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REPUBLIC OF PANAMA

ADVANCED PRE-FEASIBILITY STUDIES OF EL VALLE DE ANTON GEOTHERMAL FIELD

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The purpose of the Advanced Pre-Feasibility studies for the El Valle de Antón Geothermal Field is to obtain information required to verify and make a preliminary evaluation of the field's energy resources. A further objective of the studies is to compile reliable information to attract private investors for the development of a geothermal power project, which would also make it possible to adopt policies for the exploration, examination and development of the other geothermal fields identified in Panama.

The El Valle de Antón geothermal field is located some 75 Km south and 57° W of Panama City, inside the El Valle caldera, in the district of Antón province of Coclé.

El Valle de Antón is a complex volcanic structure, the most eastern of the country and also of the whole Central American volcanic chain. Its elevation is 1,185 m and it extends over an area of 600 Km^2. The summit of the volcano is occupied by a 20 Km^2 caldera. This volcanic complex is located in correspondence with the contact between the Nazca and Caribbean plates. In this sector, the subduction ended in the Upper Miocene; however the calc-alkaline affinity volcanism continued during the "extinction" phase until very recent times (Upper Pleistocene), producing rare but intense episodes.

El Valle de Antón is the most important result of this activity. Its history covers an approximate period of 2 My. The initial phase of this activity was characterized by effusions of limited volumes of andesitic lava accompanied by pyroclastic. The next phase caused the formation of a complex caldera structure in which two different collapse structures can be recognized, La Mesa (in the northern part of the volcanic complex) and El Valle de Antón (is a well defined caldera collapse structure with abrupt rim walls of about 200 m vertical displacement and with a flat valley floor)

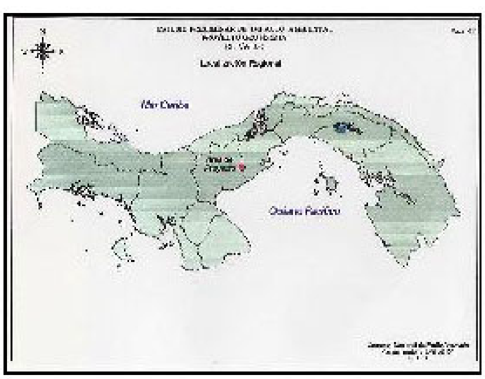
The two structures are separated by large post caldera domes. Aligned E – W along the northern edge of the El Valle de Antón caldera.

The volcanological and petrological evidences indicate that the magma chamber was formed in the subsurface of El Valle around 1.1 – 1.3 My. The most recent products are instead the result of high-energy plinian eruption involving large volumes of magma, their age is of 40-50,000 years (Río Mar site) and 34,600 years (Mata Ahogado structure). The main result of the Geophysical investigations supports the hypothesis of a totally sealed deep thermal environment. In fact a very conductive layer characterizes the subsurface of the caldera floor. Its maximum thickness cannot be estimated through resistivity data alone. A three layers reconstruction, combining resistivity and gravimetric data, points out a relevant thickness (800-1000 m) in the central part of the caldera. It is overlain by a 300-400 m thick resistive layer interpreted as post caldera pyroclastic and breccias, which hosts the shallow acquifers. This conductive layer is the geophysical expression of the bulk of the caldera filling materials and the low resistivity might be the result of intense low-medium temperature hydrothermal alteration which resulted in the total self-sealing of the sequence. Finally, the geophysical resistive basement, not reached by electrical soundings, can be reconstructed using gravimetric information.

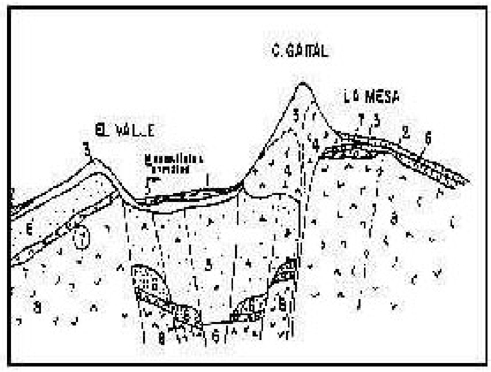
Geochemical and hydrogeological evidences show a confined thermal acquifer found at shallow depth (60 m) in the southern portion of the caldera floor. Its temperature is of 40° C and its pressure measured at bottom of exploitation wells is slightly higher than normal. Very minor thermal springs (38° C) occur along the Anton river, close to the caldera southern rim. Waters have a bicarbonate chloride composition and a geochemical temperature of 140° C for a deep reservoir with depth between 550 and 1200m. A deeper thermal component can be hypothesized.

To accomplish the objectives listed in the preceding section, the Republic of Panama is planning (with resources from the Interamerican Development Bank, Empresa de Transmisión Eléctrica, S.A. and a significant Technical Cooperation from the Japan Government) to drill the well N° 1 (+/- 2,000 meters), in the south-central part of the El Valle caldera. This well will seek to penetrate the initial surface layers, which are both resistive and permeable, in order to enter, at a depth of 800 to 1,000 meters, the conductive layer which is inferred to be the sealing formation of the reservoir, where thermal-gradient and heat-flow measurement will take.

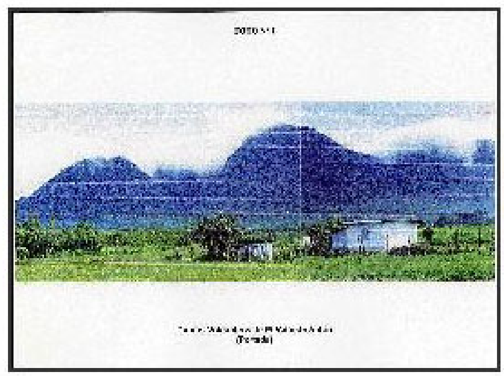
Regional Localization



Geological cross section (N-S) of the El Valle de Anton structures



Volcanic domes



References

1. A. Merla, Integración de los Estudios geocientíficos en las zonas geotérmicas El Valle y Chitra – Calobre, IRHE-BID, 1995.
2. R. Fournier, A. Duprat, P. Liguori, P. Muffler, J. Rivera, Report of the Fifth Meeting of the Advisory Panel, Advanced Pre-Feasibility Studies of the El Valle Geothermal Field, IRHE-BID, 1995.
3. E. M. Lima Lobato, T. Fujino, A. Merla, N. Haraguchi, E. Granados, Focus Mission, Advanced Pre-Feasibility Studies of the El Valle Geothermal Field, West JEC and GeothermEx, IRHE-BID, 1998.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICTY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specifiy)		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 January 2000	0.0	0.0	555.0	4063.6	552.3	2626.5	0.0	0.0	0.0	0.0	1107.3	6690.1
Under construction in January 2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Funds committed, but not yet under construction in January 2000												
Total projected use by 2005												

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 1999

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
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 1999 if available, otherwise for 1998. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Unit Rating MWe	Total Installed Capacity MWe	Annual Energy Produced 1999[3)] GWh/yr	Total under Constr. or Planned MWe
Total									

Table 2 It's not applicable

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 1999

[1] I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish and animal farming
S = Snow melting
H = Space heating & 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. (^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) x 0.03171]/Capacity (MWt)
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
		(kg/s)	Inlet	Outllet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
TOTAL										

Table 3 It's not applicable

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS
AS OF DECEMBER 1999

This table should report thermal energy used (i.e. energy removed from the ground or water) and not the heat rejected to the ground or water in the cooling mode.

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps
2) Report type of installation as follows: V = vertical ground coupled
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)
3) Report the COP = (output thermal energy/input energy of compressor) for your climate
4) Report the equivalent full load operating hours per year, or = capacity factor x 8760
5) Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Locality	Ground or water temp. (^oC)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]	COP[3]	Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr = 10^{12}J/yr)[5]
TOTAL							

Table 4 It's not applicable

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 1999

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

2) Annual 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

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

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

4) Includes district heating (if individual space heating is significant, please report separately)
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

Note: please report all numbers to three significant figures.

TABLE 5 IT'S NOT APPLICABLE

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 1995 TO DECEMBER 31, 1999

[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					
Injection	(all)					
Total						

TABLE 6 IT'S NOT APPLICABLE.

THE REPUBLIC OF PANAMA IS PLANNING TO DRILL AN EXPLORATION WELL IN JANUARY OF THE YEAR 2000

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

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1995	6					
1996	6					
1997	8					
1998	4					
1999	4					
Total	28					

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (1999) 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$	%	%
1985-1989						
1990-1994						
1995-1999	* 3.032					

* Exploration Drilling