in this zone.

With the tourist development projects now under way, the energy requirements in the area have increased and will in the near future exceed the capacity of the transmission line connected to the Provincial Interconnected System. To give some idea of the growth expected in this zone, we need only consider the increase in hotel capacity cited above; the clientele is predicted to increase by almost 300% from the present-day 1200 to more than 3000 customers. The main growth will take place in Caviahue, although there are other projects in Copahue. Estimates of future energy requirements must also account for the new ski facilities for Copahue mountain.

The growth in energy requirements will also be affected by the increased demand for heating, as this region is characterized by extremely low temperatures during several months of the winter season. Although Neuquén Province is well endowed with natural gas, the gas fields are far from Copahue, and there is no gas pipeline to this zone. Currently, liquid petroleum gas, diesel or oil are used for heating, at high cost.

To solve the problem of the increasing energy demand, a number of projects have been drawn up, one of which consists of putting the 0.67 MWe power plant at well COP-1 back into service. The work is under way at present, with a fair probability of starting operations next summer season. Another project is to put into operation the second phase of the district-heating project at the Copahue village; in this phase the geothermal fluid will be used to heat buildings. These two projects are at an advanced stage of development, because they will use facilities that are already installed.

There are another two projects under evaluation, to increase the energy available: a new 5 MWe geothermal power plant and a district-heating system in Caviahue village. For both projects, there are now about 70 t/h of steam available at the surface, without considering well COP-3, which has been abandoned for operative and environmental reasons. If the demand continues to grow, the resources are estimated to be capable of feeding a plant of about 30 MWe capacity (JICA-EPEN, 1992).

4. DISCUSSION

The research and development project at Copahue geothermal field has been under way for more than thirty years, and the results obtained so far have been satisfactory. The studies have identified a reservoir containing superheated steam, with a temperature over 240°C and pressure of about 4.0 MPa. The resources proved by these studies could feed a power plant of 30 MWe.

Some of the results of these studies suggest that the reservoir could extend to greater depths and over a wider area than covered by the studies. The parameters of the resources at the deeper levels would be higher.

Based on the growth in population and the tourist facilities, the demand for energy is likely to increase in the near future in Caviahue and in Copahue. This increase in demand would be satisfied by geothermal resources.

The first phase would be the generation of electricity in the 0.67 MWe plant, to meet the current energy demand; the second phase would consist of a 5 MWe plant for a reasonable future projection of growth, followed by a 30 MWe plant for an energy export project.

With regard to the heating supply, this would mean the operation of the Copahue heating system, and the installation of a heating system in Caviahue village.

5. CONCLUSIONS

The existence of a geothermal field with interesting characteristics, in a region with an important tourist development project would boost the economic feasibility of the tourist projects, and the consequent possibility for economic development of this region.

Another option (non-geothermal) for meeting the energy demand is to make important investments in the transport systems, with an improved electrical power line that would replace or reinforce the present line. The options for heating are either the liquid petroleum gas, diesel oil or fuel oil used currently, which are expensive, or the construction of a gas pipeline from a trunk pipeline.

One of the benefits of utilizing the geothermal resource for electricity generation and space heating is the reliability of the energy source since generation takes place in the same place as the source. Although the forms of utilization would in the beginning be restricted to electricity generation or space heating, as the project evolves the resources could be used for balneotherapy, swimming pools, greenhouses, etc. It should be noted that these activities already exist or are planned.

Another benefit that would derive from a geothermal project in Copahue is that the project could be developed on a reasonable time scale, increasing the investment when necessary or as the energy demand increases.

Last, but not least, this project means using a renewable energy source in the same place in which it is produced, without having to import a fossil fuel, with the consequent advantage with regard to the environment.

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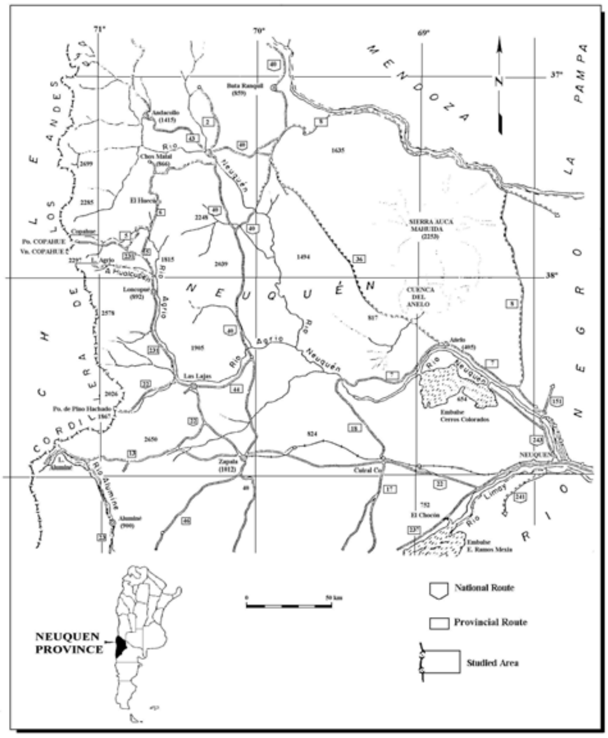

Figure 6: Location Map of the Studied Area - Based on Latinoconsults (1980) and JICA (1992).

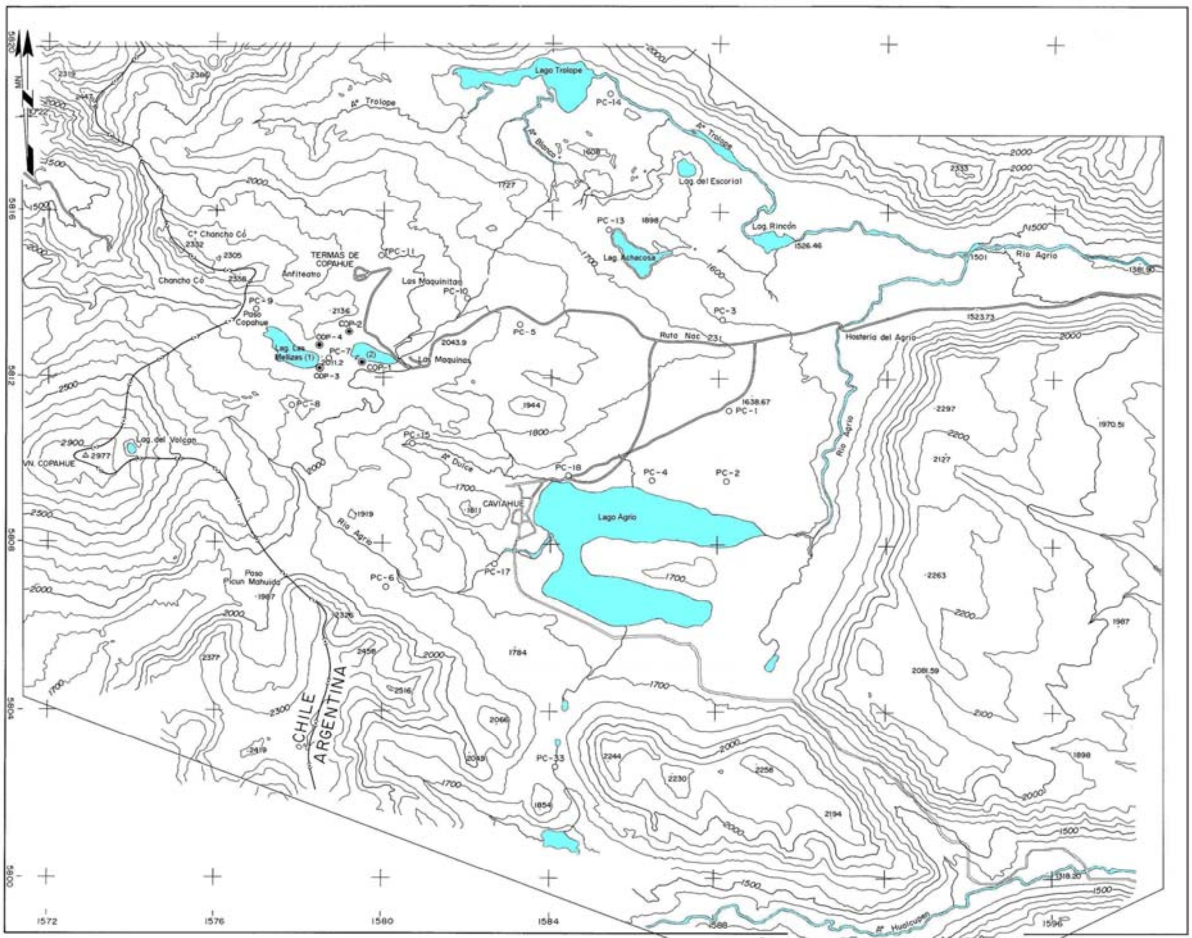

Figure 7: Copahue Topographic Map

Legend: ○ Thermal Gradient Hole

◉ Geothermal Well

0 2000 4000m

Based on Latinoconsult (1980) and JICA (1992)

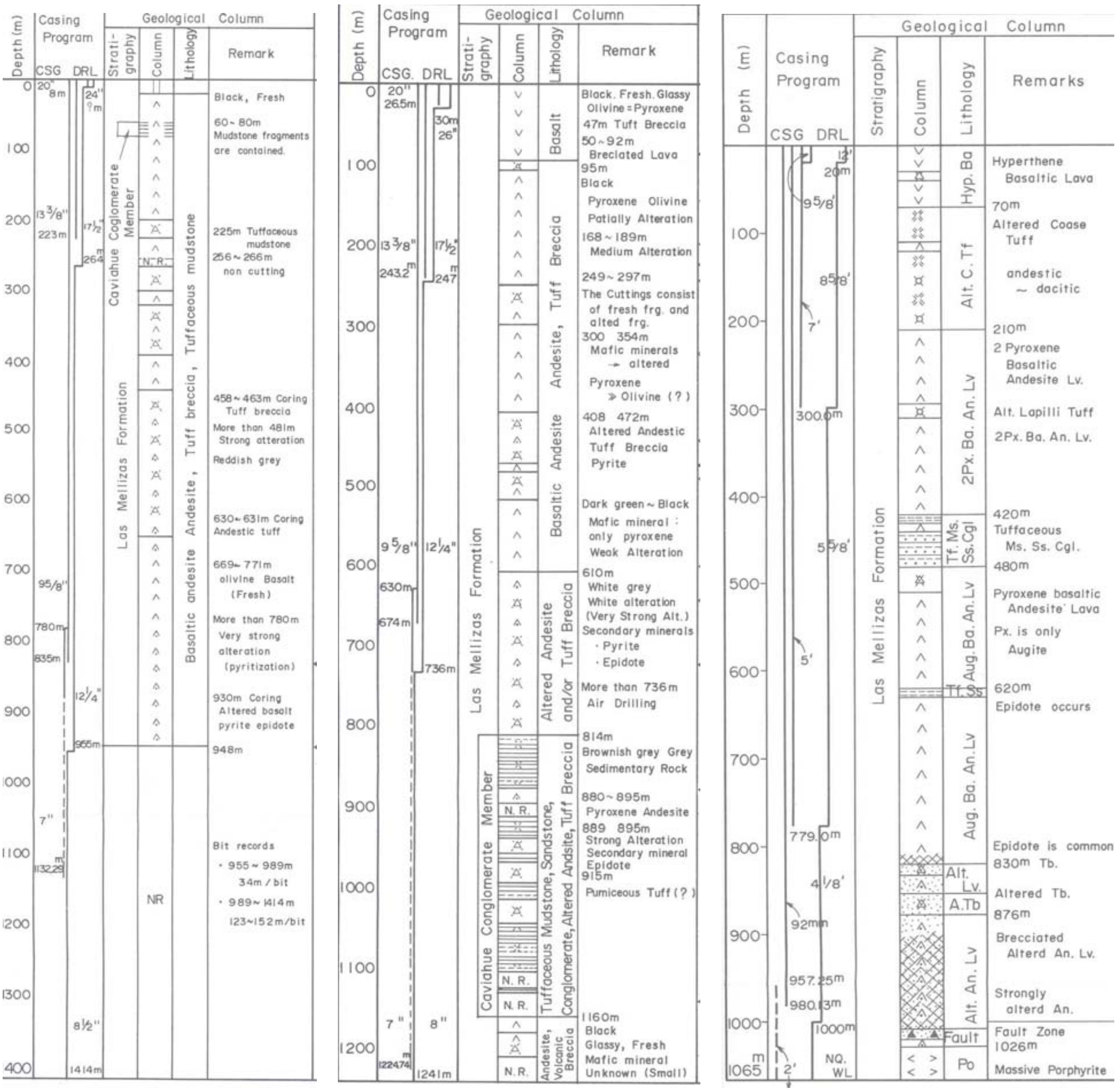

Figure 8: Columnar Sections of the wells COP – 1, COP – 2 and COP – 3; based on JICA (1992).