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Argentina Country Update

Abel Hector Pesce

SEGEMAR, Geothermal Department, Av. J. A. Roca 651, 8 Floor, Sect. “10” (1322) Buenos Aires, Argentina

apesce@mecon.gov.ar

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ABSTRACT

A remarkable development of geothermal resources has continued to take place in the last years due to the discovery of new thermal areas linked to sedimentary basins that belong together with the conductive hydrothermal systems and the advance in the investigation of thermal fields of high enthalpy. This has allowed development of new therapeutic-recreational complexes that generate a new economic alternative for the different regions of the country and an encouraging prospect is foreseen for the starting up of an energy generating plant.

Geothermal studies were carried out in 20 areas, arriving to the Development and Exploitation Stage in 14 of them and up to the Prefeasibility Stage in three. The advance in the characterization as much as in the chemical composition of their waters like in the litho-stratigraphy of the Thermal Basins allowed studies to go into knowledge in depth in the Chaco-Paraná basin and to specify their thermal system.

With regards to the thermal fields of high enthalpy studies, they continued in Copahue, Domuyo and Tuzgle. The Copahue geothermal field is the project with the largest development grade. The economical changes and the energy crisis motivated the carrying out of new technical-economic studies which indicate the viability 30 MW or more that can be developed in the area of Copahue in a first stage. In Tuzgle and Domuyo the second stage of prefeasibility has been concluded, establishing the geothermal pattern and defining the area of major economical importance, where exploration wells are scheduled to be made.

1. INTRODUCTION

In the last years, a remarkable development of the geothermal resources has continued taking place due to the discovery of new thermal areas linked to sedimentary basins that belong to the hydrothermal conductive systems and the advance in research of the high enthalpy thermal fields. This has allowed development of new therapeutic- recreational complexes that generate a new economic alternative for different regions of the country and an encouraging prospect is foreseen for the starting up of a generating energy plant. The chart of the figure 1 shows not only those projects of high enthalpy with continuous investigation but also the degree of progress in the low enthalpy projects. In this aspect it can be observed that the projects that began to be studied in the last decade are now already in exploitation or in development stage. Also, the incorporation of new thermal areas where the prefeasibility study has been completed, marks the continuous development of the geothermal activity in Argentina

ADVANCE GRADE		***PROVINCE***	***PROYECT NAME***	
High Entalpia	Production	Neuquen	Copahue	
	Development	Neuquen	Domuyo	
		Jujuy	Tuzgle	
Low Entalpia	Exploitation	Entre Rios	Basavilbaso	Chaco-Parana Basin
			Victoria	
			Diamante	
			San José	
		Santa Fe	Campo Timbó	
		Misiones	Obera	
			Cerro Azul	
			Posadas	
		Buenos Aires	San Clemente del Tuyu	Salado Basin
			Necochea	
			Mar de Ajo	
	Development	Buenos Aires	Tapalqué	
		Corrientes	Curuzú Cuatiá	Chaco-Parana Basin
			Monte Casero	
	Pre-feasibility	Misiones	Iguazu	
		Chaco	El Cachape	
		Santa Fe	Moises Ville	

Figure 1: Advance grade of thermal projects in Argentina during the last five years

2. HIGH ENTHALPY

The most important areas in Argentina are The Puna and Cordillera Principal (figure 2), separated by a horizontal subductional among the 27° and 32° south latitude where no volcanic phenomenon exists. In those areas the three most important geothermal fields of the Argentina are located.

2.1 Copahue Geothermal field

It is located in the western limit of Argentina with Chile in Neuquén Province at the 37º 50' of South latitude and 71º 05' of West longitude, seated in a border of elliptic caldera of approximately 15 km by 20 km (figure 2) .This is the project that shows more advance. The studies on the exploratory perforations allowed to settle that until the depth of 1,200 m the field is of vapor-dominated (saturated dry vapor). Inside the thermal area a zone of 1.2 km^2 has been demarcated and it is considered of major geothermal interest. It is a hyperthermic area where three exploration wells were drilled. In the reservoir verified by the drilled wells, the geothermal pattern indicates a temperature of more than 230º C to the depth of 600 - 800 m. To more depths inside the vapor-dominated reservoir temperature is almost stable (230º-240º C).

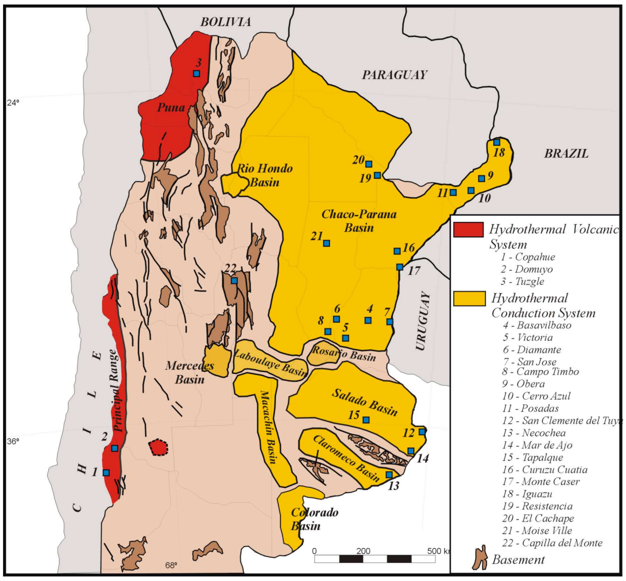

Figure 2: Distribution of thermal projects with different advance grade during the last five years

Conclusions of potential evaluation of this area indicated that electricity for 30 years could be generated, using the existing vapor to approximately 1,200 m of depth with a 30 MW capacity as a scale of generation of the power station.

At the present time the government of Argentina has called for a public bidding for private investors interested in building and operating a future electric power generation plant of 30 MW called "Las Mellizas of Copahue" with an investment of 70 million dollars. It is expected that in October 2009 the winning offer of the bidding will be known. The produced electric power will be commercialized in the electric wholesale market and transported, in a first stage, through the already existing system of 33 kilowatts. In a later stage a new line of 132 kilowatts will be built that will allow the interconnection of the project to the national electric system.

2.2 Geothermal field Domuyo

It is located to the North of the Neuquén Province, at 36° 48' of south latitude and 70° 38' of West longitude (figure 2). As a result of the geologic, geochemical, isotopic, gravimetric, geoelectrical, caloric and seismic studies, an area of 40 km^2 has been selected in the sector of the Cerro Domo and its surrounding area. According to the geo-thermometric geochemistry a range of temperatures of 214° - 223° C is calculated. The geothermal system is constituted by three areas: The first one is a small vapor-dominated area with gas fumaroles. The second is a transition area, water-vapor-mixed type and the third part is water-dominated. It is interpreted that the reservoir would be between 800 and 1,000 m, in an overbearing structure that presents a great fracturing area. Drilling exploration wells in the reservoir area is necessary to obtain temperatures and detailed data of thermal gradients that can be useful for the knowledge of the reservoir.

2.3 Geothermal field Tuzgle-Tocomar

This located in the Central Puna inside the altiplano salteño-jujeño (24º 00´S and 66º 05´W; figure 2). The pattern of hydrologic circulation postulates a not very deep reservoir (50 to 200 m) of 100 to 300 m thickness, integrated by a permeable unit (Trench Formation). The rock stamp is represented by the Formation Pastos Chicos of low conductivity. The deep geothermal reservoir is represented by a phreatic surface of low density, conductive, of hundred of meters of thickness, detected at 2 km depth. In the system, the deep temperature varies between 132º and 142° C with a low water-vapor ratio according to the geothermometers. Tocomar sector is the one that presents major interest. It has the highest temperatures among the thermal manifestations of the area (80º C) it does not present mixtures among the geothermal fluid (Temp. deep 132º-142º C) and the superficial waters. The detachment of a differentiated volume of a certain quantity of magma would have originated the deposits of Tocomar and it would be responsible for the thermal anomaly of the area. To the north of Tocomar is defined a sector of approximately 30 km^2 that is interpreted of more geothermal interest with alternative of economic exploitation, in which the studies should be deepened.

3. LOW ENTALPY: THERMAL PROJECTS FOR DIRECT USE

As a continuity of the remarkable development that is being generated in the last decades, during the last five years, 11 projects were set up (figures 1) which are in Exploitation stages. At the present time, new perforations are being carried out with depths averaging 1200 meters (Development stage) and in five new areas, the prefeasibility stage was completed. This characteristic shows the marked development that presents the direct use which allows, through its thermal fluids, to put into exploitation the new recreational therapeutic complexes and to supply drinkable water to different towns.

The new Complexes and Thermal Projects are: eight in the Cuenca Chaco-Paraná (figure 2) distributed as follows: four in Entre Rios Province (Basavilbaso, Victoria, Diamante and San José); one in Santa Fe Province (Campo Timbo) and three in Misiones Province (Obera, Cerro Azul and Posadas), these last ones are dedicated to the supply of consumption water. The three remaining ones are located in the Salado Basin (San Clemente del Tuyu, Necochea and Mar de Ajo, in Buenos Aires Province (figure 2). These new complexes confirm the marked tendency of the health thermalism in Argentina as a development alternative

(Pesce, 2001; 2002a; 2002b and 2003). The tendency continues with the new perforations that are being carried out in Corrientes Province (Chaco-Parana basin; in the towns of Monte Caseros and Curuzu Cuatia and, in the Salado Basin one in the town of Tapalqué (figure 2).

The studies that completed the prefeasibility stage, are in three new areas which began the studies in these last years, with the main objective of encountering thermal fluids with appropriate temperatures for direct uses. They were carried out in the Chaco-Paraná Basin (figure 2), in Chaco Province (El Cachapé), Santa Fe Province (Moses Ville) and Missions Province (Iguazú).

Thermal projects that are presently in exploitation were already described in previous congresses as in prefeasibility or development stages. Their production start-up has generated much advance in the chemistry of its waters as in the litho-stratigraphic of the Thermal Basins. This thermal development allowed to deepen the knowledge - mainly in the Chaco-Paraná basin - and to specify its thermal system.

4. CHACO-PARANÁ BASIN: PARANENSE THERMAL SYSTEM

The Paranense Thermal System (Pesce, 2005), located in the East-central of South America extends through the Chaco-Paraná basin into the territories of Argentina, Uruguay and Paraguay, and through the Paraná Basin into the Southeast of Brazil occupying an extensive sedimentation fanerozoic surface. The low temperature geothermal resources that are distributed in this wide volcano-sedimentary basin are characterized by having a normal to low geothermal gradient (Pesce, 2001, 2002b). It belongs together with a epicratonic basin located on the unit Cratón of the Rio de la Plata - Solid of Brazil, cratonized toward ends of the Cycle Brasiliano (Almeida and Melo 1981), of tectonic origin that can end up overcoming the 5,000 m of thickness of sedimentary rocks and basalts. Their origin is related to a slow regional subsidence, as indicated by the great extension of fine eopaleozoic sediments that are on to the crystalline basement, and the lack of local accumulations of thick sediments near to a hypothetical opening area.

The investigations carried out during these last decades, not only in the Entre Rios, Misiones, Corrientes, Chaco and Santa Fe Provinces, but also in the western sector of the Uruguay allowed to settle down in the Paranense Thermal System (PTS) two main thermal levels (Pesce, 2008). The PTS is a hydrothermal conductive system (Sorey, et al., 1982) and at regional level, they integrate the Thermal Level Chaquense and Thermal Level Guarani (figure 3). Associated to them, different sub-levels are presented that vary according to the basin litho-stratigraphic characteristics.

The main variations are in the Guarani Thermal Level (GTL), which are different because of their stratigraphic location, mineralogy and chemical composition of the waters, three denominated thermal Sub-levels: Entrerriano, Solari and Oberá. The GTL maintains a regional outline of "sweet" waters, with a relative low saline content. The geologic, geophysical and geochemical studies, developed in the different Thermal Projects allowed to settle down in the Northeast of the Argentina (Corrientes and Misiones Province) two reservoirs that correspond to two sub-levels with thermal different litoestratigrafics, one lower and another one upper (figure 3).

The Thermal Sub-level Oberá that corresponds to the lower is integrated by the sedimentites of the Rivera Formation (Herbst, 1971) or Botucatú Formation (Sanford and Lange 1960) and their roof is in the North region of Missions to the -930 meters. In the center-southern area of the county enters to -1125 meters and toward the south of the Misiones Province and north of Corriente (figures 4) to -974 meters. The mineralogy of the reservoir is composed by quartz, feldspar and opaque. The temperatures of the fluids are on the order of 51º C. The chemical type of their waters is Sodium Sulfate, has a slightly alkaline pH (between 8,8 and 8,4) and an EC between 2140 and 4430 µS/cm.

The Thermal Sub-level Solari, (upper level) belongs with the homonymous Formation (Herbst, 1971) and it is characterized to be inserted in the middle and inferior sectors of an extensive and potent volcanic sequence (Serra Gral Formation, Falconer, 1931). In the north area of the Misiones Province their roof is -378 m., in the center at -420 and toward the south of Misiones and north of Corrientes to -454 meters deep. The sandstone of the thermal Sub-level is composed by quartz, feldspar, fragments of volcanic rocks, epidotic, augite and opaque. The temperatures vary between 32° and 35° C, their waters are Sodium Bicarbonate, they have an alkaline pH (between 9.5 and 10.2) and an EC between 565 and 722 µS/cm.

MAIN CHARACTERISTIC	***PARANENSE THERMAL SYSTEM***			
	CHAQUENSE THERMAL LEVEL	***GUARANÍ THERMAL LEVEL***		
		Entrerriano	***Solari***	***Oberá***
Main Reservoir	Formations Diverse	Rivera o Botucatú F.	Solari Formation	Rivera o
Facing of reservoir	between 756 y 1520	between -811 y -1260	between -414 y -454	between
Temperatures ° C	between 36° y 49°	between 38° y 43°	between 32° y 35° C	51° C
Characteristic of the waters	Salt water	Fresh water	Non drinkable water	Non drinkable
Chemical types	Sodium Chloride,	Sodium Bicarbonate,	Sodium Bicarbonate	Sodium Sulfate
Surgencia	without flowin	flowin	without flowin	without flowin
pH	6,5 – 7,9	7,8 – 8,7	8,5 – 10,2	8,8 - 8,4
E C (µS/cm)	18900 -120000	554-1250	1180-4430	560 -722

Figure 3: Main characteristic of the Paranense Thermal System

Toward the south of the Cuenca (South of Corrientes and Northeast of Entre Ríos, figure 4) the regional outline of two sub-levels stays. The Thermal Sub-level Solari is exploited to north of the structural High Concepcion. Their roof is to -470 meters with characteristics equals to the already described previously. On the other hand the inferior level presents a marked change in the chemical composition of its thermal fluids, the waters are drinkable and the perforations are emerging, factors that allow defining the Thermal Sub-level Entrerriense. This is constituted by sandstone of quartz-containing of fine grain to stocking, very well selected. The sedimentary structure observed in Rivera area (Uruguay) it is the eolic intertwined stratification of type, tabulate-planar and cuneiform-planar that belong together with the Rivera Formation (Herbst, 1971) or Botucatú (Sanford and Lange 1960). The roof of the unit varies between -811 and -1260 meters and its temperatures vary between 38° and 43° C. The chemical types of its waters are drinkable, they vary among: Sodium Bicarbonate, Sodium Chloride and Sodium Chloride Bicarbonate. They have a pH of neuter to slightly alkaline (7.8 – 8.7) and an electric conductivity between 554 and 1250 µS/

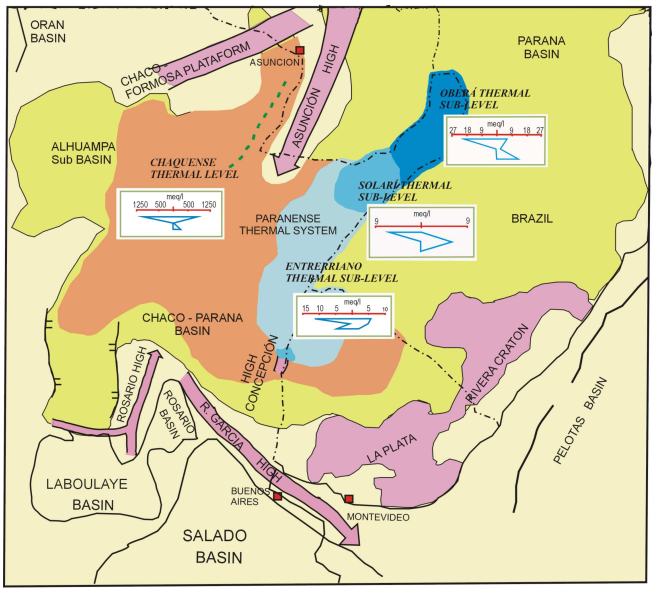

Figure 4: Distribution of the Paranaense Thermal System in the south part of the Chaco-Paraná Basin and their main characteristics. The Staff diagrams indicate the chemical composition of the Thermal Levels and Sub-levels

The Thermal Level Chaquense (TLCh) has a wide development in the basin, with a great extension of the level in the Western sector, and continues toward the south of the basin, skirting the TNG and covers a wide region in Uruguay (figure 4). This characteristic makes it represented by numerous formational units and at different profanities, as it is the sector of the basin that is analyzed. But all the thermal units have a common factor that is their marked salinity that arrives to make a very salty water practically in some cases (Diamante Project). The roof of the unit varies between the -756 and the -1520 meters deep and because the source of heat is the natural geothermal gradient, the temperatures vary between the 36° and 49° C. The predominant chemistry type is Sodium Chloride that like it was pointed out, presents in all the cases a high salinity that is manifested in an electric conductivity between 18900 and 120000 µS/cm

5. PROJECTS IN DEVELOPMENT STAGE

The thermal perforations that are being carried out in the Projects Monte Casero and Curuzú Cuatia (figure 2), Corrientes Province, indicate clearly how gradually new Provinces join to the economic development that is being generated in the region of the Chaco-Paraná basin by means of the use of the thermal fluids.

5.1 Monte Caseros

The results of geothermal studies carried out in this town, as it was expected respond to the general outline of the basin. The thermal fluids that are located in the underground are recharged in the center part of Uruguay where the continental sediments of the Rivera Formation (Herbst, 1971) appear as the carrier of the fluids. This unit slowly deepens below its roof of 576 meters in this town.

The studies allowed preparing a profile that is considered to be in the underground of Monte Casero that was used, for the design of the perforation that is being carried out. The profile indicates that it should cross about 46 meters of silts first, then near 530 meters of volcanic rock (Serra Geral F.) and lastly to penetrate about 150 meters inside the thermal aquifer (Rivera F.), establishing that the perforation could have a total depth 730 meters. The studies also pointed out that to 342 meters would be intercalations of sandstones of the Solari Formation. It is interpreted, for the opposing resistivity that the waters would be sweet and that it would have a temperature between 38° and 39° C and for the characteristics of the sector of the basin the flows would be very good and they would emerge naturally.

5.2 Curuzú Cuatia

As is observed in figure 2 this town is located 62 kilometers to the Northwest of Monte Casero, so the regional scheme pointed out previously also belongs together for Curuzu Cuatia. According to information of the geothermal study a stratigraphic profile was developed. In it three geologic units can be distinguished: A superior level where there is a thin layer that corresponds to salty and calcareous sediment, a potent laundry sequence, partly with pyroclasic intercalations and maybe with some reef it cuts that overcomes the 820 meters of thickness that corresponds to the Serra Geral Formation and below this the sedimentary continental carrier of the thermal fluids from the Rivera Formation. Therefore according to the geoelectric report made, the base of the lava deposits and the roof of the sandstones carrier of the thermal fluids are between 820 and 830 meters deep. At the present time the first meters of the thermal perforation are being carried out.

5.3 Tapalqué

This Thermal project is located in the Salado basin (figure 2). Nowadays it is the second basin in importance where new thermal projects oriented to the tourism health are being generated. Starting from the geoelectric parameters a lithologic column of the underground has been reconstructed, constituted by five horizons, in which has been placed the thickness, the probable lithology and the geologic Formation that represents that lithology.

The first horizon (geo-electric unit 16-20 Ωm) is integrated by slimes and slimes something loamy saturated with water of low salinity, with thickness that vary between 17 and 26 meters and that belong together with the Pampeano Formation. The second horizon (6-8 Ωm.) is integrated mostly by loamy or sands saturated with waters of high salinity, with thickness between 30 and 76 meters belong together with the Puelche Formation. The third geoelectric unit (11-13 Ωm), is integrated by saturated continental sands and stones of a relatively good electric resistivity with brackish water. It belongs together with the Olivos Formation with a thickness that varies between the 200 and 300 meters. The fourth geoelectric unit (true resistivity of 20 Ωm), is the one that presents the biggest geothermal importance. It belongs together with continental silts, of sands, limolitas and aquifer quartz-containing gravels, corresponding to the General Belgrano Formation. The thickness of this geologic unit varies between 160 and 330 meters and it is interpreted that it would be carrier of thermal fluids of salty characteristics and temperatures of between 39° and 42° C. The fifth geoelectric unit (4370 Ωm) represents the crystalline basement that is appearing toward the south of the study area and its roof is 850 meters deep.

In function to all these elements a thermal perforation is being carried out to a minimum depth 850 meters that will have a bottom well diameter of 8 5/8". In the open section of the well will be made a geophysical profile of multiple type and a registration of temperature. These studies will allow knowing with accuracy the characteristic lithology of the producer geologic unit and it will allow to program the filter type that will be placed.

6. PROJECTS IN PRE-FEASIBILITY STAGE

In these projects that are located in the Chaco-Paraná basin (figura2), the studies allowed establishing the litho-stratigraphic profile and also the depth of the geologic unit carrier of the thermal fluids.

6.1 Project Iguazú

A model geologic-hydrogeologic of the investigated area has settled down, with a column that presents from up to down four geoelectrical units; The first unit (204 Ω.m.) represents the edaphic sector. The second unit corresponds to basalts (F. Serra Geral; Falconer, 1931) with high values of true electric resistivity (370 Ω.m.) that correspond to more compact rocks, with smaller fracture, smaller quantity of vesicles and/or a smaller grade of humidity or saturation. The third represents basalts that possess first floor values of true resistivity between 157 and 260 Ω. m. These are more fractured, with high content of vesicles. And they could be indicating the presence of sedimentite intercalations (F. Solari; Herbst, 1971), besides possessing great humidity or to be saturated. Below the 887 to 960 m the last geoelectrical layer is presented with an electric resistivity between 45 - 70 Ω.m. that corresponds to the infrabasaltic sandstones. In general form in the Cuenca Chaco-Paraná, the same range of values of true resistivity of the last geo-electrical layer, is obtained for the sandstones of the Formations Rivera or Botucatú, in other thermal areas of the basin (Pesce, 2000). According to this model, the execution of a recognition poll is proposed until penetrating the sandstones at 100 or 150 meters, with detailed extraction of cuttings and with posteriority a geophysical profile of multiple type, to make a correct design of a producing well.

6.2 Project The Cachape

The studies have allowed making a satisfactory correlation geologic-geophysics in a structural frame without more complexity but with marked geological changes product of facial changes in the Cuenca Chaco-Paraná. By means of the geothermal study five geoelectrical units were determined and their litho logy and their litho-stratigraphy characterization were established.

The first geoelectrical unit (8-10 Ω.m. of true resistivity) is the most superficial and covers the sectors in-saturated and saturated of the grounds of the region up to the first 15 meters. It consists mainly of silts of medium permeability, clays and loamy slimes.

In the second geoelectrical unit (34-38 Ω.m.) the horizon has a variable thickness between 65 m and 115 m and it is represented by slime-sandy, permeable silts and carrier of water of low salinity. Geologically, it represents the Pampeano Formation. These modern deposits would be present up to 130 m depth, approximately.

The third geoelectrical unit is a highly conductive body that has a variable thickness between 380 and 460 meters and true resistivities in the order of 2. Ω.m. that reveal the presence of silts loamy and probable marine origin. It is very probable that the geophysical impossibility of determining the limit between both bodies is due to the high salinity of the saturation water in both bodies.

The fourth geoelectrical unit (0.6 and 1 Ω.m.) defines another more conductive horizon with a variable thickness between 370 and 470 meters. And it has a similar situation to the previous one as it would be involving the geologic Chaco and Mariano Boedo formations until approximately 950 m depth.

In the fifth geoelectrical unit the true resistivity varies between 9 and 15 Ω.m. attributable to the presence of sands and sandstones of fine to medium grain. These deposits are located below 780 - 930 m depth. This detected geologic level would be that of the Las Breñas Formation that it presents characteristic rock reservoir, being interpreted that it is the first level of aquifer thermal recognized in the study carried out in the area. You should penetrate about 100 meters to extract an important flow. The waters would be salted, probably of sodium chloride composition and their temperature would be between 40° to 42° C.

The geologic pattern developed with the information of underground of the basin differs with the litho-stratigraphy described in the oriental sector of the basin and it indicates that in those depths they would not be the basaltic coladas of the Serra Geral Formation. In this way (figure 4) we can trace a western limit of deposit of the sandstones of the Serra Geral Formation that differentiates inside the basin two different litho-stratigraphic areas.

6.3 Project Moises Ville

The geothermal studies have been able to establish a model geologic-hydrogeological of the investigated area. Seven geoelectrical horizons have been determined up to a penetration depth of approximately 1,700 meters. In all the cases, the true resistivity is extremely low, surely due to the high salinity of the underground waters of saturation.

The initial geoelectrical unit has two electric horizons (6 and 3.75 Ω.m.). The first one would represent the in-saturated area of the superficial cover that corresponds to the position of the phreatic surface that would be located at 10 m depth. The inferior is the saturated sector of the unit up to depths of 42-52 meters.

The second unit is represented by sands and loamy sands saturated with water of high salinity, since the resistivity is extremely low and of the order of 1.1-1.3 Ω.m. The thickness varies between 80 m and 118 meters.

The third electrical horizon (0.5-1 Ω.m.) would be integrated by a monotonous alternation of clays and sandstones aquifer of probable marine origin, with waters of saturation of high saline content. The thickness varies between 200 and 400 meters

The fourth unit represents a conductive body (1 Ω.m.) and, same as the overlying unit is composed by layers of clays and sandstones of different thickness forming a deposit of 125-290 m of power.

The fifth unit would correspond to a basalt "sensu strictu". This lava body has little thickness compared with other regions of its distribution area. In this area it varies between 120-135 m and the true resistivity is of the order of 10. Ω.m. Comparatively the certain true resistivity is very low, but this could be highly attributed to the conductive bodies that overlay and to the high salinity of the saturation water. Neither could be disregarded that the coladas would present sectors with cracks, fractures and alveoli stuffed by anhydrites, hematite, etc.

The sixth unit has the more hydro-geological importance since it contains sandstones potentially aquifer, although with important loamy intercalations that diminish its transmission characteristics. The thickness of this horizon is considerable, since it varies between 570 m and 610 m, while its true resistivity is between 3.3 and 5.3 Ω.m, values that reveal its continental origin and the high mineral concentration of the saturation waters.

To the seventh geoelectrical unit is considered the hydrogeological basement since below 1,400 m any recovery of water would come at a very high cost of exploitation. It is interpreted that they are lava basal. The roof is located between the 1,360 and 1,380 m depth and its true resistivity varies between 3 and 5.5. Ω meters. These values are inferior to those of the present coladas between 550 and 650 m, possibly due to a bigger fracture state and the presence of vesicles that facilitate the presence of water of high salinity.

The unit of more interest is the sixth that is integrated by a potent alternation of sandstones and clays, of which the first ones can be aquifer. The very low values of true resistivity determined in all the units are remarkable. This circumstance is due to factors such as the origin and lithology of the different deposits. In general they are of marine nature and must add a very fine grain with presence of plasters, anhydrites, chlorite and a time of water-silt contact is very high. These characteristics probably originate from the big distances from the recharge areas and the very low hydraulic gradient of the aquifers.

Inside this horizon, the sector of interest would be located between 750 and 1250 m depth. It is promoted the realization of a perforation study of a minimum depth of 850 m and maxim of 1,250 m, with detailed extraction of samples starting from the 650 m. In the open well a geophysical profile of multiple types will be made to determine the levels of more hydrologic contribution inside the sandstones.

7. CONCLUSION

A remarkable advance in the knowledge of the geothermic continues in Argentina, as well as the starting up of new projects. In the high enthalpy geothermal areas is impelled the building and operation of a future generation of electric plant of 30 MW denominated power "Las Mellizas of Copahue" with an estimated investment of 70 million dollars. In the low enthalpy areas there were numerous projects that passed the exploitation stage in these last years, same as the new areas where the investigations began. The geothermal prospect in Argentina continues to be encouraging, since this is a resource that is generating an interesting economic development in numerous regions of the country.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity)

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in December 2009	0.67		17600	50302	9950	30600	935	6835	52	148	28537.67	87885
Under construction in December 2009												
Funds committed, but not yet under construction in December 2009												
Total projected use by 2015	30.67		22850	65304	62000	190673	3232	23626	160	455	88272.7	215407

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2009

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2004 if available, otherwise for 2003. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe	Annual Energy Produced 2004[3)] GWh/yr	Total under Constr. or Planned MWe
Copahue (NQ)	Copahue	1988	1	Not operating	Binary (Pilot)	0.67	0	0
Total			1			0.67	0	0

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

1) I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality		Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
			Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
			(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Federación	(ER)	B-H	125	41	35			3.14		81.3	0.6
Concordia	(ER)	B	5	41	35			0.19		4.5	0.6
Villa Elisa	(ER)	B	3.3	38	33			0.1		2.3	0.6
Colón	(ER)	B	35.8	33	28			0.75		14.6	0.6
La Paz	(ER)	B	33.3	41	30			1.53		43.5	0.9
Villaguay	(ER)	B	8.3	41	28			0.45		12	0.8
Maria grande	(ER)	B	9.7	43	28			0.60		15	0.79
Gualeguaychu	(ER)	2B	5.5	33	28			0.41		3.3	0.9
Concordia	(ER)	2B	69	43	30			3.7		111	0.9
Basavilbaso	(ER)	B	19.5	42	35			0.57		15.70	0.87
Victoria	(ER)	B	12.5	37	30			0.37		11.54	0.99
Diamante	(ER)	B	4.72	47	35			0.24		6.33	0.84
San José	(ER)	B	3.33	36	33			0.1		1.32	0.42
Campo Timbo	(SFE)	B	18.06	36	32			0.30		8.44	0.89
Obera	(MIS)	B	44.4	51.3	33			3.4		111.1	1.04
Cerro Azul	(MIS)	O	10.56	32.3	20			0.54		12.98	0.76
Posadas	(MIS)	O	17.22	35	20			1.08		31.66	0.93
Uritorco	(CBA)	B	20	38	29			0.7		23	1.04
Cerro San Mart	(RN)	B	8.32	41	18			0.79		21.2	0.85
La Carrindanga	(BA)	G	6.94	55	35					20.1	1
San Clemente	(BA)	B	8.9	41	35			0.22		5.54	0.8
Necochea	(BA)	B	2.2	37	35			0.1		0.58	1.18
Mar de Ajo	(BA)	B	11.67	38	35			0.15		4.35	0.92
Medanos	(BA)	B	33.3	74	50			3.35		1.1	0.25
Copahue	(NQ)	S	8.33	75	35			2		31.6	0.24
Gan Gan	(CHU)	F	8.8	21.5	18					3.1	1
Caimancito	(JY)	B	1.6	45	35			0.1		1.1	0.5
Aguas Caliente	(JY)	B	1	45	35			0.1		4.7	0.45
El Sauce	(SAL)	B	7	35	30			0.14		2.1	0.45
Termas de Inti	(SAL)	B	0.5	60	35			0.1		0.7	0.45
Rosario de											
La Frontera	(SAL)	B	1	60	40			0.1		1.7	0.63
Incachule	(SAL)	B	7	45	35			0.29		3.2	0.35
Tocomar	(SAL)	B	1	55	35			0.1		1.3	0.35
Fiambala	(CAT)	B	2	53	33			0.16		1.9	0.4
Aguadita	(CAT)	B	0.1	30	25			0.1		0.01	0.4
Villavis	(CAT)	B	1	60	30			0.13		1.1	0.4
Llampa	(CAT)	B	1	30	27			0.1		0.2	0.4
Los Nacimientc	(CAT)	B	1.5	36	30			0.1		0.5	0.4
Ojo de Villa Vis	(CAT)	B	6	24	22			0.1		0.7	0.4
La Copia	(CAT)	B	1	25	22			0.1		0.2	0.4
La Cienaga	(CAT)	B	2.5	24	22			0.1			
Vis Vis	(CAT)	B	7	31	25			0.18		0.4	0.4
La Soledad	(SGO)	B	15	41	35			0.38		19.6	1
Rio Hondo	(SGO)	B	1000	45	35			42		46.03	1
Santa Teresita	(LR)	B	3	42	35			0.1		2.81	0.8

Ambil (LR)	B	5	27	25			0.1		0.8	0.4
La Laja (SJ)	B	4	26	22			0.1		0.84	0.4
Guayaupa (SJ)	B	0.5	27	22			0.1		0.11	0.4
Despoblados (SJ)	B	1	75	35			0.17		0.8	0.15
San Crispin (SJ)	B	2	57	33			0.20		0.6	0.15
Cajón de la Bre (SJ)	B	0.2	35	30			0.1		0.06	0.35
Rosales (SJ)	B	4	40	30			0.17		2.1	0.54
Pismanta (SJ)	B	7	43	35			0.23		5.53	0.43
Rio Valdez (TdF)	B	18.1	37	32			0.32		5.6	0.47
Los Molles (MZA)	B	2.5	41	35			0.1		1.6	0.25
Borbollon (MZA)	B	1	24	22					0.08	0.48
Cacheuta (MZA)	B	3.95	44	33			0.18		3.3	0.54
Carrillo (MZA)	B	0.5	38	33			0.1		0.2	0.54
Alto Verde (MZA)	B	0.5	23	21			0.1		0.08	0.33
Villavicencio (MZA)	B	2	28	25			0.1		0.6	0.5
Copahue (NQ)	B-H	1.76	58	35			0.17		25.34	0.48
Domuyo (NQ)	B	2	65	35			0.29		4.05	0.48
El Quicho (CBA)	B	45	38	33			0.94		10.5	0.24
Talacasto (SJ)	B	12.5	26	22			0.16		2.6	0.4
Epulaufquen (NQ)	B	1	65	35			0.13		0.7	0.25
Bahia Blanca (BA)	H-B-G-F	1000	55	35			83.7		63.26	0.4
Larroude (LP)	B	0.9	29	26			0.1		0.28	0.8
TOTAL							157.72		814.4	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	22.4		
District Heating [4]	0		
Air Conditioning (Cooling)	0		
Greenhouse Heating	21.48		
Fish Farming	7.03		
Animal Farming	14		
Agricultural Drying[5]	0		
Industrial Process Heat[6]	0		
Snow Melting	1.39		
Bathing and Swimming[7]	88.18		
Other Uses (specify)	1.3		
Subtotal	155.78		
Geothermal Heat Pumps			
TOTAL	155.78		

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2009 TO DECEMBER 31, 2009 (excluding heat pump wells)

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)					
Production	>150° C					
	150-100° C					
	<100° C			11		8.93
Injection	(all)					
Total				11		8.93

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	7		6			3
2006	7		6			5
2007	8		6			5
2008	8		8			7
2009	9		8			7
Total	39		34			27

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	4.8	1.2			70	30
2000-2004	1.5	3.5			85	15
2005-2009	5.3	6.5			80	20