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Argentina Country Update

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ABSTRACT

The progress of the knowledge of the geothermal resources during the last five years was remarkable and continuous in its positive tendency and the use oriented towards generating development from the direct use of the thermal fluids, as promoted during the last decade.

Important advance was achieved in integrated knowledge of Argentine Geothermal Resources generating maps of different Hydrothermal Systems, identifying areas of the country depending on similar hydrothermal characteristics.

Geothermal studies have been undertaken in nineteen new areas, arriving to Development and Production Stage in seven of them, Pre-feasibility Stage in eleven and Reconnaissance Stage in one area.

Continuous remarkable development in the Northeastern area of Argentina, particularly Entre Rios Province, has now extended to new provinces (Misiones and Santa Fe).

In Entre Rios Province five new thermal wells have been drilled with temperatures between 36° y 42° C allowing exploitation of four therapeutic recreational complexes (La Paz, Maria Grande, Barrio Belgrano and Las Golondrinas) and one thermal medical Center in Villaguay locality.

Uritorco project in Cordoba Province and Cerro San Martin project in Rio Negro Pronvince, which are also both directed to Spa and balneology, complete the new seven thermal wells that show a new tendency: Thermal Spas in Argentina.

The growing importance of this resource and the important role of this development in the regional economy in our Country are sustained by the several areas that have been studied during the last years with the objective of encountering thermal fluids with appropriate temperatures for direct uses.

In Misiones Province (Obera and Alem), one of the new provinces incorporated to geothermal resource development, thermal well is drilled for potable water consumption purposes.

While in other projects like in Cordoba Pronvince (Huerta Grande, La Falda, Valle Hermoso), Buenos Aires (Carhue), Entre Rios (Nogoya, Basavilbaso, Diamante and San Jose) and Santa Fe (Carlos Pellegrini) thermal fluids are directed to Thermal Spa and balneology which now a days appear as a remarkable alternative of economical development in Argentina.

At the same time Copahue Project is being reviewed presently (Vapor Dominated Hydrothermal System) towards to electricity generation also during the last two years both Government and Parliament have been involved in preparing a Geothermal Law (Electric power generation) and a Thermal Investment Law in order to adequate legal framework to benefit development of direct uses.

1. INTRODUCTION

The progress of the knowledge of the geothermal resources in the last five years has been oriented towards generating development from the direct use of the thermal fluids. Geothermal studies have been undertaken in nineteen new areas, arriving to Development and Production Stage in seven of them, Pre-feasibility Stage in eleven and Reconnaissance Stage in one area (Table 1)

An important element has been added this time and it is that during the last two years Government and Parliament are trying to establish an adequate legal framework in order to generate renewed economic interest in geothermal energy for electric power generation and incentives aimed at investment projects related to direct use of thermal fluids.

2. CLASSIFICATION OF GEOTHERMAL RESOURCES IN ARGENTINA

Progress in integrated knowledge of Argentine geothermal resource was achieve by identifying regions based on distribution of hydrothermal systems (Figure 1)

First great division is constituted by great segments with active or recent volcanic activity where there are Hydrothermal Systems related to volcanism. The most important because of the geothermal characteristics are the ones located along the Andes Mountain. In this area two sectors are well identified: Puna and Cordillera Principal, which are separated by a horizontal subductional segment, located between 27° y 32° south latitude where no volcanic phenomenon exist.

Another three regions that present recent volcanic evidence are Payenia, Macizo de Somun Cura and Isla Decepcion in Argentine Antarctica (Figure 1)

The Puna region, which is a high plateau of over 3.700 m.a.s.l., corresponds to a line of mountains formed by volcanic stratum from the Upper Cenozoic.

Reconnaissance studies performed in this region allowed selection of eleven Thermal Areas where water-dominated type hydrothermal systems and hydrothermal convection systems with delimited thermal reservoirs can be encountered.

From this group, studies in depth have been performed until completion of pre-feasibility stage in geothermal field Tuzgle-Tocomar.

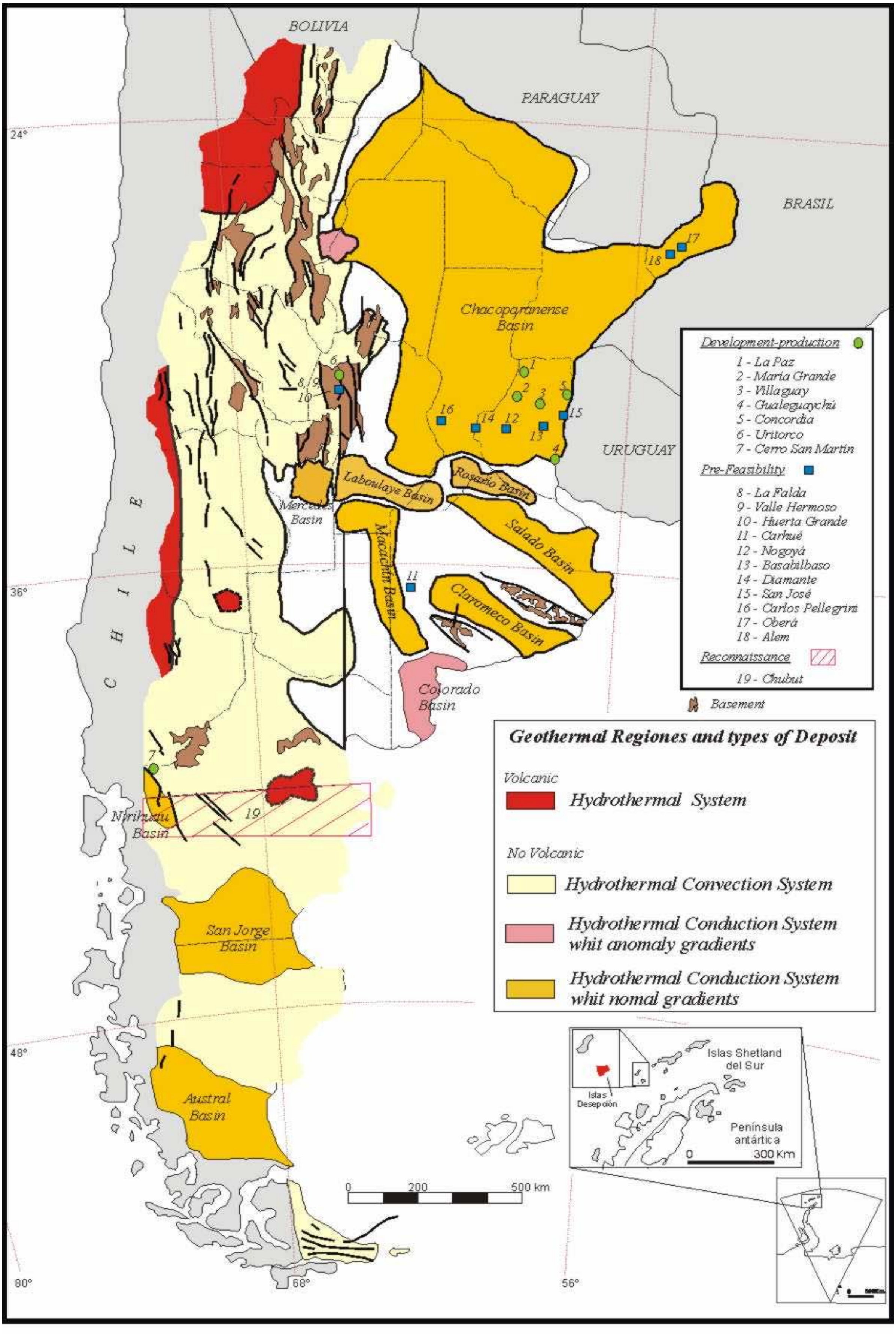

Figura 1: Distribution of hidrothermal systems in Argentina and new thermal projects during the last five years

Table 1 – Stage of New projects in Argentina during the last five years

STAGE OF NEW PROJECTS (19)	PROVINCE	PROJECT NAME
DEVELOPMENT-PRODUCTION (7)	Entre Ríos	La Paz
		María Grande
		Villaguay
		Gualeguaychu (Barrio Belgrano)
		Concordia (Las Golondrinas
	Córdoba	Uritorco
	Río Negro	Cerro San Martín
PRE-FEASIBILITY (11)		La Falda
		Valle Hermoso
		Huerta Grande
	Buenos Aires	Carhué
	Entre Ríos	Nogoya
		Basavilbaso
		Diamante
		San José
	Santa Fe	Carlos Pellegrini
	Misiones	Oberá
		Alem
RECONNAISSANCE (1)	Chubut	

To the south, from 33° south latitude, arises again a Pleistocene volcanism arc along the Cordillera Principal, up to 38° 30´ where active volcanos get into the Chilean territory. Along this region there are several deposits associated with vapor-dominated hydrothermal systems and water-dominated hydrothermal systems associated with Quaternary volcanic complexes where eight Thermal Areas have been selected based on the importance of them. These areas are: Puente el Inca, El Sosneado, Peteroa, Los Molles, Domuyo, Picunleo, Copahue-Caviahue and Epulaufquen. From this group studies were performed in two chosen areas Domuyo and Copahue-Caviahue. In Domuyo area such studies were enlarged up to a pre- feasibility stage while in the other up to Development stage. In Payenia, Macizo de Zomun Cura and Argentine Antartica (Isla Decepcion) (Fig. 1) reconnaissance and pre-feasibility studies have been performed.

In no volcanic areas Hydrothermal Convection Systems, Hydrothermal Conduction-dominated Systems and mixed systems were identified.

Hydrothermal Convection Systems, where circulation of water transports thermal energy to reservoirs at shallow depths or to the surface is located along the extra-Andean Region (Fig. 1) where tectonic plays an important paper . In this large zone 348 areas have been identified where the only evidence that a geothermal reservoir exists at depth is a group of closely spaced springs.

In Hydrothermal Conduction-dominated system, upward circulation of fluid is less important then the existence of high vertical temperature gradients in rocks that include aquifers of significant lateral extent. These conditions occur beneath many deep sedimentary basins throughout the Argentina. In some of them, the most important like Tacorralo – Rio Hondo and Bahia Blanca - Pedro Luro (Fig 1)) thermal systems area characterized by a heat anomaly presence. In the first one at 300 m depth thermal fluids in reservoirs are at 80 y 85° C while in the other one at 800 m depth, temperature is between 75 y 82° C. In the rest of sedimentary basins in which thermal systems have been determined (Chacoparanense, Rosario, El Salado, Laboulaye, Macachin, Niriguau, San Jorge and Magallanes, among others) geothermal gradient registered is normal.

Mixed systems, occur in areas where the sedimentary basins were affected with active tectonism only in part.

3. THERMAL PROJECTS AIMED AT DIRECT USE

3.1 Projects at Development-Production Stage

New seven thermal projects (Fig. 1) with wells in production stage are located in three different geological areas, within the no volcanic hydrothermal systems and five of them are in a large sedimentary basin of Hydrothermal conduction-dominated system. The other two ones are associated with structures, which originated secondary reservoirs. Uritorco Project, associated with basement rocks and the other is Cerro San Martin Project associated to a Tertiary Upper volcanic rocks sequence.

3.1.1 Entre Rios Province

Same as during the last five years, a remarkable development was produced in the

Parana Thermal System in the Northeast Argentina where studies in five new areas were performed and new thermal wells were drilled. The Parana Thermal System (PTS) located at central-eastern of South America extends through the Chaco-Parana basin in Argentina, Uruguay and Paraguay territories and through Parana basin at Southeast of Brazil covering a large extension.

These low-temperature geothermal resources are found in a vast volcanic-sedimentary basin hosted in an inter-cratonic region of low-to-normal thermal gradient (Pesce, 2002a). Three thermal aquifers with large potential for direct geothermal applications have been identified and characterized. (Pesce, 2001). The governments of different countries have recognized the importance of these hot waters and are promoting the development of the spas and tourist centers around the wells tapping them. In Entre Rios

Province projects have been developed and they are at the Development-Production stage in **La Paz**, **María Grande, Gualeguachu 2** (Barrio Belgrano), **Concordia 2** (Las Golondrinas) and **Villaguay** locality. (Table 2).

Research during these last years have extended to Misiones and Santa Fe Provinces and allowed a clear incorporation of new regions in exploitation of geothermal resource.

The wells supplying thermal water to the spas produce from different levels of the Parana Thermal System (PTS), depending on location. The lower aquifer exploited at Gualeguaychu 2 (Barrio Belgrano), is quite saline; it is in Lower Carboniferous-Middle Permian glaciomarine deposits. The middle and most important thermal aquifer is in Lower Triassic to Lower Jurassic sedimentary rocks (eolian at the top, fluvial, deltaic and lacust-rian toward the bottom). Generally, this highly productive aquifer is of low salinity, however as it deepens towards the east southwest its salinity increases. The new wells and spas at Concordia 2 (Las Golondrinas), Villaguay and La Paz correspond to middle level. The upper aquifer is in Lower Jurassic to Upper Cretacic sedimentary rocks that are interlayered with thick basaltic flows, particularly toward the bottom. The well and spa at María Grande extracts water from this unit.

3.1.2 Uritorco Thermal Project

Uritorco project has a special feature because it has been developed in secondary structures of basement rocks. This Thermal area is geologically located in the so-called Sierras Pampeanas Orientales at 1200 m.a.s.l. in Cordoba Province.

This mountainous region is part of orogen generated during the Proterozoic area where a process occurred close to the Precambian period giving magmatic events and metamorphism as a result.

Stratigraphy of the area essentially integrated by a basement plutonic-metamorphic, composed in most part by Precambrian gneiss and migmatite then intruded in Lower Paleozoic by granite batholiths (Bonalumi et al., 1999)

This mountainous region present a structure of fault block, limited by main longitudinal faults originated or reactivated during the andine orogen.

Dislocations are tectonic upgrade with 50º a 70º inclination to the elevated block and its vertical reject would be more than 800 meters. Minor faults with vertical rejection of only a dozen of meters appear in a parallel way in at East as well as at West of the principal fault line design.

The areas where studies have been performed and thermal well was drilled are located at scarps foot, where minor fault systems can be encountered. These systems are composed of one or several faults, parallel or sub-parallel

and associated to them there are distensive systems acting at subsoil as secondary reservoirs. The Drilling that reached to 510

meters depth allows extraction of Calcium Bicarbonate waters with a great concentration of Carbonic gas at 38° C temperature and 72 litros/m^3 flow.

In this area presently a Spa is being developed.

3.1.4 Proyecto Cerro San Martín

Cerro San Martín Project is located at homonym mountain, in Rio Negro Province near San Carlos de Bariloche City (Fig. 1). Even though this project is located in a geological province of Cordillera Patagonica Septentrional, which main characteristic is the important development of Paleocene volcanic rocks, in this area there is no recent or active volcanism.

Geological studies (Pesce et al 2001b) indicated that stratigraphyc section, in the thermal area; it is a volcano-sedimentary complex on granites from Patagonic Batholithic directly related to tertiary orogenic. The rocks correspond to F. Ventana (Paleocene-Oligocene) integrated by lava and pyroclastic, andesites, rhyolite y basaltic, and ignimbrite and ryolite tuff (Giacosa and Márquez, 1999).

Besides, there are arcilitas, sandstones and conglomerate of marine and continental environment. Marine sedimentitas have fossil level with plentiful of bivalves and gastropods fauna.

It corresponds with the Andic cycle that starts during Paleocene with a calco-alkaline volcanic arc, remaining up to middle Eocene. At eastern part of Cerro San Martin, there is an area of convergence structures, which have generated on subsoil an area of secondary permeability able for thermal fluids.

In this region, with a lot of fractures a geophysical study has been performed, Electro-Vertical drill (SEV) and Electrical Profile (PE) in order to establish the aquifer parameters depth. By Electro-Vertical drill (SEV) it has been established that a -1340 meters depth there is a litologic change to low porosity rocks, more compact and drier. This limit would correspond to a more impermeable surface that may behave as a fluid accumulation level.

As well as, true resitivity values of geo-electrical stratum indicated that fluid mineralization would correspond to freshwaters.

Table 2 -Chemical characteristics of new Geothermal Areas

Geothermal Areas	Total Depth (mbbp)	Temp. (ºC)	Water Type	pH	EC (µS/cm)
La Paz	1001	41	Sodium Chloride	6,5	98900
Villaguay	1357,5	41	Sodium Chloride	7,7	78600
María Grande	1375	43	Sodium Chloride	6,58	56860
Gualeguaychú 2	1000	33	Sodium Chloride	7,6	7950
Concordia 2	1142	43	Sodium Bicarbonate	8,4	650

By means of Electrical Profile (PE) three sectors were identified, which have been associated to fractured areas that may behave as fluid circulation routes.

Above mentioned points indicated favourable areas to make an exploration drill. Maximum depth foreseen to make an exploration drill is 1350 meters. The exploration well reached to -1222 meters with final diameters of 8”. Waters are Sodium bicarbonate, with a temperature of 41° C, and 20-m3/h flow. Presently a Thermal Spa is being developed.

3.2 Prefeasibility Projects (1)

Eleven new areas are being studied in different regions in Argentina and they have different progress degree (Fig 1).

Cordoba Province: Huerta Grande, La Falda and Valle Hermoso.

Buenos Aires Province: Carhue.

Entre Rios Province: Nogoyá, Basabilbaso, Diamante and San José.

Misiones Province: Alem and Oberá

Santa Fe Province: Carlos Pellegrini

3.2.1 Cordoba Province

In a basement rocks environment at Northeastern part of Cordoba Province, so called Valle de Punilla, first phase pre-feasibility studies have been performed. This area covers La Falda, Valle Hermoso and Huerta Grande localities (Fig. 1). Said municipalities request analysis of this area with the objective of generating thermal projects aimed at health tourism that presents now a day as a new economical development alternative in Argentina.

A group of mountain chains that correspond to fault systems, separated by longitudinal valleys, integrates Cordoba hills. Movement of these blocks towards the East produces an asymmetric morphology on these valleys (Gordillo and Lencina 1979) where steep slopes can be found at East and laid slopes at West. Valle de Punilla corresponds to one of those longitudinal valleys, which are flanking Sierra Chica elevations, one of the principal orographyc units of this region. In regional geology of Valle de Punilla predominance of crystal form basement rocks is stand out.

Metamorphic complexes are located at East of Valley mentioned before and are mostly constituted by tonalitic gneisses, biotitic, amphibole schist and marble (Bonalumi et al., 1999).

Even though this region at fist sight does not respond to geothermal characteristics that may presume existence of thermal fluids, the major effort, at this stage, is being put in structural analysis in the region with the objective of finding distensive areas that might have generated a secondary reservoir.

3.2.2 Misiones Province

As already pointed out, development in Argentina Northeastern thermal basin, where Parana Thermal System (PTS) is located, research extended to new provinces. In Misiones geothermal studies have been performed in Obera and Alem localities (Fig. 1).

Misiones province is characterized by its red soil, which constitutes the regolith of underlying basalts that cover the entire province surface.

3D Stratigraphic model of the basin together with litostratigraphic and geophysical studies allowed determination of position, stratum thickness where in STP the thermal fluids are. First step was elaboration of a geological profile for both localities (Pesce et al., 2001c and 2000c). This profile constitutes a first stratigraphic interpretation of the sector, which later on has been complemented with geophysical studies.

Basement that comes to the surface at South-East of Paraguay gets deeper to the East (Almeida and Melo, 1981), may be at 1600 – 1800 meter under the sea level in Obera and Alem areas. The top of F. Rivera and Tacuarembo formations, according to models could be at -1200 – 1400 meters under sea level for Obera and Alem areas respectively. Serra Geral formation is outcrop and sub-outcrop in whole province, so the top position would practically coincide with topography.

By means subsoil indirect studies, geo-electrical research by Vertical electric Sounding (SEV), have been determined electrical units and its correlation with geological units.

Geophysical studies presented similar characteristics for both localities, with variations in depth that was compared with information from other areas of this basin already studied (Pesce, et al. 2001d and 2002d).

From the second geo-electrical stratum until the sixth inclusive, resistivity values are 68.2 y 949.2 Ohm.m with thickness between 528.7 to 681.7 meters, Serra Geral formation basalts are represented. Same range Electrical resistivity of same range was observed in Entre Rios Province and Uruguay.

Basalts with low resistivity values are more fractured, with more sandstone intercalation and pyroclastic materials, less humidity or saturation degree.

Electrical resistivity values at penultimate geo-electrical stratum vary between 47.0 y 76.2 Ohm.m. Basalts with sandstone intercalation (F Solarti, STP Upper Level, Pesce, 2002c)) represent this stratum. In a general way in this Thermal Basin (STP) (Cuenca termal) same range resistivity values of the last geo-electrical stratum can be obtained as in sandstones of Rivera + Tacuarembo formation in thermal areas located at the South of Entre Rios Province (Federación and Concordia). By analogy with these areas and according to values obtained, the water kind expected for Obera region would correspond to fresh water type.

A probable lithological-stratigraphyc column was defined which contains different geo-electrical stratums that meet particular litological characteristics as Serra Geral formation. Basalts thickness according to SEV data varies between 906.6 y 1257.6 for Obera and 1345 y 1450 for Alem locality. Most important variation is from 600 meters up to 1250 at Oberá and 1450 at Alem. In this stretch the beginning of continental sandstone intercalation carrying fresh water (STP Upper Level) between different flows are registered.

From 1250 and 1450 meters lava sequence ends and starts sedimentites corresponding to Rivera–Tacuarenbo Formation (Intermediate Level).

From a resistivity data, aquifer located in Rivera + Tacuarembo formation is fresh type presenting a mineralization (SDT) between 300.0 - 600.0 mg/l and temperature is expected to be at 42° to 45° C.

3.3.3 Entre Rios Province

New studies continued being performed in Sistema Termal Paranense between Basabilbaso, Nogoya, Diamante and San Jose. In all these localities pre-feasibility stage have been completed (Geological and Geo-physical studies and the thermal model has been established for thermal drilling development. First three localities mentioned are located at South-West sector of Entre Rios Province, region where the basin gets deeper y STP lower thermal level predominates, while in San José Upper thermal Level is interpreted to be reached.

a.) Nogoya Project: by means of basin modeling studies and subsoil indirect studies (geo-electrical), it has been established location of production level within the STP. In volcano-sedimentary basin Litostratographyc scheme lava dense sequence from Serra Geral formation basalts acquire a remarkable importance acting as an element that confines production level which is underneath.

It has been established in Nogoya that total sedimentary stratum from surface to basalt roof is 816 meters (Pesce et al. 2001a). From 1440 – 1460 meters lava sequence would end and start infrabaltic sedimentites corresponding to Rivera + Tacuarembo formations (production level). Thermal aquifer top sandstones) would be located at 1460 meters and an interest flow would be obtained penetrating approximately 100 meters in this unit. Synthetically, it is estimated that in Nogoya area a drilling of 1560 meters depth would have an interesting flow and appropriate high temperatures for thermal treatments.

From aquifer resistivity data, associated with interpolation values of wells in La Paz and María Grande, it is established that correspond to salt-water with mineralization values (SDT) between 47,30 a 54,84 gram per liter.

b.) Basavilbaso Project: In Basabilbaso area total sedimentary stratum from surface to basalts roof has a total thickness of 637 meters al thickness basalts of Serra Geral Formation probably may reach 621 meters. Therefore, Thermal aquifer (infra-basaltic sediments, constituted by sandstones and silt), containing STP lower level, are located at approximately 1258 meters in drilling scheduled area. Average thickness is 433 meters. Low electrical resistivity values of sedimentites associated to interpolation values in wells of the area (La Paz, Maria Grande al Villa Elisa) allow concluding salty water presence with high mineralization values (STD).

c.) Diamante Project: In this locality a basin deepens it is interpreted and also possibility of two thermal aquifer levels. Upper level would be in basalts lower section, would have a thickness of approximately 200 meters and would start at 1300 meters. It is interpreted that is related to sandstones from Solari Formation (STP upper level) with thickness that may vary from 10 to 30 meters intercalated in lava flow or basalt still. In this basin sector, intercalation of sedimentites, may be from sandstone silts would be saturated with high salinity waters.

This lava flow may be scattered in low section of Serra Geral Formation and temperature may be between 42° and 46° C. Second level, may be the one more productive and probably spring forth, would be located at sediments under vulcanites under 1500 meters. Even though total thickness could not be established, we consider that it may have more than 200 meters. It is interpreted that in this basin sector prevails the Geological Unit called San Cristobal Formation which laterally inter-digitates with Rivera and Tacuarenbo Formations. This may be constituted by intercalations of silt sandstones, clay silt and clay with a temperature higher than (48° ± 2°C).

d.) San Jose Project: STP Upper thermal level , constituted by continental sandstones from Solari Formation (Herbst, 1971) which presents intercalated in basalts lower levels of Serra Geral Formation (Falconer, 1931) is exploited in Entre Rios eastern sector in Colon Project (Fig. 1) and in western sector in Maria Grande Project. At Colon Area upper thermal level is between 450 and 750 meters depth and with fresh water while in María Grande is between 1.100 and 1.330 meters and thermal fluid presents a high salty level. Besides East-West deepens of basin in eastern sector (Colón) a high basement structural is registered (Pesce, 2002) product of Horst Colon-Concepcion del Uruguay that generated an area of no deposit of STP lower and middle levels. Positive area may haven been existed in basin and acted like conditional element in deposit in different geological units that integrate de STP. In San José area, the total sedimentary stratum from surface to the basalts top has a thickness of 290 meters and basalts corresponding to Serra Geral Formations are 360 meters high. Therefore, intercalated sandstones in STP Upper level would be located between approximately at 470 and 650 meters . From 650 meters electrical resistivity values indicate beginning of crystalline basement.

3.3.4 Santa Fe Province

In STP field studies are being performed in Carlos Pellegrini project located to the West of the volcano-sedimentary basin. First phase of pre-feasibility studies have been made and a thermal basin model has been established with and integrated stratigraphyc profile for Carlos Pellegrini locality. Depth values and average thickness of thermal interest levels that have been established must have been confirmed with indirect subsoil studies (Geo-physical). Different geological units integrated by sedimentary deposits covering vulcanite have a thickness of approximately 830 meters. From 830 meters over seal level, may go through Serra Geral formation, and may remain 220 meters.

Finally, it has been established that it may get in aquifer formations STP intermediate Level at -1050 m over sea level and thermal fluid temperature is expected to be between 42° to 44° C.

3.3.5 Buenos Aires Province

Carue Thermal Project is located on occidental sector of Buenos Airs Province approximately at 600 Km of Buenos Aires City located near of Epecuen Lake, which constitutes a closed basin with high salinity levels and it is a well known place because of the curative waters. Thermal treatments haven been performed in hotel establishments arranged for that use.

Epecuen Lake is a hyper-marine endorreic basin and the water is hyper-marine with PH8.9 and SDT (mg / L) 131.528.

Carue Thermal Project is located at Cuenca de Macachin that because of its genesis correspond to an intracratonic rift from the Cretaceous era related to Atlantic Ocean opening (Zambrano, 1974).

First phase of pre-feasibility studies have been performed and a thermal basin model has been established with an integrated stratigraphyc model for Carue locality.

Cuenca de Macachin may be delimited by extensional fractures, which may correspond to great magnitude cortical debilities .

Constant al continuous development of this basin that since the Late Cretaceous, shows two tectonic stages defined by a first distensive movement and subsequent structure inversion.

Cuenca de Macachin (Salso, 1966) has an elongate shape north-south direction and has been characterized as a narrow and deep rift, where a total of 4000 meters of sediments may be may be over the crystal basement.

Cuenca de Macachin in constituted by Arata, Abramo, Macachin formations and Pampeano sediments that correspond to Permo-Triasic to Plio-Pleistocene.

A first conclusion of studies arises that it is possible to find thermal fluids in Carhue Thermal Project, generating a positive alternative that encourages continuing with a second stage studies.

Towards the west and northwestern of Carhue locality basement deepens and sedimentary sequences are more developed where would be a possibility to find a thermal aquifer.

3.4 Project in Reconnaissance Stage (1)

3.4.1 Chubut Province

In northern sector of Chubut Province two interesting areas were located Nacientes del arroyo Telsen and Aguada Tibia de Gan Gan (Fig. 1).

In general way, waters from these thermal spring of Telsen locality (T 20° y 23°C) and Gan Gan (T 18.5° y 20.7°C) present similar characteristics. In both localities water is bicarbonate composition fresh type and sodium bicarbonate with pH values between 7.4 y 7.9. Electrical conductivity values measured at springs fluctuate between 0.400 y 0.451 mS/cm that together with dissolved solids quantity (244-316 mg/L) shows that they are week mineralization waters.

Related to mineral saturation index, results show a slight (leve) saturation degree in Telsen area (closer to equilibrium considering probably analytic errors) in respect to chalcedony (over saturation), calcite (sub saturation). For springs located at Agua Tibia (Gan Gan) same minerals are found in a slightly higher saturation ratio.

Oxygen isotopes studies (Oxygen –18) and H (Deuterium) indicate that water of springs of both localities is from meteorology origin.

On the other hand, they show tritio high content not only for Telsen stream but also for Aguada Tibia springs (8 ± 0.6 y 4.9 ± 1.0 U.T, respectively). They contrast with obtained results from superficial water T-2 sample that showed 2.5 U.T.

In order to calculate possible sub-soil temperature for Telsen and Gan Gan springs, a group of geo-thermometers was applied from chemical data. Preliminary results of geo-thermometry in liquid phase indicate, in general that springs temperature may be at a range of 40°C y 60°C.

Because of the isotopic composition, waters of Telsen stream and Agua Tibia (Gan Gan) spring are from meteorology origin. Taking into account tritium content it is established that they are “young” waters with a short period of transit in aquifer rocks. Same idea arises when chemical composition and week mineralization is considered.

On the other hand it is strange to remark obtained results through application of some liquid phase geo-thermometers and diagrams SI vs. temperature. Considering first ones it is possible to estimate temperatures of 40° a 60° C while looking at diagrams S.I. vs. T [°C], equilibrium temperatures would no exceed 70°C (60° ± 10°C for Telsen area).

Taking into account results detailed in paragraph above both areas may be considered as part of a low temperature geothermic system, however, water chemical composition and tirito data, suggest that necessary time to reach temperatures of such range would not be enough.

4. CONCLUSION

During the last five-year period progress on Argentine geothermal resource integrated knowledge has been achieved studying new areas and classifying different regions of the country depending on distribution of hydrothermal systems.

Geothermal resources at Northwestern Argentina continue with the growing dynamic and new projects that are being developed in Entre Rios Province, together now with Misiones and Santa Fe Provinces located at STP field, open a very encouraging and positive perspective.

Geothermic aimed at health tourism appears as a new appealing economical development alternative. In Cordoba and Buenos Aires Provinces also new geothermal projects have been incorporated. This panorama allows thinking on a constant growing perspective in utilization of thermal fluids and it is marking a new thermalism tendency in Argentina.

The so-called Thermal centers or Integral health Spa’s boom, not only in our country by also all over the world is very remarkable. Success achieved is indeed generating an outstanding increase in resource direct use. Framework of thermal demand is constantly growing and provinces motivate tourism industry based on geothermal fluids as main attractive.

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TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2004

[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 2004 (other than heat pumps)

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

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

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^oC) - outlet temp. (^oC)] 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. (^oC) - outlet temp. (^oC)] 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.

Locality		Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
			Flow Rate	Temperature (^oC)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity Factor[5)]
			(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	
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
Gualeguay	(ER)	B	-	-	-	-	-	-	-	-	0
Concepcion del Uruguay	(ER)	B	-	-	-	-	-	-	-	-	0
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
María Grande	(ER)	B	9.7	43	28	-	-	0.60	-	15	0.79
Gualeguaychu	(ER)	2 B	5.5	33	28	-	-	0.11	-	3.3	0.9
Concordia	(ER)	2 B	69	43	30	-	-	3.7	-	111	0.9
Uritorco	(CBA)	B	20	38	29	-	-	0.7	-	23	1.04
Cerro San Martín	(RN)	B	8.32	41	18	-	-	0.79	-	21.2	0.85
La Carrindanga	(BA)	G	6.94	55	35 (*)	-	-	-	-	20.1	1
Medanos	(BA)	B	33.3	74	50 (*)	-	-	3.34	-	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 Quinta	(JY)	B	1.6	45	35 (*)	-	-	< 0.1	-	1.1	0.5
Aguas Calientes del Tuzgle	(JY)	B	1 (*)	45	35 (*)	-	-	< 0.1	-	4.7	0.45
Banos 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
Aguaditas	(CAT)	B	< 0.1	30	25 (*)	-	-	< 0.1	-	0.01	0.4
Villavil	(CAT)	B	1 (*)	60	30 (*)	-	-	0.13	-	1.1	0.4
Llampa	(CAT)	B	1 (*)	30	27 (*)	-	-	< 0.1	-	0.2	0.4
Los Nacimientos	(CAT)	B	1.5 (*)	36	30	-	-	< 0.1	-	0.5	0.4
Ojo de Villa Vil	(CAT)	B	6	24	22 (*)	-	-	< 0.1	-	0.7	0.4
La Coipa	(CAT)	B	1 (*)	25	22 (*)	-	-	< 0.1	-	0.2	0.4
Termas de 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	-	19.8	1
Río 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
Corral de Piedra	(SJ)	B	1	25	22 (*)	-	-	< 0.1	-	0.17	0.5

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 Brea	(SJ)	B	0.2	35	30 (*)	-	-	< 0.1	-	0.06	0.35
Rosales	(SJ)	B	4	40	30 (*)	-	-	0.17	-	2.1	0.54
Rodeo	(SJ)	B	6	37	30 (*)	-	-	0.18	-	-	-
Pismanta	(SJ)	B	7	43	35 (*)	-	-	0.23	-	5.53	0.43
Río Valdez	(TdF)	B	18.1	37	32 (*)	-	-	0.38	-	5.6	0.47
Cerro Campanar	(MZA)	B	5	51	35 (*)	-	-	0.38	-	-	-
Banos del Azufre	(MZA)	B	48	39	35 (*)	-	-	0.80	-	-	-
Los Molles	(MZA)	B	2.5	41	35 (*)	-	-	< 0.1	-	1.6	0.25
El Sosneado	(MZA)	B	7.53	33	28 (*)	-	-	0.16	-	-	-
Puente del Inca	(MZA)	B	15.67	34	-	-	-	-	-	-	-
Borbollon	(MZA)	B	1 (*)	24	22 (*)	-	-	-	-	0.08	0.48
Cacheuta	(MZA)	B	3.95	44	33 (*)	-	-	0.18	-	3.3	0.54
Cerrillo	(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-H	2 (*)	65	35 (*)	-	-	0.29	-	4.05	0.48
Taco Ralo	(TUC)	B	30 (*)	40	35 (*)	-	-	0.63	-	-	-
Roque Saenz Peña	(CH)	B	-	-	-	-	-	-	-	2.37	0.48
Tanti Viejo	(CBA)	B	-	-	-	-	-	-	-	0.12	0.48
San Marcos Sierı	(CBA)	B	-	-	-	-	-	-	-	-	-
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
Bahía 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								149.88		609.14	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2004

[1] Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}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. (^{o}C) - outlet temp. (^{o}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	31.6	0.24
Bathing and Swimming[7]	83.58		
Other Uses (specify)	0		
Subtotal	149.88		
Geothermal Heat Pumps	0		
TOTAL	149.88		

[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, 2000 TO DECEMBER 31, 2004 (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		7			7.88
Injection	(all)					
Total			7			7.88

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)
2000	6		3			1
2001	6		3			1
2002	5		3			
2003	4		2			
2004	4		2			1
Total	24		13			3

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) 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$	%	%
1990-1994	7.2	3.7		0	30	70
1995-1999	4.8	1.2		0	70	30
2000-2004	1.5	3.5			85	15