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GEOTHERMAL DEVELOPMENT IN BOLIVIA

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ABSTRACT

Bolivia is located in the center of South America; and currently has two important electricity policies: to secure electricity generation for internal consumption, and to diversify the energy matrix encouraging renewable energy projects including geothermal.

Bolivia started geothermal development in the '70s with a reconnaissance study in the western region. This study concluded that there is a significant geothermal potential in the southwest region and Laguna Colorada could have the most important geothermal potential. Then six geothermal wells were drilled from 1988 to 1992.

After some changes in electricity policies in 2010, the government of Bolivia started discussions to finance the construction of the 50 MW Laguna Colorada Geothermal Power Plant project. In 2011 the preparatory phase (called phase zero) of the project started. The well testing from November 2012 to May 2013, using different methods of analysis: tracer flow test method (TFT), PTS logging, lip pressure (James-Tube method), capillary tubing and others, confirmed the productivity and reinjectivity of existing wells.

In 2015, it is planned to start the procurement process for drilling new wells, the construction of power plant and the steam pipeline. A total of 100 MW is expected to be constructed.

1. BACKGROUND INFORMATION

1.1 Location and description

Bolivia is located in the center of South America, between the meridians 57°26′- 69°38′western longitude and 9°38′- 22°53′ southern latitude; and along with Paraguay are the only two landlocked countries in that part of the continent.

The South American tectonic plate is bordered by the Nazca and Antarctic plates to the west. These three plates meet at the Chile triple junction, and Bolivia is located above the subduction of the Nazca Plate.

Bolivia is divided into the Andes to the west and Amazon land to the east. The Bolivian Andes are comprised of three main ranges: Cordillera Occidental to the west (on the border with Chile) and Cordillera Central or Oriental to the east.

In addition to these mountain ranges, the Altiplano plateau extends over a large area between the Cordillera Occidental and the Cordillera Central. The plateau is around 700 km long and has a maximum width of approximately 200 km. The average elevation is close to 3,750 m a.s.l.

1.2 Policies and electricity situation

As of 2014, Bolivia relies mainly on hydro and thermoelectricity (33.5% hydro and 66.5% thermo). From 2008, in order to change this situation, Bolivia has two new important energy policies: to secure electricity generation for internal consumption and to diversify the energy matrix encouraging renewable energy projects such as geothermal, wind power and solar energy.

The peak demand reached 1,242.7 MW in February 2014 (CNDC, 2014). According to the Optimal Expansion Plan of the National Interconnected System (SIN) from 2012 to 2022, electricity demand forecasts indicate that total of 2,787 MW will be required in 2022.

The National Interconnected System (SIN) is an electric system comprised of facilities of generation, transmission and distribution which provides electricity to 7 of the 9 provinces of the country. The electrification was approximately 79.4% (95.0% of urban areas and 50.5% in the rural areas) (INE, 2012).

2. GEOTHERMAL EXPLORATIONS AND DEVELOPMENT IN BOLIVIA

2.1 Background

Bolivia started its history of geothermal development in the ‘70s with a reconnaissance study in Cordillera Occidental in the Western Andes Mountains that constitutes the border with Chile, 42 major geothermal manifestations have been studied and it has been concluded that there is significant geothermal potential in the south-western region.

In 1976, Empresa Nacional de Electricidad, ENDE (National Electricity Company) and the Ministries of Energy and Hydrocarbons, with funds from the United Nations Development Programme–UNDP, began evaluating Bolivian geothermal potential, seven prospective geothermal areas were identified: Volcán Sajama, Empexa, Salar de la Laguna, Volcán Ollague-Cachi, Laguna Colorada, Laguna Verde and Quetena. Three of seven fields were considered the most prospective: Laguna Colorada, Sajama and Valle de Río Empexa. They are located along the Occidental Cordillera of the Andes.

From 1978 to 1980, ENDE carried out the prefeasibility study for a geothermal power plant construction project at Laguna Colorada (it should be noted that Laguna Colorada is not the name of the geothermal field, but the name of the area where ENDE has its field camp – Sol de Mañana is the geothermal field’s name), with an Italian consultant. In 1982 a technical-economic evaluation was done considering the installation of a 30 MW plant.

In 1988, the government of Italy through ENEL and with the technical cooperation of the YPFB (Bolivian Oil Company) drilled first geothermal well in Bolivia, Apacheta–1, then continuous wells SM-01, SM-02, SM-03 and SM-04 were drilled from 1988 to 1989, resulting in steam production. Only SM-04 resulted in no steam, but good permeability as a reinjection well.

From 1991 to 1992, ENDE deepened the reinjection well SM-04 from 1474 to 1726 m and drilled the production well SM-05. The wells' production varies between 350 and 370 t/h of geothermal fluid (steam and brine), reservoir temperature and pressure are 250-260°C and 30-48 bar respectively.

Unfortunately, due to a change in the political situation the project was suspended in 1993.

From 1996 to 1997, ENDE contracted the Engineering Services of CFE of México to define the geothermal resource potential. CFE's study confirmed the minimum potential of the field is 100 MW.

CFE concluded that the potential of the field is 120 MW for 25 years with the required development of 20 production wells and 7 reinjection wells for approximately 4400t/h of brine.

In 2010, Japan International Cooperation Agency, JICA and the government of Bolivia started discussions to finance the construction of the 50 MW Laguna Colorada Geothermal Power Plant. As of now, 1st project is considered as the construction of 50 MW, while the total project would be 100 MW, based on the feasibility studies done in 2008 and 2010 by West–JEC with JICA cooperation.

In April 2010, the Environmental Impact Assessment for the Laguna Colorada Geothermal Project and transmission line finished.

2.2 Preparatory phase of the project.

In May 2011 the preparatory phase (called phase zero) of the project started. The main field activity of this phase, the well testing of the production wells SM-01, SM-02, SM-03 and reinjection well SM-04 was carried out from November 2012 to May 2013 (Figure 1). Due to obstacles in well SM-05, it was not possible to do well testing

FIGURE 1: Installation of MicroMod Tracer Injection Unit (TFT method) during well testing of SM – 03 in February 2013

Production tests were done for three wells with good results. During these production tests two different methods were used: TFT method and James–Tube method, both results corresponded very well as shown in Figure 2. (The green curve indicates the total flow by James, the blue curve is the total flow by TFT, respectively. The red curve indicates the steam flow and the purple curve is the brine flow both by TFT).

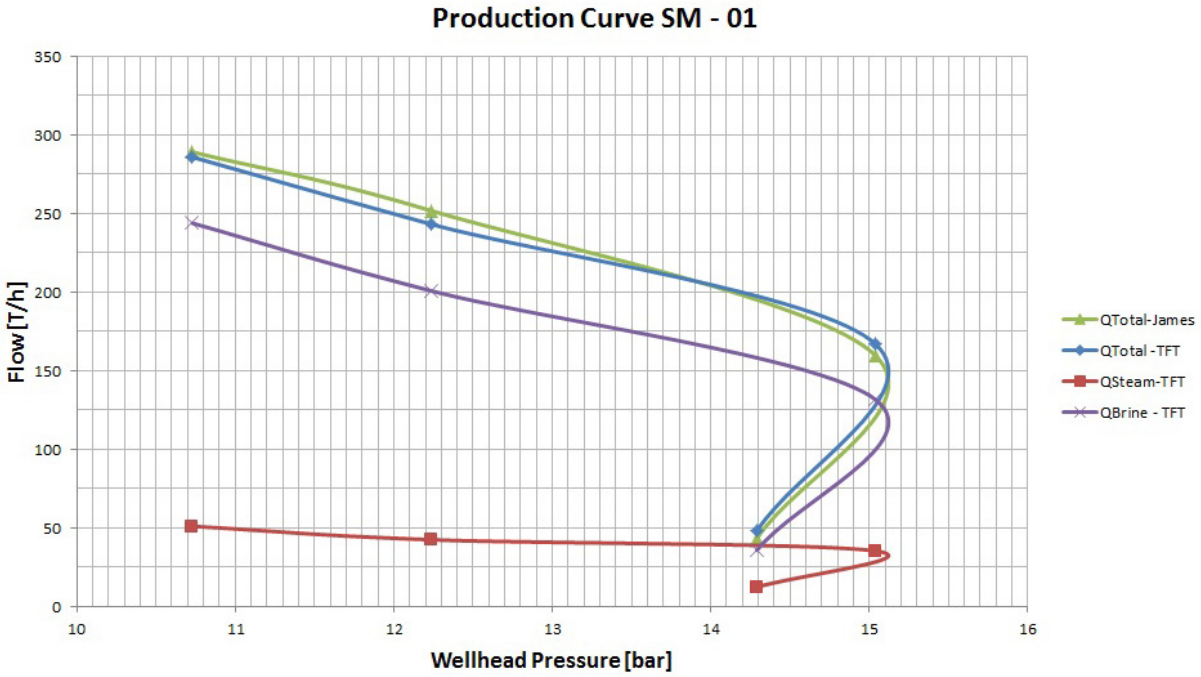

FIGURE 2: Production curve of SM-01 obtained using the TFT method and James–Tube method in December 2012

During phase zero well logging was also done for four wells with Kuster PTS memory tools. Dynamical and static logging confirmed the state of wells and a bottom temperature higher than 250°C (Figure 3). During reinjection to SM-04 the water level was monitored and confirmed good permeability of this well.

For the interference test, the pressure of two wells was always monitored during production. The results were very low interference between the wells (Figure 4). This implies that the size of reservoir could be large enough.

2.3 Current status of the geothermal project and future plan

Currently, ENDE continues environmental monitoring from 2011, with geotechnical studies, topographical studies, MT surveys, and others. All of them were done in the Sol de Mañana field.

In 2015, it is planned to start drilling procurement process for production and reinjection wells, in total 7 wells are planned to be drill. The construction of the power plant and necessary steam pipelines for 50MW will be also expected to start immediately.

Another 50 MW of development is expected after the 1st construction of the power plant, 100 MW in total is expected to be constructed.

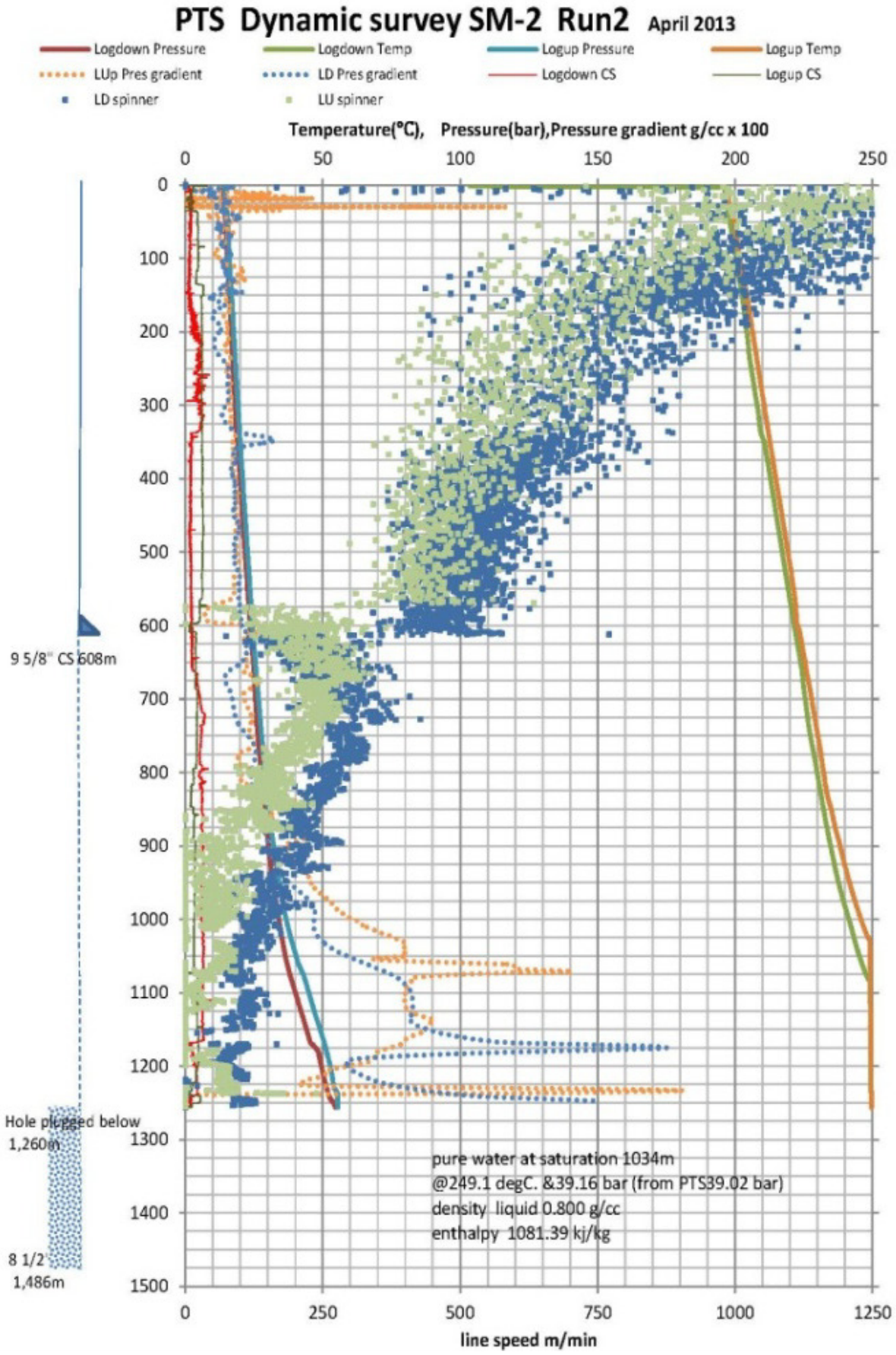

Figure 3: Logging PTS during production well SM-02 in April 2013

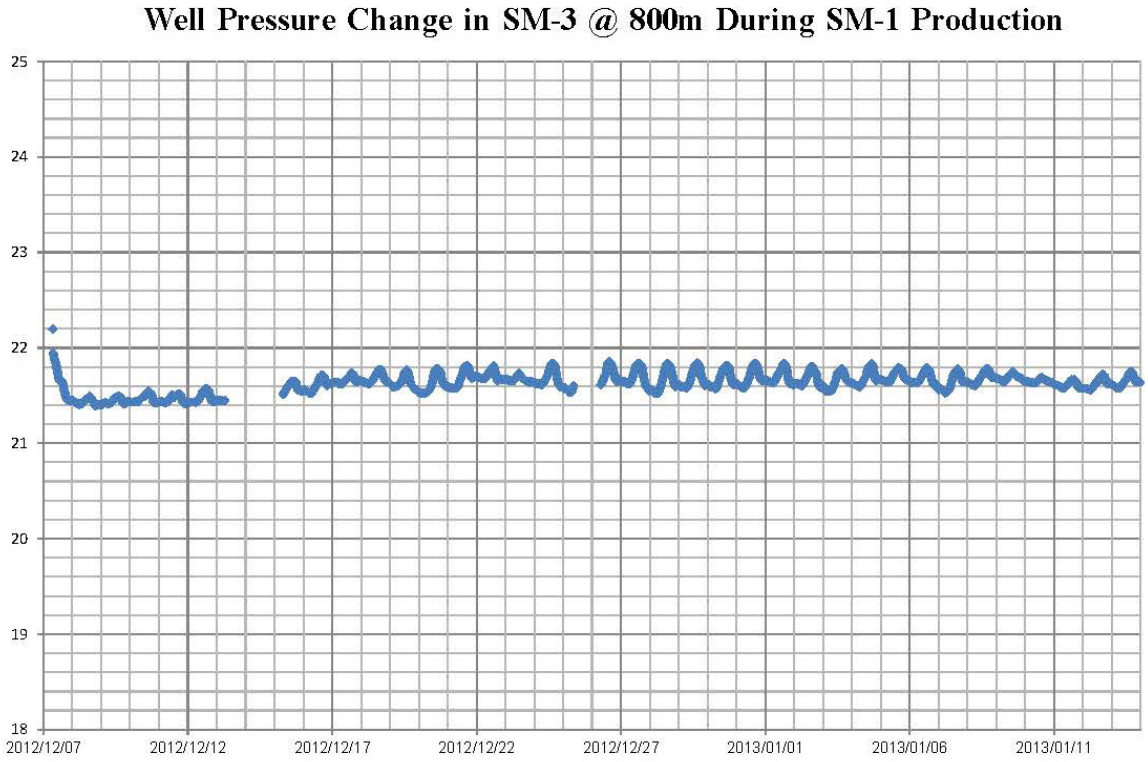

FIGURE 4: Monitoring pressure (bar) at 800m depth in SM-03 during SM-01 production

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