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# The First Geothermal Exploration Well in Ecuador

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## ABSTRACT

Drilling is the breaking inertia experience that every geothermal project is looking for. All the surface exploration and conceptual models are confirmed or discarded by wells. The first well in Ecuador represents, so far, the most important milestone in its road to developing geothermal electricity. PEC 1 was drilled to 1978 m depth in 2017, through Japanese Cooperation to the National Utility CELEC EP, representing a totally groundbreaking experience for Ecuador.

The Chachimbiro project has been studied since the 1980s when INECEL collected information and classified some of the geothermal projects until the geothermal department was closed in the 1990s. The former Ministry of Electricity and Renewable Energies appointed CELEC EP in 2010 to develop geothermal projects. In 2011 to 2012 a complete surface exploration took place. The drilling stage took some years and many complications in technical, political, financial, and legal aspects. In addition, even though Ecuador is a producer of oil, the availability of equipment and experience had to be complemented to reach the first geothermal well.

The drilling of PEC-1 confirmed a geothermal system with a cap rock of ≈300 m thickness, hosted in Pleistocene volcanic deposits from the Chachimbiro volcanic complex. Multiple fracture zones cross the basal rocks of Chachimbiro, and Cretaceous rocks; as well as a propylitic alteration zone in the final stages of the drilling was found.

PEC-1 is analyzed in all its aspects like financing, institutions, logistics, equipment, procurement, local capacity building, results, social and environmental that were involved in accomplishing the target. Geothermal development is quite complex, and feedback plays a key role in the next steps. A set of lessons learned in each aspect are presented to finalize in conclusions that could be considered for the next stage and any other country starting geothermal development.

## 1. INTRODUCTION

The first geothermal well of Ecuador "PEC-1" is located 100 km north of the capital city, Quito. It lies on Pleistocene volcanoclastic deposits from the Chachimbiro volcanic complex at 3525 masl. The geothermal evidence on the surface includes several hot springs, gas emissions, and hydrothermal alteration zones in the surrounding areas of PEC-1 (Figure 1).

The PEC-1 was drilled in 2017 as a part of CELEC EP – JICA (Corporacion Electrica del Ecuador, in Spanish, and Japan International Cooperative Agency) agreement. It took almost three months to reach the final depth at 1978 m. The PT logging carried out in the well in 2018 found geothermal fluids with high temperatures exceeding the 200ºC, and the initial assessment predicts a 50 MW capacity for the Chachimbiro geothermal project.

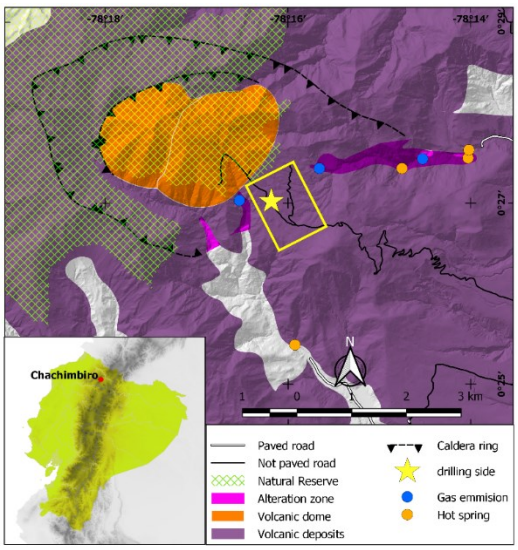


**Figure 1: Location of Chachimbiro geothermal project and the drilling side of PEC-1 (Asimbaya, 2018).**

## 2. PEC-1 EXPERIENCE

Ecuador is an oil producer country, with more than 60 years of experience, and well-developed industry. In contrast, some geothermal exploration was done between 1981 to 1992 and was forgotten until 2008, when the government decided to restart the geothermal projects. The Chachimbiro Project is the most advanced project in Ecuador and the very first experience of drilling (Figure 2).

**Figure 2: Photo during drilling of PEC-1 (September 6th, 2017).**

In the following lines, the PEC-1 experience is told from different points of view to finish with some of the results and the planned next steps.

### 2.1 Financing

The Government of Ecuador decided to restart the geothermal studies after 2009 when a National Geothermal Plan was made for the former Ministry of Electricity and Renewable Energies. Between 2011 - 2012, public funding was allocated through CELEC EP to contract SYR, an Ecuadorian geosciences company, to develop the Initial Prefeasibility studies (geoscientific surface exploration) with an investment of 1.3 MUSD. The studies concluded in a geothermal conceptual model with a proposed deep exploration of slim holes mainly to test temperatures.

Allocation of budget for one slim hole was done, but the lack of experience contracting drilling made it very difficult to advance. In 2014, the former Ministry of Finances requested the Government of Japan for a loan through the Japanese Official Development Assistance (ODA) for a Geothermal Plant Construction Project in Chachimbiro. In response to the Ecuadorian Request, experts from the Japanese International Cooperation Agency (JICA) came to visit and understand the project. They concluded the necessity to make a preparatory study with an exploration well included before giving a loan. The Japanese Government through JICA and the Ecuadorian Government through CELEC EP agreed that JICA would finance (non-reimbursable funds) complementary geoscientific studies, the drilling, the planning of the next stage, and the support of an expert. As a counterpart CELEC EP would acquire geophysical equipment, do civil works along the access routes, install laboratory facilities for geology and geochemistry, ask the permits, assess environmental issues and improve community relations, all of that with a complete staff involved to assure the transfer of technology. The Minutes of Meetings was signed in June 2015. With the results, JICA would analyse the possibility to finance the next stage through an Official Development Assistance (ODA) Engineering and Services Loan.

The committed activities were done from the second quarter of 2016 to the second quarter of 2018, and the total investment was approximately 10 MUSD from JICA and 3 MUSD from CELEC EP (without including salaries). The total investment in the project so far is around 14.3 MUSD.

### 2.2 Institutions

In order to make this work possible, the following institutions were involved representing Ecuadorian Government:

The former Ministry of Electricity and Renewable Energy (MEER) was the ruling body and electric sector planner for efficient public service of electricity. The institution was in charge, among others, of the identification and follow-up of the project executions, the

elaboration of the Electricity Master Plan, the promotion and execution of renewable energy plans and programs, the mechanisms to get electric efficiency based on what is established on the Constitution and the law. This Ministry was in charge of allocating the budget for the new projects through the former Ministry of Finance. In 2018, the MEER merged with the Ministry of Hydrocarbons and the Ministry of Mining to form the Ministry of Energy and Natural Non-Renewable Resources (MERNNR).

The former Ministry of Finances (MF) was in charge, among others, of the indebtedness in the best possible conditions. In 2017, The Ministry of Finances and Ministry of Economic Policy Coordination merged into the Ministry of Economy and Finance (MEF) of Ecuador, the State portfolio responsible for the economic and financial policy of the country. MF officially requested the ODA Loan to the Japanese Government for the Chachimbiro project in 2014. Everything was in line with the National Development Plan established by the former National Secretariat of Planning and Development, now National Secretariat "Planifica Ecuador", which prioritized the projects of national interest.

The Strategic Public Company Electrical Corporation of Ecuador CELEC EP (Corporación Eléctrica del Ecuador in Spanish), which was commissioned to develop geothermal power projects since 2010 by the former Ministry of Electricity and Renewable Energy, through the Official letter No. 882-DM-SGP-2010. CELEC EP is a state-owned company in charge of carrying out the generation and the complete transmission of electricity in Ecuador. The installed capacity of CELEC EP is 6,366 MW (CELEC EP, 2019); it means 90% of the generation capacity of the country.

CELEC EP has 14 branches, and this study was carried out by the branch Termopichincha, led by its Projects Department in coordination with people from other departments. The Projects Department was conducting, among other things, research on renewable energy projects as wind, biofuel, solar and geothermal. Nowadays, the development of projects passed to the Planning of Expansion Department in the Headquarters of CELEC EP. The next stage of the project should be approved by the Board of Director of CELEC EP.

The members of the Board of Directors of CELEC EP are the Minister of Energy and Non-Renewable Natural Resources, the President of Ecuador's Coordinator of Public Companies (Spanish acronym EMCO) and a Delegate of the President of the Republic, according to CELEC EP, 2019.

Representing the Japanese Government, the Japanese Embassy had an important role in managing the Ecuadorian request through the Ministry of Foreign Affairs of Japan. The Japanese International Cooperation Agency (JICA) was the executor of the appraisal of the project and the contracting of the consultants to develop the preparatory study mentioned before.

### 2.3 Procurement

JICA contracted the consortium Mitsubishi Materials Techno Corporation and the Mitsubishi Materials Corporation (MMTEC) to carry out the Preparatory Study. This study included complementary geology, geochemistry sampling, and geophysics (MT and Gravimetry) to improve the level of current studies and converge in a constrained model with a drilling target. After the studies mentioned, MMTEC opened tender processes for services and goods. The following procurements were awarded: Casing to Tenaris, casing accessories, and casing head to Mission Petroleum, wellhead to TNG, liner hanger to TIW, logging tools to Kuster, slickline service to Equipetrol, cementing and Integrated drilling services to Halliburton (Rig from Petroworks and Noroccidental for rig mobilization) and mud services to Cetagua. The Mexican consultancy company ENAL also supported MMTEC. All the procurements were private to private, this makes a big difference with the procurements that CELEC EP must do in the future because the tenders should follow the financer rules (normally FIDIC), the public procurement law or to tailor specific rules as the National Oil Company does. Some of the people from the contracted companies are shown in Figure 3.

**Figure 3: Last drilling day of PEC-1 (November 19th, 2017).**

### 2.4 Equipment

Ecuador is an oil country; for this reason, most of the equipment can be found in the local market. Finding the drilling rig was quite a challenge due to the site conditions (around 3500 masl). Large equipment is usually used in the oil field, but for the Chachimbiro Geothermal project, a compact drill rig that could climb up to the site was required. At the drilling site, most of the afternoons were foggy. Therefore, it was necessary that the distance between the rotary table and the drilling pipe handling were close enough to see all kinds of maneuverings to install the casing and drilling pipes. The drilling rig selected was the HH 220 Drillmec which is a compact rig that can be installed in small pads due to area restrictions. The rig belongs to the Company Petroworks in Colombia.

### 2.5 Logistics

Logistic was one of the most challenging aspects of the study. Customs procedures to temporary import were done with the support of CELEC EP experts since public companies do not pay taxes in this kind of projects. Moving big cargos from Colombia, cross the borders and travel on the Ecuadorian roads required the support from police and Urcuqui's firemen department. For most of the local people, it was the first time they saw a large truck. Convoys passed through small towns like Urcuqui, Azaya, and Cochapata. All the time, convoys had a leading car provided by the Police or Urcuqui's firemen department. The leading car depends on the road that the convoy was passing through. The social specialist had to hold meetings with local authorities, community leaders, police and firemen department in order to inform them which kind of cargo would be moving, and which ones were the risk to local people.

Due to the sinuous of the access road, two power tractors assisted the large cargo. It was required to keep all parties communicated all the time to avoid accidents. On the other hand, during the well drilling, special tools were required. It was important to count with companies who had experience in drilling field to give quick support. A challenge that must cope in future geothermal projects is that Ecuador has not a large market to provide cheap and quick solutions.

Regarding the laboratory analysis of cuttings, these were made in Japanese labs and CELEC EP developing lab, having good results for thin sections and X-ray diffraction.

### 2.6 Professionals and local capacity building

The gradual advance in the exploration of the geothermal resource in Ecuador was caused by the lack of technicians who are interested in developing the geothermal projects in Ecuadorian territory. For that reason, for developing the Chachimbiro geothermal project, it was included a strengthening of local capacities and infrastructure through the JICA-CELEC EP cooperation.

CELEC EP-Termopichincha strengthened its laboratory with equipment for water, gases, and rock analysis with geothermal purposes; as well as it acquired geophysical equipment for geothermal resources exploration.

On behalf of JICA, there was a geothermal specialist who, in joint work with CELEC EP project specialists, led and managed the project activities. Also, during the project execution, the capabilities of the CELEC EP technicians were strengthened as follows (Table 1):

| Stage | N° | Specialist | Capacity building |
|---|---|---|---|
| EXPLORATION | 2 | Geologist | Mapping and sampling in a geothermal context. |
| | 2 | Chemists | Geothermal fluid Sampling and interpretation. |
| | 1 | Geologist | Installation, analyses, and interpretation of geophysics data. |
| | 1 | Electromechanical Engineer | |
| | 1 | Sociologist | Socialization of geothermal project activities. |
| DRILLING | 3 | Mechanical engineer | Drilling and reservoir engineering. |
| | 1 | Electromechanical Engineer | |
| | 2 | Electrical Engineer | |
| | 1 | Civil Engineer | Inspection of civil works. |
| | 1 | Geologist | Analysis and interpretation through DRX technique. |
| | 2 | Geologist | Cutting sample analysis with a geothermal context. |

**Table 1: Number of Ecuadorian specialists worked in the exploration and drilling stages.**

In addition, two specialists from El Salvador were involved by CETAGUA to joint work with Ecuadorian specialists in the drilling fluid management and people from the surrounding communities were involved during drilling activities in guardianship, catering, road maintenance, and drilling works. The geothermal drilling experience was also new for people involved in the drilling operations. Three Mexican geothermal specialists worked as well in the project, and 8 Japanese experts were involved in the whole project.

Finally, as a result of the activities related to the project, five technicians took specialization courses in geothermal energy. Also, five laboratory specialists made a technical visit to LaGeo laboratory in El Salvador in order to know the implementation methodologies in analysis from samples with a geothermal origin.

Local communities, which are located nearby the project, got a great opportunity to improve its life quality. Local people were involved during the whole study, either working directly or indirectly. Training programs were carried out by government entities address to the local people so that they can provide unskilled labor. Local communities were also provided with new water pipes that guarantee that the people receive clean water.

CELEC's technical staff that were involved in the study shared and obtained knowledge and new experiences from international experts that worked on the study. This sharing creates a greater capacity in Ecuador to develop new geothermal projects. Local companies that were involved in the study also obtained new experiences in the geothermal field, which is a new field in Ecuador.

**2.7 Social**

The Project is located in the canton Urcuqui, mostly rural with 16,976 inhabitants, with an average age of 30 years old. Urcuqui is one of the smallest places inland with 778.8 $km^2$. The most important business activities are agriculture and cattle raising, followed by services in the town, and tourism, because of the thermal springs in Chachimbiro and Timbuyacu. Recently, Yachay Tech University had generated employees in the construction, catering services, among others. The unsatisfied basic needs are around 72.5%, and the illiteracy rate is around 12.4% (over 15 years old), and women are almost double than men. On the other hand, the school dropout is around 20.8%, and this reflects the parents' little commitment to keep their children in the educational system. The 88.63% of the population has a primary school formation, 42.72% reach high school, and just 9.73% goes to University, according to the Development and Territorial Ordering Plan of the Municipality (GAD Urcuqui, 2014).

The Social Management of the project had been focused on three levels: communities, public, and private institutions. So far, the social and political viability has been achieved by the field surveys and the first exploratory well. The closest communities are two villages on the route to the project, the first one is Azaya with 80 families and the second one is Cochapata with 20 families. Azaya is closer to Urcuqui town, the municipal headquarter, and their main occupations are farming, and construction works. Cochapata is nearby the project area, and their main occupation is farming. Two nearby communities are considered for the next stage of the project, Ajumbuela and Pinguchela conformed by around 150 families.

The project's acceptance is good, and these communities provided unskilled labor during civil works and drilling. An organized group of women in Azaya provided catering services for the civil workers and during rig mob and demobbed. The communities trust in the developing of geothermal, and they see possibilities to generate benefits and opportunities in the future. CELEC EP had been careful about avoiding the creation of false expectations. People know that long-term projects like geothermal always help to improve the quality of life of the population, and it is framed on the Ecuadorian Constitution as well (Tanya Cobos personal communication).

Part of the activities to strengthen the community relations were: dissemination campaigns to inform about activities in the area, support to community development initiatives in health, education and sanitary infrastructure; attention to vulnerable groups to health campaign and nutrition workshop for the elderly in coordination with Health Ministry. In addition, tax and handling food safety training were provided by CELEC EP. Everything was done in coordination with the community leaders.

On the other hand, the public institutions as the municipality and local authorities were supporting the project. CELEC EP had coordinated the social activities with them and provided as much information as they requested. Furthermore, the permits for construction were managed with Urcuqui's firemen department. The police were informed, and they together helped to coordinate the transit and safety during transportation of the rig and equipment.

Yachay, the University and public company located in the area, was an important actor too. It temporarily gave their use of water permit to CELEC EP, this with the authorization of the National Secretariat for Water SENAGUA through a Cooperation agreement. The university also has a Geoscience faculty, and they could take part in the research in the future. Other public stakeholders were the Secretariat for Risk Management, Ministry of Environment, Ministry of Health, Chachimbiro EP (public baths), and Imbabura Geopark project, among others.

At the same time, the relations with private actors were strengthened. Since Chachimbiro is a touristic zone, some entrepreneurs are concerned about possible earthquakes and decrease in hot springs. It became important to implement a good communication plan. The owner of the land is in the wood-based industry NOVOPAN, who had always shown openness to the investigation of this project and signed a cooperation agreement with CELEC EP for the use of the land.

In summary, social management is crucial to advance in the project. Involving the communities in the process, mapping all the private and public stakeholders and communication had been the strategy of CELEC EP to carry out this project so far.

**2.8 Environmental**

In the Ecuadorian Constitution, nature is a subject of rights. In accordance, it is mandatory to be as careful as possible when new projects are being set and to have coordination with the National Authority, which is the Ministry of Environment (MAE). All the regulations about this issue are in the Environmental Management Law (Ley de Gestion Ambiental in Spanish) and the Unified Text of Environmental Legislation (TULAS Texto Unificado de Legislación Ambiental in Spanish) for the electricity sector.

According to the Ecuadorian regulation, geothermal projects are considered to be for electrical developments, so they must follow the environmental requirements for this kind of projects. In this context, for projects with less than 10 MW or research stages, it is not necessary to ask for a license, but the project must have an Environmental Management Plan that should be sent to the Environmental Authority for their information and so it could be supervised anytime. The Environmental Management plan includes: a) Impact prevention and mitigation program, b) Waste management program, c) Community relation program, d) Health and

industrial safety program, e) Environmental education, diffusion, and training program, f) Abandonment and rehabilitation program, g) Response program for emergency and contingency and g) Monitoring, follow-up, and evaluation program.

During drilling, Environmental, Health, and Safety were some of the main concerns. Not only in the drilling pad, but also in the route and the possible effects on the nearby communities. One example of this was the no transit policy during entry and exit times of local schools in the route of transportation. Many informative talks and discussions took place, and the constant follow up was imperative such as daily reports, talks with stakeholders, and monitoring visits. Some small incidents happened, for instance, the break of Azaya electricity cable during heavy equipment transportation. Nonetheless, the speed of response of the companies and the utility was very short, and the continuous feedback contributed to improving the whole operation.

Moreover, since Chachimbiro is located around 3500 masl, health checkups and breathalyzer test were mandatory. As well, safety was an important factor to comply, among other things, the speed of cars was strictly controlled, and the use of personal protection equipment. Another thing to take care about was the fact that the drilling area was surrounded by a private pine forest and close the Cotacachi Cayapas National Park, so fire campaigns were launched and a controlled smoke place installed.

Environmental care is fundamental for any project, and PEC1 experience was not an exception. The joint work between CELEC EP, the companies' staff, communities, social specialists, and JICA reached a final good result and many lessons learned for the next stages.

### 2.9 Technical results

The objective of the study of the Chachimbiro Geothermal Project was to confirm the existence of geothermal resource by identifying three main parameters: Temperature greater than or equal to 200°C, permeable rock and geothermal fluid. In order to reach that objective, an exploration well was proposed to drill.

In 2016, MMTEC, together with CELEC EP carried out some geoscience studies, and its output was the drilling target based on the conceptual model shown in figure 2. At the end of August 2017, the first geothermal drilling in Ecuador started drilling. The geothermal well was completed at 1978 meters depth on November 11th, 2017 (Figure 4).

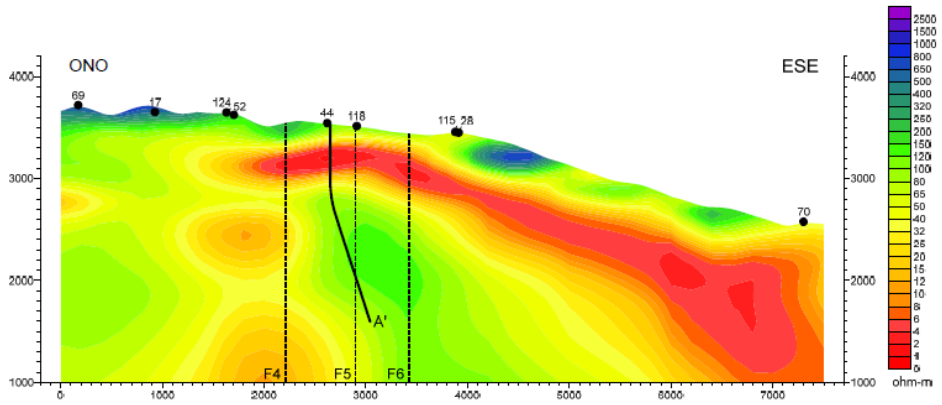


**Figure 4: Cross-section of the resistivity model showing the drilling target (MMTECH-JICA-CELEC, 2016).**

During the well drilling, several lost circulations were recorded due to the presence of fractures zones, as in Figure 3. Therefore, some lithological samples could not be collected, and cementing operations increased significantly from what it was planned. In total 18, cement plugs were carried out; hence, the total drilling days went up from 71, what it was originally planned, to 82 days.

The drilling of PEC-1 crossed the dacitic volcanoclastic deposits, and andesitic to dacitic lava flows from the Pleistocene Chachimbiro volcanic complex, as well as two core samples, which were taken in the last drilling stage, confirmed volcanic and sedimentary rocks from the cretaceous basement, as in Figure 5.

An argillic alteration zone related to the caprock of the geothermal system was found hosted in the andesitic to dacitic deposits from the Chachimbiro volcanic complex. Fault and fracture zones were showed in the drilling cuttings, especially in the last stage of drilling. These features confirm the permeability and fluid inclusion analysis. Also, the propylitic alteration showed a geothermal fluid with temperatures which exceed the 200ºC.

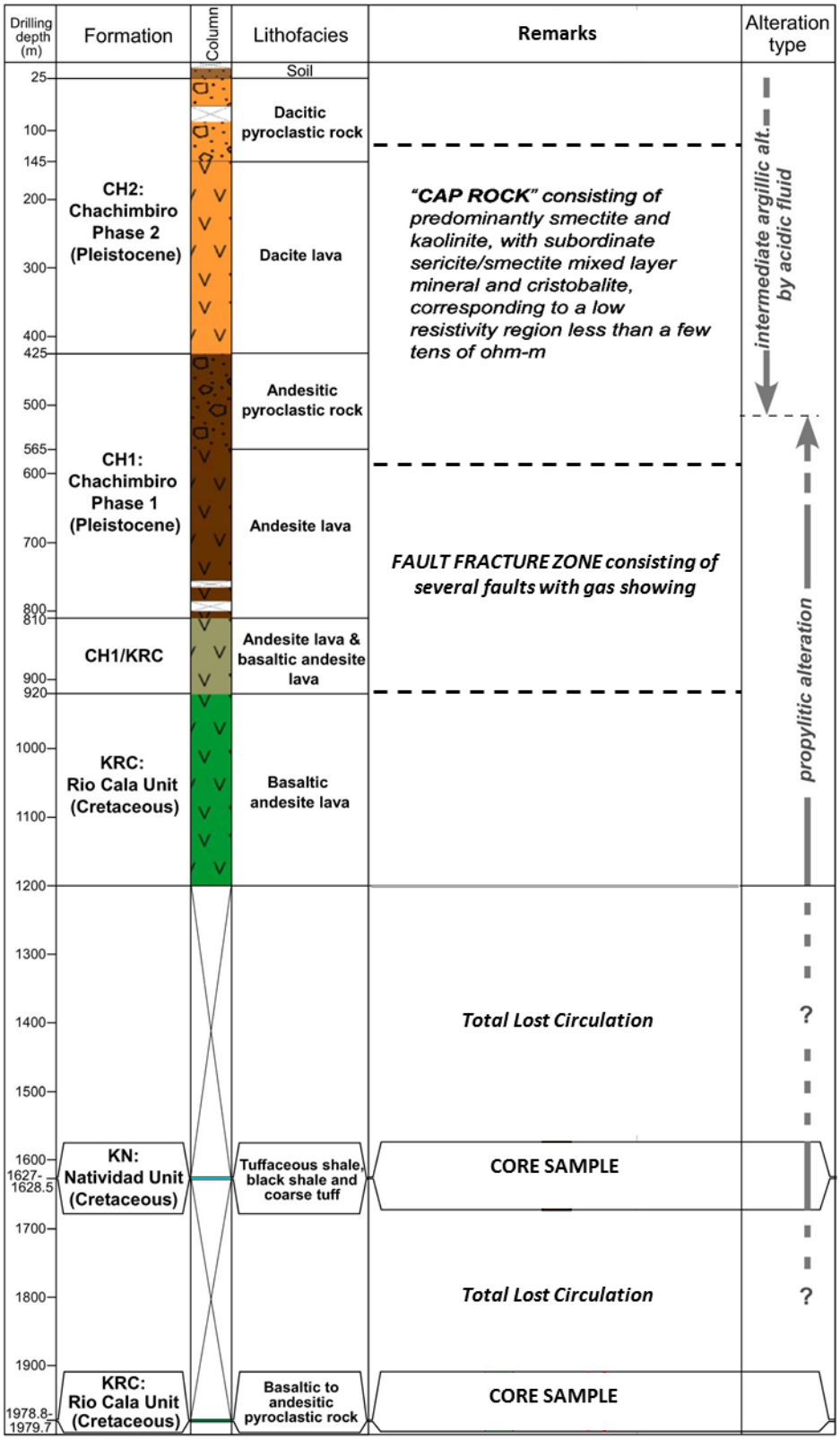


**Figure 5: Summarized borehole stratigraphy and lithology (Modified from (MMTEC-JICA-CELEC, 2016)**

Once the well was concluded, pressure and temperature logging were conducted, as well as injection and fall-off test in order to obtain temperature and pressure profiles and to calculate the permeability-thickness.

### 2.10 Next steps

The next phase will need around 70 MUSD budget and will comprise of drilling of regular size appraisal wells through a drilling contract. Five wells will be drilled in total, of which four will be production wells, drilled to 2500 m depth and one reinjection well drilled up to 2000 m depth. The scope of the drilling contractor will be the provision of drilling services, the supply of drilling materials, and provision of water supply facilities. A wellhead power plant of 5 MW will be constructed on one of the drilled wells

together with a construction of a 22 km long, 13.8 kV transmission line. The existing Yachay substation included in the service contract will also be administered to carry out testing of production wells for the purpose of power plant design.

## 3. LESSONS LEARNED

Some points are very important to consider in further planning. In the following lines, there are mentioned as feedback of the previous section:

- Bilateral and Multilateral Organizations play a key role to boost geothermal in a developing country. The beneficiary countries must show real intentions and efforts to build a power plant.
- Coordination and good communication between Governmental Institutions involved are imperative to reach a common objective. Also, it is important to keep the authorities informed about the benefits of each stage of geothermal and the advance of the project.
- Drilling procurements are very particular and different from other kinds of contracts, and it is recommended to have specialized people with experience to help during the process.
- It is impossible to predict the borehole activities because everything depends on what is underground. It is important to make contracts flexible enough to cover every possibility.
- It is important to differentiate geothermal drilling and oil drilling, especially in oil countries where the prices and services could be affected by the oil market.
- Heavy transport mobilization. Taking the orography into account, the logistic for heavy transport mobilization was a challenge to reach the well pad of PEC 1 located almost on the top of the mountain.
- Coordination with Police, Firemen Department, and any other local institution is imperative to keep order and prevent any incident.
- Before the rig up, facilities for the crew should be installed and ready to use.
- The geothermal industry in a country must build local capacity, it is important to involve local personnel in activities and try to keep the same personnel for the next stages.
- Without good social management, projects are impossible.
- Involve nearby communities in the project assures the continuity of the project. The same with local authorities and local institutions as municipalities, to understand better the social environment in the project and concentrate the benefits of the project where it is more needed.
- Mass communication strategies, education, and training must be part of the Social Plan. It is important to avoid creating false expectations and let the people think in geothermal as long term projects. With dialogue, spaces are possible to know people's concerns and expectations to be considered in every step to do.
- Social management times should be considered in the schedule. Any stakeholder should be underestimated.
- It is important to have good communication and sensitization about social and environmental issues in the internal staff of the project. Continuous communication, discussions, talks, feedback are good to get conscious about to maintain the best relationships inside and outside the project operations. The social and environmental work is not just from one specialist but from the whole team.
- It is important to train and include in the field experience the administrative staff to understand better this stage of development.
- Because of geothermal areas are mostly touristic, meticulous technical and environmental care should be applied, to avoid the risk of weakening the built confidence as well as for Nature conservation.
- EHS is an important factor to monitor and care about during operations, especially if the project is new. Any mistake could have repercussions in the further steps.
- Working in high altitudes makes it mandatory to double-check the health conditions of the crew and keep good habits during operations. Heart or pulmonary diseases could be fatal.
- Due to the topographic fluctuation in the area, the gravity data need special processing to show the real anomalies related to a depth structure. During the gravity survey, some points were relocated or eliminated for processing because of big pine trees which made it impossible an acceptable GPS accuracy.
- Keep in mind the water supply for drilling works. In the project area, there is only one water ditch near the drilling site, where Yachay owns much of the flow. For that reason, an agreement was made to use the necessary flow for drilling works. In the future, a groundwater survey for drilling works is contemplated.
- All the permits needed as use of lad, permit for construction, use of water, etc. should be mapped in advance.
- An analysis of the well conditions is necessary in order to choose an appropriate compressor for production testing.
- Taking the orography into account, the logistic for heavy transport mobilization was a challenge to reach the well pad of PEC-1 located almost on the top of the mountain.
- Immediate delivery to the laboratory for fluid inclusions and hydrothermal alteration analysis helps in the decision process. In the case that CELEC's laboratory can´t support the sampling demand, during the superficial exploration were found some public and private laboratories which can support the demand of water, rocks, and soil analysis.
- To make feedback with all the companies and staff involved in the project at the end of every activity.
- Collect as much information as possible from the well for future planning and to try to use appropriate software to keep the database.

## 4. CONCLUSIONS

The very first geothermal drilling in Ecuador was a great experience for the country. As it was mentioned before, drilling is the breaking inertia step in the geothermal development, so having it makes it possible to continue with further steps with more confidence. The government of Japan, through JICA, has played a fundamental role to boost this project and local capacities. With PEC-1 well, two of the three main parameters proposed to obtain at the beginning of the study were reached, which means that the study was successful and it can be move on to the next stage.

Being in harmony with the nearby communities and environment is one of the key factors to have a successful development in the Chachimbiro Geothermal Project. It must continue the great relationship between the communities, local authorities, public institutions, private stakeholders and the project.

To sum up this paper, communication, and feedback in all aspects is important to have a good experience and to continue in the development. Analyzing with the people involved in each aspect of the work will make a project grow continuously.

## 5. ACKNOWLEDGMENTS

This paper is a result of the Preparatory Study for the Geothermal Plant Construction Project in Chachimbiro performed by MMTEC between 2015 and 2017. First, we would like to thank JICA for its great support to develop the Chachimbiro Geothermal Project. JICA has not only given Ecuador its financial support, but it has also shared its knowledge and experience, it has been a wonderful life experience.

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