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Fact-finding and assessment of the CO2 source of Sillunchi. Field report

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Field report of Sverrir Thorhallsson
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Wells at Sillunchi

The production of CO2 started some 50 years ago at Agua y Gas de Sillunchi S.A. near the city of Machachi 30 km South from Quito. The early sources were gas rich springs along the Río San Pedro river but drilling commenced in 1956. Hot springs are found along the river banks and possibly the river courses are fault controlled. Usually a group of springs is found along the river- near Quito, Concuncyacu, El Tingo, La Merced and Alangasi, together with several springs found within a distance of 30 km of each other along the Río San Pedro, and encircle an extinct volcano Illaló and also of Pichincha (Fig 1. ref. A Note on the Hot Springs of Ecuador, A. De Grys et al., U.N.Symp. Pisa 1970). The same could hold true for the many other volcanoes nearer to Sillunchi. By the river some 2.5 km south of the Silluchi plant the Tesalia company, the bottler of the Gütig brand, is tapping carbonate rich mineral water. A total of 18 wells have been drilled, mostly close to the springs and along the river where the company has acquired such rights. The property extends some 2 km along the river to the north of the factory and 0.3 km to the South and is about 200 m wide. In 1997 there are five wells tapped for CO2 and the others have either become unproductive or have very small flows. A total of 10 wells are monitored for flowrate every month and have been so for two years. The approximate location of these wells is shown on a copy of a map made available to us by Sillunchi (Fig. 2).

The wells are drilled with conventional water well drilling rigs and technology. The following description is based on information from a folder on the drilling of well Alborada B in 1993. Conventional tri-cone bits are used and bentonite mud as drilling fluid. The wells are drilled with two diameters of bits. No surface casing is set and no blow-out preventors or diverters are used. No serious safety problems have been encountered while drilling the wells and the deepest one is 180 m. Some delays in drilling are encountered because of gas flows. The drilling progress curve of well Alborada B drilled in 1993 is shown in Fig. 4. The drilling of the well took about a month to complete but the actual working days were 13 for drilling and 7 for civil works.

The production casing and liner are of the same diameter, usually 6". The casing is PVC plastic with threaded connections, because of its resistance to corrosion in such water. Five rather crude crosswise cuts 1/6 of the circumference (appr. 4 mm wide) are made in the casing on alternative sides along the length of the pipe. From photographs it could be judged that the slotted liner is not a fabricated well screen which would have more slots of a smaller size. The bottom 66 m are slotted and the casing string is of uniform diameter as can be seen in Fig. 3. Some wells have required a 8"surface casing as can be seen by the two pipes protruding out of the ground. Attempts to case the Alborada B well with 8" casing failed because of obstructions down hole and it had to be cased with 6" pipes.

There is no flange on the well and no valve. The well can thus not be shut in while there is no demand for the gas or for repairs. The connection from the well to the separator is made by PVC pipes with sockets. This connection is leaking on several wells and the general appearance of the wellheads is not good. The only way to stop the flow to the separator is to open the pipeline by pulling the elbow off the casing. This is also done during well cleaning operations. There is a deep sump full of water by most wells making acess to the wellhead difficult.

Once the casing has been landed the well is stimulated to induce flowing by cleaning out the bentonite mud. This is achieved by air lift pumping the well for a long enough period to enable the natural gas lift from CO_2 bubbles to take over. An air compressor is used for this operation and a flexible tubing (air hose) run down the hole. Trials to stimulate newly drilled wells into flowing by putting blocs of dry ice into the hole have not been very effective as a longer period of air assist is required to "kick the well off" than can be provided from the dry ice. The dry ice method can, however; be useful when a dormant well requires a small "lift". It is interesting to note that the well is induced to flow before the gravel pack is put in the annulus. After the well has been cleaned out and flowed the filter sand with a grain size of 3 mm is placed in the annulus. This is done by dumping the filter sand, a bucket at a time, into the annulus until the sand is 1.8 m form the surface. Then a plastic sheet is put on top of the sand and covered by gravel and a cement plug placed to surface to permanently seal the annulus. This sealing has not always been successful as can been seen on well Tatatambo Alto some 100 m south of San Guillermo where the flow of gas and water is issuing out at the surface (appr. 6 l/s) through the annulus. At the same time nothing is flowing out of the production casing.

Attempts were made to obtain information on the depth and casing program of each of the Sillunchi wells but they did not succeed in the short time available. The depth of two wells is known; San Guillermo 180 m which is the deepest well and Alborada B 146 m.

The gas collection system

The water and gas is separated at the wellhead, either in large concrete tanks or at two wells in steel tanks. A schematic diagram of the separator installation is shown in Fig. 5. The concrete tanks are well made from reinforced concrete but the steel tanks are a temporary arrangement, one tank being a used tanker. The separator tank at San Guillermo is particularly large with inside dimensions of 6.7 m x 12.7 m and 3.45 m high. Four 4" HDPE plastic collection pipes are connected to the tank. The separation is by means of gravity whereby the gas bubbles rise to the surface in the slow moving water. The tanks contain internal barriers to assist in the separation. There is a slight over pressure in the separators of 15-45 cm H_2O as measured by a U-tube manometer on each tank and shown in Table 1 where available. All of the collection system is made from HDPE plastic pipes, mainly 4" with several pipes run in parallel. Because of the long distances and need to maintain as low a pressure in the separators as possible, two Roots type blowers (double lobe, constant displacement) are used as boosters. The control of this system is somewhat difficult as there is no gas holders or storage available and the flow and pressure balance of the system is simply adjusted by a bypass valve at each booster blower. If the gas production exceeds the pipeline flow the pressure will build up in the separator until the water seal is broken. A separate vent pipe and water seal acts as a pressure control or overflow. The pressure level in the separator above which the gas excapes in this way can simply be adjusted by changing the submergence of the vent pipe in the water sump (see Fig. 6). The reverse problem seems to have occurred when the blower pulled enough vacuum to collapse and destroy one stainless steel gas separator. There are moisture traps on the gas pipelines that are simple tanks with a drain. The whole operation of the gas collection system is manually controlled (mainly by adjusting the bypass valves) and depends on the fine-tuning and the keen feeling of the operators.

The effluent water passes through dug out earth canals to Río San Pedro river. They are deep and dangerous in places as they are partly covered by lush vegetation. A rust red precipitate covers the water passageways, caused by the iron in the water. No chemical anaysis is available of the effluent water to assess its environmental impact. The water is, however, not expected to carry any environmentally damaging components. I heard a story that a gas rich well near Cotapaxi was proven unsuitable for watering in greenhouse due to its boron (B) concentration.

Well output - Water

The water flowrate of the wells is a very important parameter as it directly influences the gas flow. The CO_2 gas is dissolved in the water until it reaches a certain level (depth) where degassing starts due to decompression. The inception of degassing (bubble point) occurs when the partial pressure of CO_2 is higher than the down-hole static pressure. Where degassing starts is governed by the concentration of gas, temperature and fluid chemistry, mainly pH. Geochemical models have been developed to calculate the partial pressure of the CO_2 gas at the given conditions thus allowing estimates of the depth of degassing. Without the required chemical data one can use AGAs own tables of solubility of CO_2 in water as a function of temperature and pressure to estimate the pressure below which the gas will be released (AGA

CO2 handbook). According to it that satutation is reached at 2.5 bars. The gas bubbles play a very important role in maintaining the artesian flow of the wells, as without the gas most wells would not self-flow. The output of the wells is thus assisted by this "air-lift pumping". Unfortunately no well tests have been performed to determine the characteristic output curve, flow vs. change in down hole pressure, which is specific to each well. These tests are difficult to perform now as there is no valve on the wellhead or means to throttle the flow. The down-hole pressure needs also to be logged during the flow test below the bubble point, either by a pressure transducer or a bubbler tube arrangement.

Table 1. *Summary information on CO2 wells at Sillunchi 1997*

Source Name Fuente +	**Age in 1997**	**Flow typ. (l/s)**	**Flow 31 Oct**	**Temp. °C**	**Sep. cm/H2O**	**Cond. µS/cm**	**Status**	**Method gas coll.**
San Guillermo Alto	7	33,15	26,98	32,00	15	7900		
San Guillermo bajo						4650		
San Guillermo bajo						4650		
Tatatambo A	>40	18,33	22,06	26,70		3725		
Tatatambo B	4	3,43	2,51	24,90	15	3225		Steel tank
Tatatambo Alto	4		4,99				Dsiconn.	
Marcela	8	5,36	3,52			3325	Disconn.	
San Andres	12	9,39	7,08	24,20		2950		
Alborada A	16	0,65	1,12	20,60		1900	Disconn.	
Alborada B	16	3,02	2,30	18,60		1925	Disconn.	
Maria Faviola	8	0,88	1,40			1400	Disconn.	
Manuel	3	1,10	1,29				Disconn.	
Margarita	3	31,54	27,89	24,70	45	3650		Steel tank
Santa Teresa A	>40	0,13	0,10			3725	Disconn.	
Santa Teresa B	>40	3,29	3,05			3750	Disconn.	
Total flow (l/s)		110,27	104,29					

The well output has, however, been measured monthly by the plant since 1995. The water flow rate is measured volumetrically by the filling time (measured by a stopwatch) of a 55 gal. drum (208 l). The data has been reported by the quality control department and compared to the expected. The report also shows which wells are disconnected from the plant. We were given copies of these measurements and a sample copy can be found in the appendix. The flowrate of the five wells connected to the plant is shown in Fig. 7 and for all 10 wells monitored in a table and figure in the appendix. The total flow of the wells is some 110 l/s whereof 86 l/s is form wells presently serving the plant.

At Margarita and at Sam Guillermo the water from the sump flows over a sluice which allows direct measurements of the flow as is resembles a rectangular sharp crested weir. Measurement were made at these wells during the field inspection on November 11th. In the case of Margarrita the width of the weir was 46 cm and water height 7 cm corresponds to a flow of appr. 16 l/s. In the case of San Guillermo the weir was 75 cm and water height 4 cm corresponding to a flowrate of appr. 11 l/s. This is about half the reported flow rate of these wells and I have no clear answers to expain the difference. The measurements by the plants personnel are not made at these locations but down stream in the channel where there is room for a barrel. This should be checked further and a thin plate rectangular weir of the proper width installed permanently in the water boxes (overflows) of the separators. That will allow more frequent measurements of the flow. As it stands now we are told that the wells require cleaning twice a year due to a loss of flow, while the data provided to us shows no such change.

It is interesting to note the simultaneous gradual decline of output from the two largest wells San Guillermo Alto and Margaritta which are about 1.5 km apart at opposite ends of the production area.

Well output - Gas

No direct measurements have been made on the gas flowrate from the wells. As down-hole chemical samples have neither been collected, nothing is known about the contribution of CO_2 from each well to the plant. The only measurement made is the total weight of CO_2 produced each day. A Toledo electronic weight indicator is attached to the 100 ton storage tank. As most of the gas is recovered, except for leakage and losses, this data can be used to get a mass balance over the well output. The concentration of CO_2 in the reservoir water can thus calculated by recombining the two fractions.

The Sillunchi rule of thumb, based on experience, has been that 1 l/s of water flow is sufficient to produce 14 kg/h of CO_2. This corresponds to 3.8 g CO_2 per liter of water (or 0.38%).

The CO_2 produced on the 10th of November was 19.280 ton and the corresponding water flow is assumed to be 86.52 l/s based on the measurements of the 31st of October. This corresponds to 2.57 g CO_2/ l water. The plant has been in continuous operation in November and the daily production figures are showing Fig. 9. The average production is 19.340 ton of liquid CO_2 per day for 9 day period ending November 10th 1997. The three compressors each have a capacity of 1000 kg/hr of CO_2. Thus no CO_2 needs to be lost due to inadequate compressor capacity. Only at well Margarita did we once notice some loss of gas through the pressure release line, as seen by gas bubbles in the sump by the end of the plastic pipe (see Fig. 6). This discrepancy between the rule of thumb and the calculated CO_2 concentration is 33% and is too significant to overlook.

Data on the monthly production of CO_2 was provided to us and is shown in Fig. 8 (see appendix). This data is unfortunately for the combined production of liquid CO_2 and dry ice. To produce 1 kg of dry ice some 1.8 kg/s of liquid CO_2 is required according to Sillunchi. For 1997 the operating hours of the compressors per month is also recorded (see appendix). Using this data the average output is some 15 ton per day for liquid CO_2 and dry ice. The total production of liquid CO_2 per day is higher, as much gas is lost in the dry ice production. Thus this data supports the more recent production figures of some19 ton per day.

In summary the only way to estimate the CO_2 content of the water is to do a mass balance calculation and using the measured output of the plant and water flowrate. It is important to improve this estimate by more direct measurements. One important conclusion can be drawn from this data and that is that the present maximum capacity of the plant is limited by the well output to 20 ton per day.

Gas purity

One of the favourable characteristics gas source at Sillunchi is its high purity. No gas samples have been taken directly from the individual wells for analysis. The CO_2 content of the gas is measured in triplicate each day at three locations by the quality control department. The sampling points are after the two booster blowers and after compression in the plant. The purity analysis is made by field equipment manufactured by Zahm & Nagel that takes about 10 minutes to perform. The results are reported in % CO_2 by weight to two decimal places and are recorded on the daily report sheet. The remainder is assumed to be air or non-condensible gases. The purity is in general better than 98 % at the source and 92 % after compression (see appendix). Worse purity after compression probably results from leakage or contamination and should receive further scrutiny. Results from the period 1995-1997 reported by Empresa SGS is 99,9% CO_2 and 1.2 ppm moisture in the product. Another lab reported the purity as 99.92% and CH_4 9.8 ppm and <1 ppm rest (see appendix).

During my stay I checked the H_2S concentration of the source by sampling the gas before the second booster. Precision gas detector tubes made by Kitagawa (Japan) for measurements of H_2S were used having a range of 1-150 ppm. No H_2S was detected (<1 ppm H_2S). Two gas samples were taken at the same location in 100 ml glass flasks that will be analysed at Orkustofnun by gas chromatography. No smell of H_2S could furthermore be detected by sniffing the gas, a very sensitive qualitative method. The high purity of the source has allowed the plant to compress the gas without any treatment such as scrubbing or activated carbon filtration. This adds to the value of the CO_2 source at Sillunchi.

Chemical composition of the water

Unfortunately the chemical composition of mineral water from the wells in use for gas production at Sillunchi has not been analysed. Analysis has, however, been made of mineral water from Santa Teresa A and B, as these sources are tapped at present for bottle water. A copy of the June 23rd 1997 analysis of Pepsi Cola is in the appendix. The water is sold under the Agua Linda trade name and bottled by Pepsi Cola in Guayaquil. The water is transported by trailer trucks (20 loads/month) after activated carbon filtration and UV disinfecting by the source. The mineral water wells are not utilised for CO2 production at the present time and have a low flowrate of 0.1 l/s and 3.05 l/s (31/10 1997).

The only other data indicating the composition of water from the wells are measurements of conductivity (µS/cm) made by the plant's Chemical Engineer. This data indicates quite different composition wells and gas content between the different wells. The San Guillermo wells have the highest conductivity (7750-7900 µS/cm) and the other wells have rather similar conductivity (2950-3725 µS/cm), except for Alborada A and B and Maria Favilola which have the lowest conductivity (1400-1925 µS/cm). These realties are shown in Table 1, along with typical flow rates for these wells.

Water temperature

One important factor in locating areas of upflow of this low-temperature geothermal water is to measure its temperature, both down-hole and at the wellhead. Such measurements can help in identifying the main upflow zones and assist in deciding where to drill make-up wells. No systematic temperature measurements have been made to-date but the wells were considered to have a temperature in the range of 27-30°C. During the field inspection of November 11th we measured the water temperature at the exit of the gas separators with a digital thermometer. At Alborada B it was possible to measure the temperature directly in the well throat. The water may have lost some heat by the time we could measure the temperature. The results of the temperature measurements is shown in Table 1. Interestingly there is considerable variation in the temperature between the wells, the range being 18.6-32°C.

Well cleaning and maintenance

Information on the filed operation and maintenance was somewhat difficult to obtain. It is clear from answers given that the wells have been cleaned at intervals of about 6 months, but for what reason and with what results was not fully clarified. It seems that the wells are cleaned to restore the flowrate. The usual method is to remove the wellhead elbow and allow the well to flow freely. If this is not sufficient dry ice is put in the hole and if that does not work the well is stimulated by an air compressor. From this description is seems that these operations would not clean the hole very much but could assist the well in "kicking-off" by causing degassing to occur deeper in the well, which in turn will improve the flowrate. One way to analyse what the problem is to perform a flow test of the well. Then the flowrate and down hole pressure would be recorded to determine how different rates of air-lift pumping improve the output. Analysis of this data will reveal whether local flow restriction is the cause. There are seven workers that are responsible for the field operation. The company has a drilling rig and an air compressor for these jobs. The concrete separators have 50 cm thick walls and additionally a10 cm thick mortar layer on the inside. The concrete seems to stand up rather well to corrosion attack and the corrosion allowance is ample in case it should get attacked. Mild steel is rapidly corroded in the low pH gas rich water so plastic is used in the pipelines and well casings. Stainless steel stands up well to corrosion as is to be expected and inspection of the collapsed SS 304 gas separator confirmed that. There seems to be a gradual loss of flowrate for the wells and they need to be replaced to maintain the flow to the plant. New wells drilled in the vicinity of terminal wells have been good producers, indicating that the loss of productivity is primarily associated with the wells and their close proximity and not the source. Monitoring of the pressure in the reservoir should be initiated as soon as possible to monitor any changes in the reservoir pressure. A tube could also be run into a producing well to monitor the down hole pressure. The least expensive way to make these measurements is by the bubbler tube method. Then nitrogen gas is used to displace the water from a 1/4" tube and the back pressure recorded. Drilling of make-up wells has several times been shown to drastically reduce the flow of nearby wells as was the case for the Alborada wells when Margarita was drilled and also for Tatatambo when an older well some 200 m to the south stopped flowing. This should be no surprise as flow from artesian wells is extremely sensitive to pressure changes in the feed zones in such fracture dominated systems, where pressure changes are transmitted over great distances.

Discussion

1. The source of CO_2 for the Sillunchi plant is carbonate rich geothermal water coming from shallow wells along the Río San Pedro River. The only systematic investigations that have been carried out into the hydrogelology of the area were made by INECEL over 10 years ago into the geothermal potential. Considerable work needs to be carried out to make a resource assessment that would tell how much additional water can be tapped at the present site. This area should be considered as one area hydrologically connected. It is important to start to monitor the reservoir behaviour. Drilling of gradient wells would be one way of locating the fractures and upflow zones that would be good targets for production drilling. Only after such work and well testing is there enough information available to make forecasts as to the effects of increasing the production substantially.
2. The CO_2 gas at Sillunchi is a very clean and has not required any cleaning.
3. The factory has prduced up to 5000 ton of liquid gas and dry ice in a year.
4. The daily production at the present time is limited to 20 ton per day from the five connected wells (Fig 9) an only be improved by a few tons per day by making use of the other existing wells or making design changes.
5. The flow measurements of the wells should be reconfirmed by witnessing the tests made by Sillunchi. The observed flow from the two largest wells does not match the figures reported by the company. Furthermore the flow measurements do not show any fall in output that warrants twice yearly cleaning, nor do they show any recovery of output.
6. In order to increase the flow new wells would have to be drilled. Additional drilling could increase the flow, but because the water is self flowing to the surface the flow is very much affected by small changes in the reservoir pressure. Thus production from new wells may affect the flow from existing wells. A comprehensive resource assessment is required to make predictions as to how much the production could be increased. The present extraction is not very invasive as no pumping is performed and the conditions are close to the natural ones which have remained similar for ages.
7. A one year program of investigations should be undertaken that would include well testing, reservoir monitoring, geological investigations, drilling of gradient wells (exploration wells), chemical analysis. The purpose of these investigations is to determine the most economical ways of sustaining the CO_2 production, evaluate the potential for increased production, determine the causes for gradual decline in well output, analyse why well cleaning is required and site new wells.
8. Wells should be sited on low lying areas to have greater self flow and be near temperature anomallies as they indicate porximity to upflow zones and fractures.
9. The first new wells should be similar to the existing wells but have a valve to allow the wells to be shut-in. There are several advantages to being able to close the wells. Because of gas accumulation and depression of the water level in the hole while shut-in the wellhead and casing has to be designed to take the maximum pressure (ca. 8 bar). This requires the production casing part also to be cemented.
10. The factory has little excess capacity of CO_2 sources at the moment and thus drilling of make-up wells and stand-by wells should be considered. By being able to close the stand-by wells they will not deplete the source unnecessarily or influence the other wells. Any plans to increase the production should be based on having proven the a good portion of that by drilling and well testing. Although I have no information on drilling costs in Ecuador a new well should cost no more than 20.000 USD.
11. Considerations should be made to drill the wells with air or airated drilling fluids to minimise formation damage from the use of bentonite.

12. The collection of data needs to be improved in several ways in order to collect data for day to day operations and to allow a hydrological reservoir model to be made. They include:
    - Abandoned wells should be considered for observation wells by placing bubbler tubes in the 2-3 wells. A similar system could be placed in one production wells to identify increased inflow resistance that may require well cleaning.
    - Twice monthly measurements should be made of the flow from each well through a rectangular weir. For the largest wells a data logging system should be considered.
    - The pressure in the separators should be monitored and controlled continuously.
    - Temperature measurements should be made monthly.
    - Chemical analysis should initially be made once a year of the water and gas from each well.
13. The control of the gas collection system should be improved and automated. A gas holder at the plant should be considered for surge capacity and ease of control.
14. Future gas separators can be smaller in size and could blend better into the environment, e.g. by covering with soil and grass. Plastic tanks such as are produced for underground installation e.g. septic tanks could also be considered for use as separators.

Quito, 14. November 1997

Sverrir Thorhallsson

Figures and Photographs

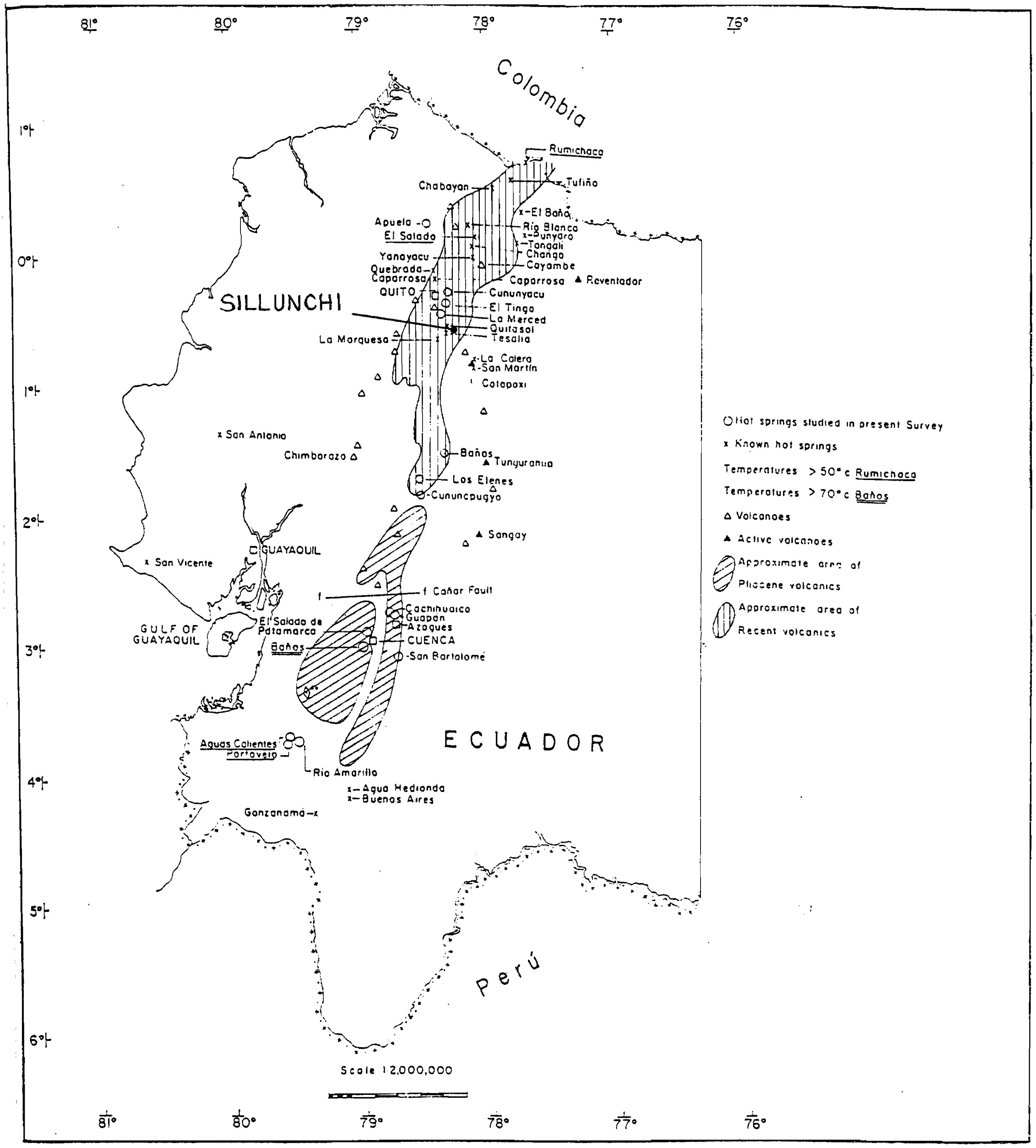


FIG. 1. — *Location of hot springs.*

Fig.1 Location map of the Sillunchi plant and location of hot springs in Ecuador (De. Gyr 1970)

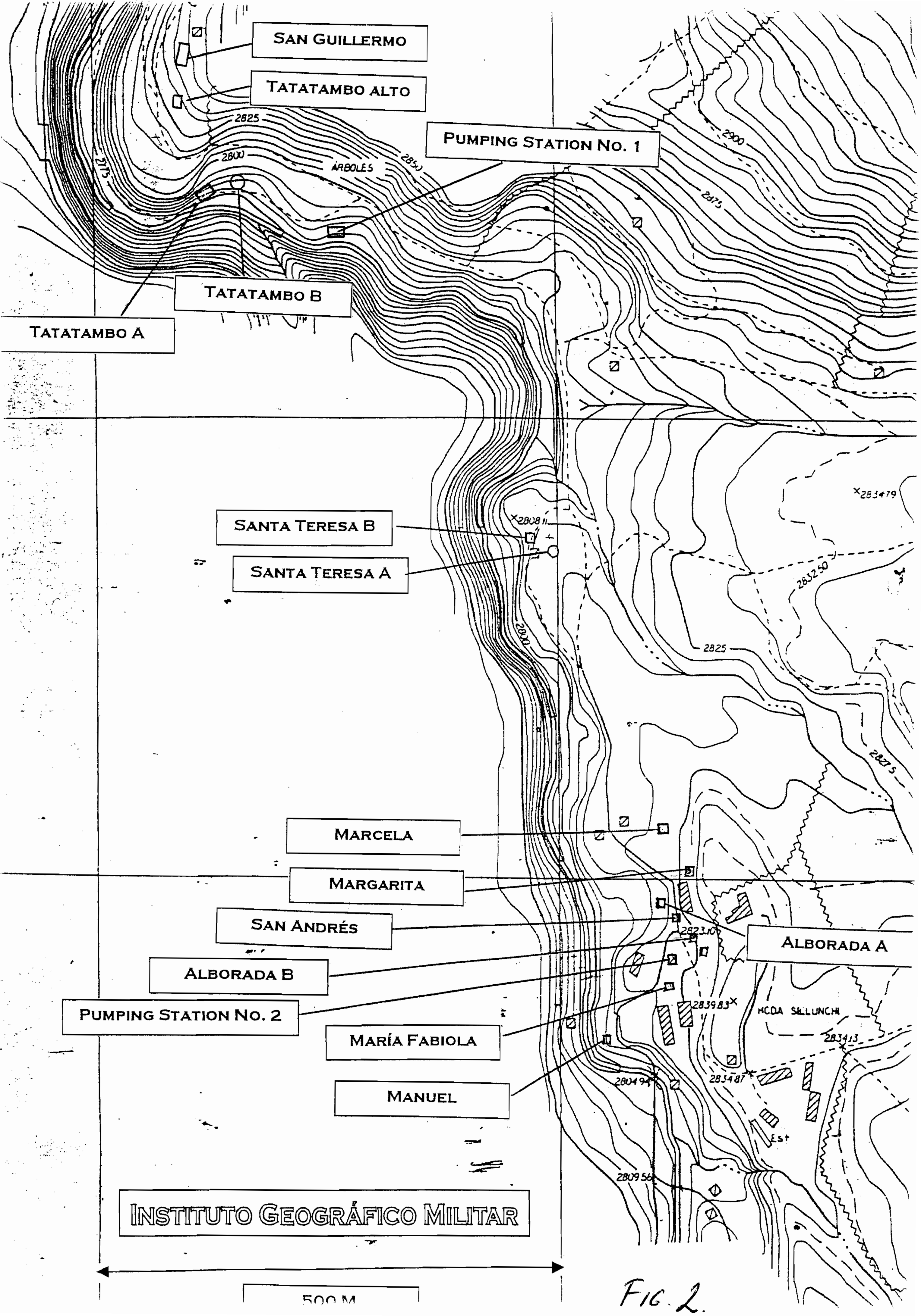

SAN GUILLERMO
TATATAMBO ALTO
PUMPING STATION NO. 1
TATATAMBO B
TATATAMBO A
2825
2800
2850
2900
2875
ÁRBOLES
SANTA TERESA B
SANTA TERESA A
MARCELA
MARGARITA
SAN ANDRÉS
ALBORADA A
ALBORADA B
PUMPING STATION NO. 2
MARÍA FABIOLA
MANUEL
HCDA SILLUNCHI
INSTITUTO GEOGRÁFICO MILITAR
500 M

FIG. 2

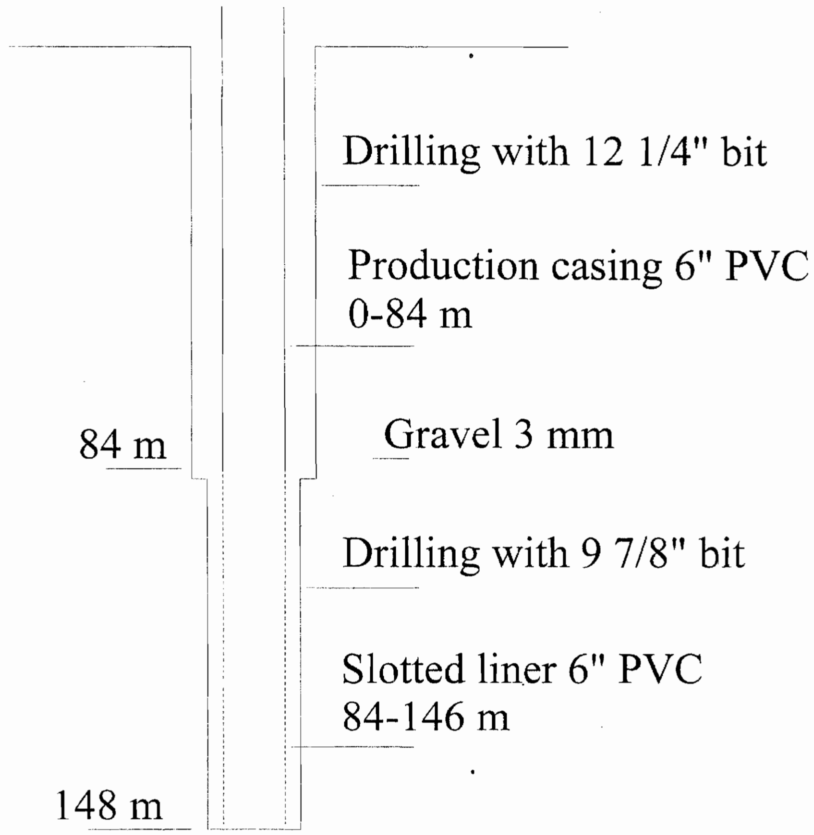


Fig.3 Casing profile of well Alborado B drilled in 1993.

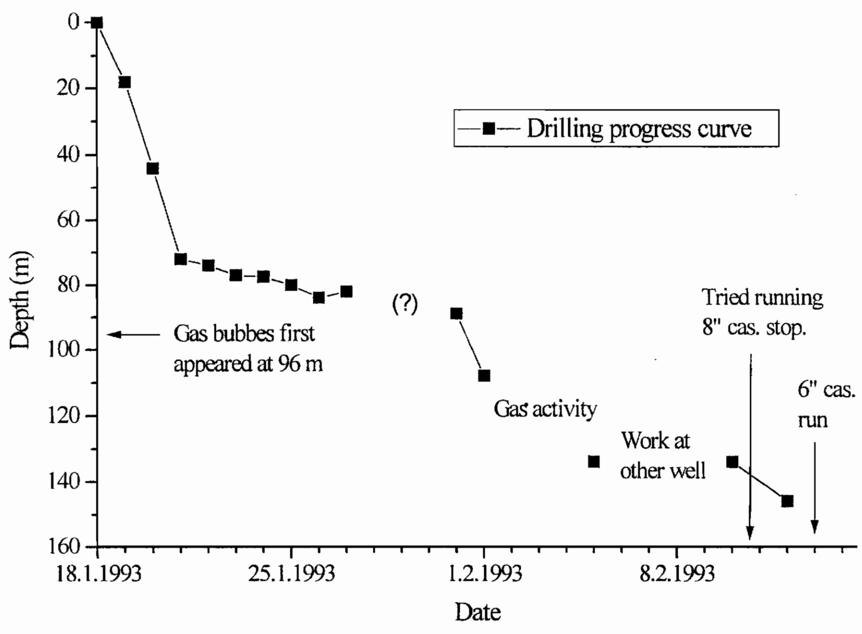


Fig.4 Drilling of well Alborado B. Drilling took 13 working days and civil works 7 days.

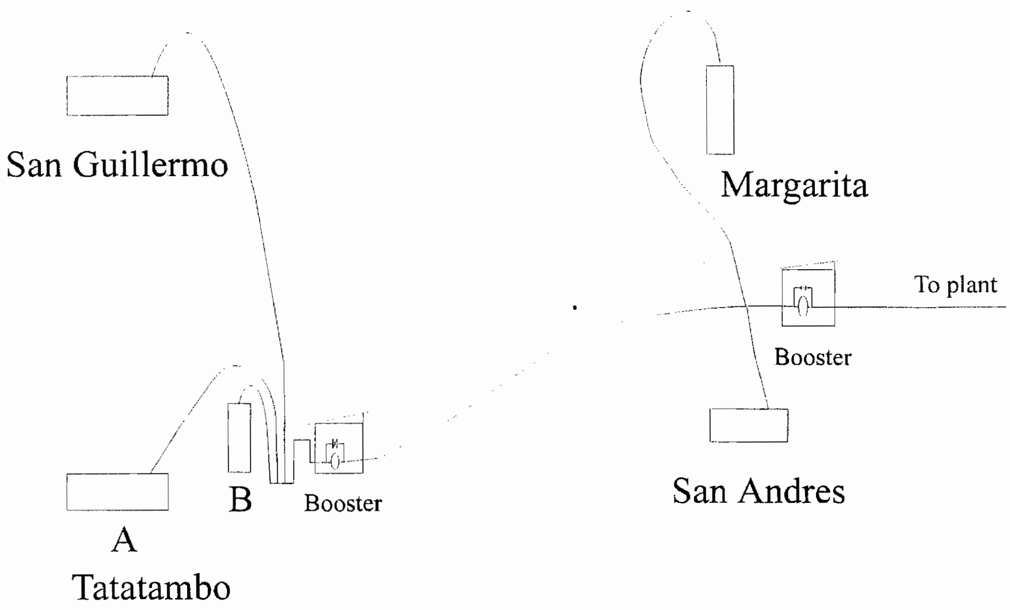


Fig.5 *Gas collection system from the five wells in use end og 1997*

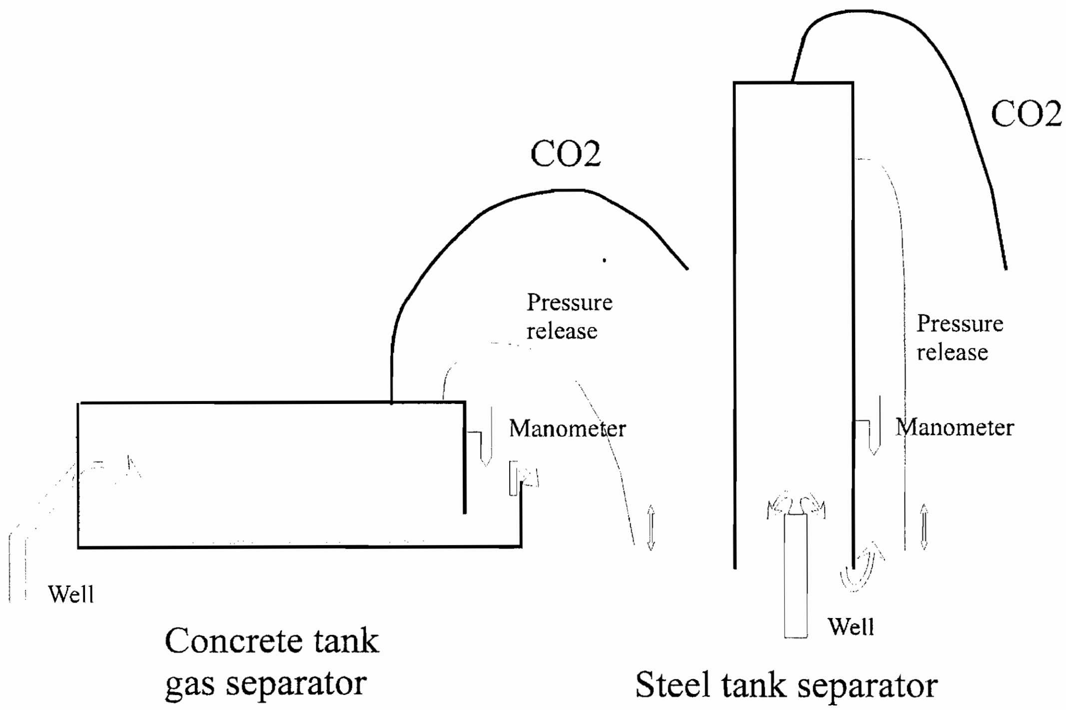


Fig.6 *Cross sections of two types of gas collection tanks*

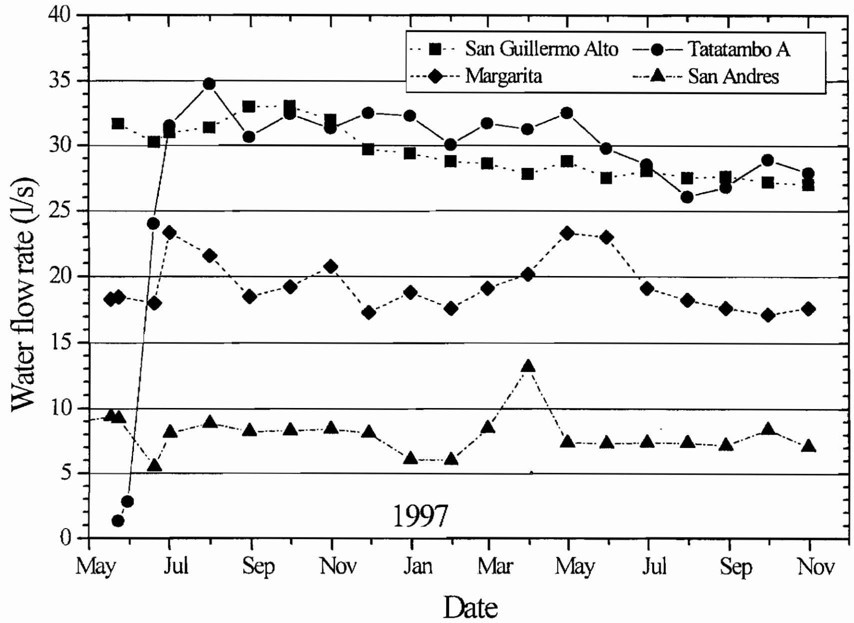


Fig. 7 *Measured water flow rate of the most productive springs/wells at Sillunchi 1996-1997*

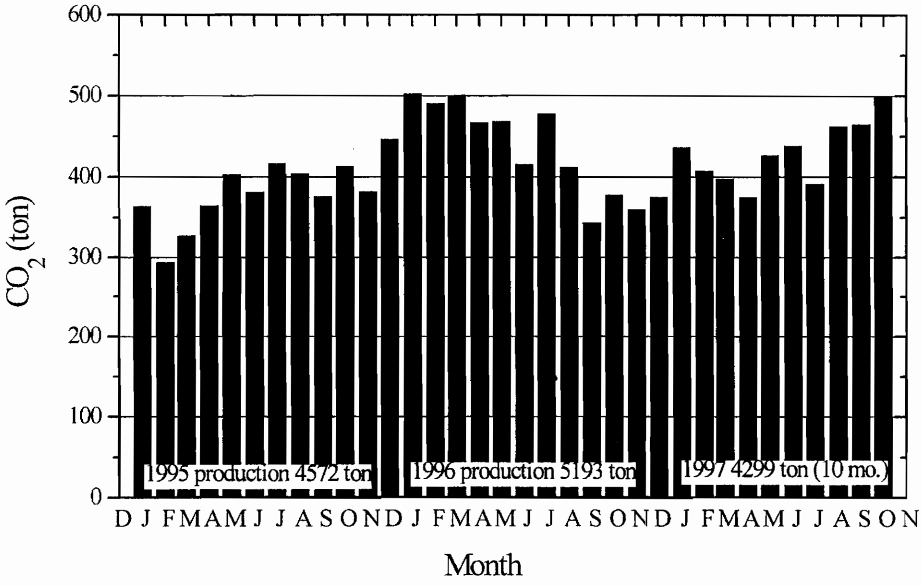


Fig. 8 *Production at Sillunchi of liquid CO2 and dry ice for each month 1995-1997*

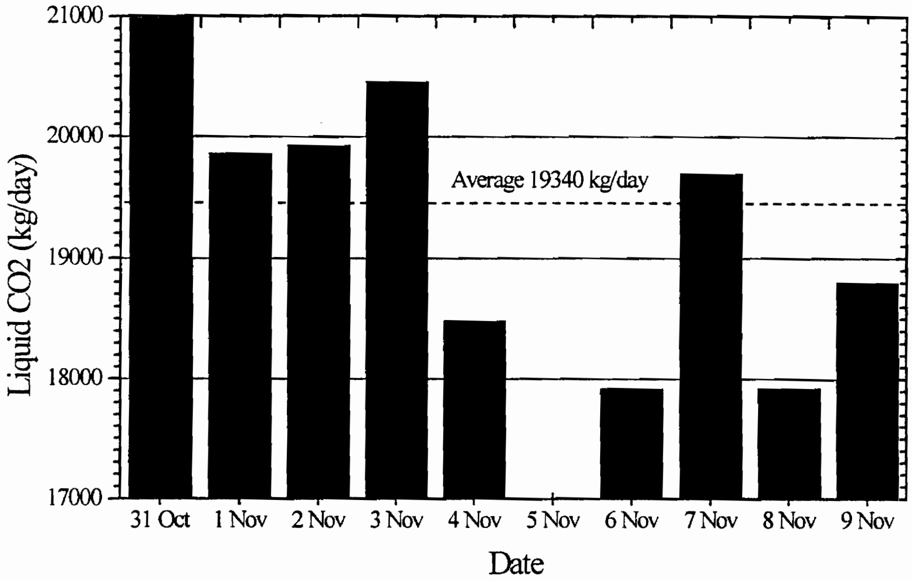
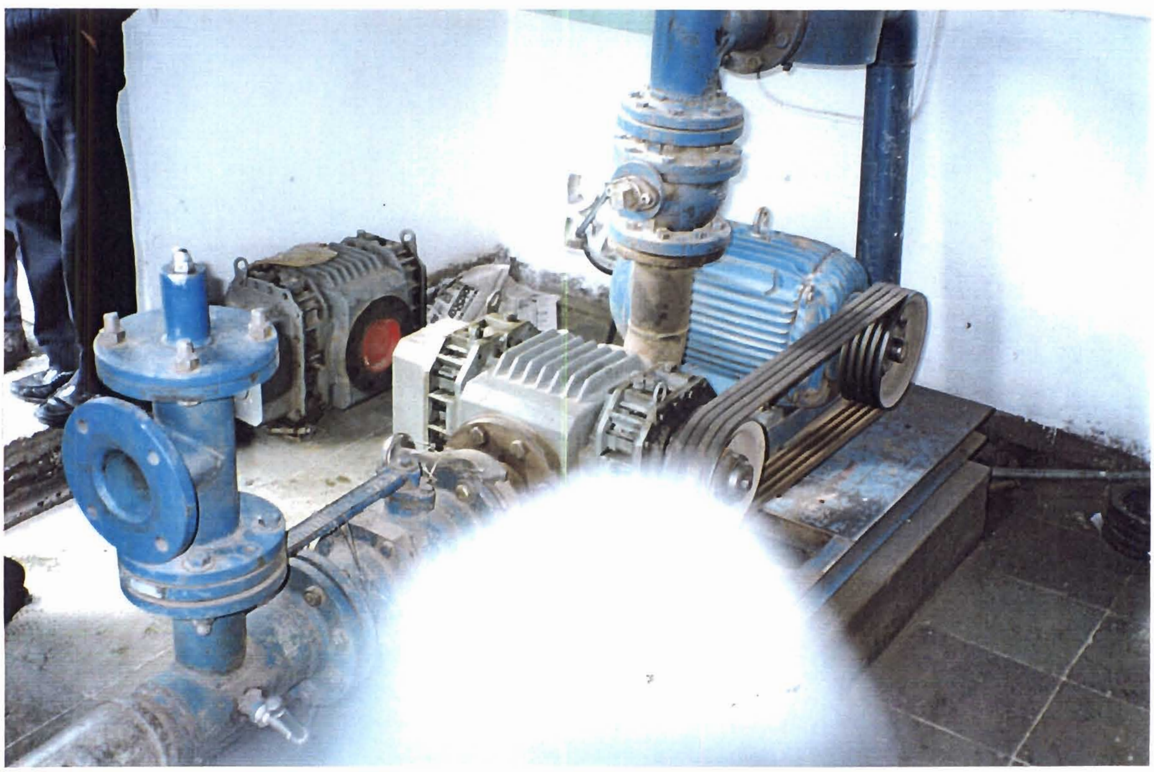


Fig.9 *Latest figures on liquid CO2 production. The average production is 19340 kg/day.*

Picture 1. *Agua y Gas de Sillunchi SA. The plants mini-hydro 125 kW is by the river.*

Picture 2. *Three abandoned wells, Manuel, just below the plant by Río San Pedro*

Picture 3. *The gas header before the second booster pump. Plant and office in background.*



Picture 4. *The Roots type blower in the second booster station. Controlled with by-pass.*

Picture 5. *The gas separator at San Guillermo with water outflow box on the corner.*

Fig. 6 *The wellhead of San Guillermo and connection to the concrete separator.*

Picture 7. *The water overflow from San Guillermo through the rectangular weir was used to measure the flow.*

Picture 8. *Tatatambo Alto note uncontrolled gas outflow through the annulus.*

Picture 9. *A visible fracture in the gully across from the Tatatambo wells*

Picture10. *The HDPE gas collection pipelines from booster station 1, close to Tatatambo*

Picture 11. *Steel separator on well Margarita by the plant.*

Picture 12.
The overflow from the sump by well Margarita. Note overflow where the flowrate was measured

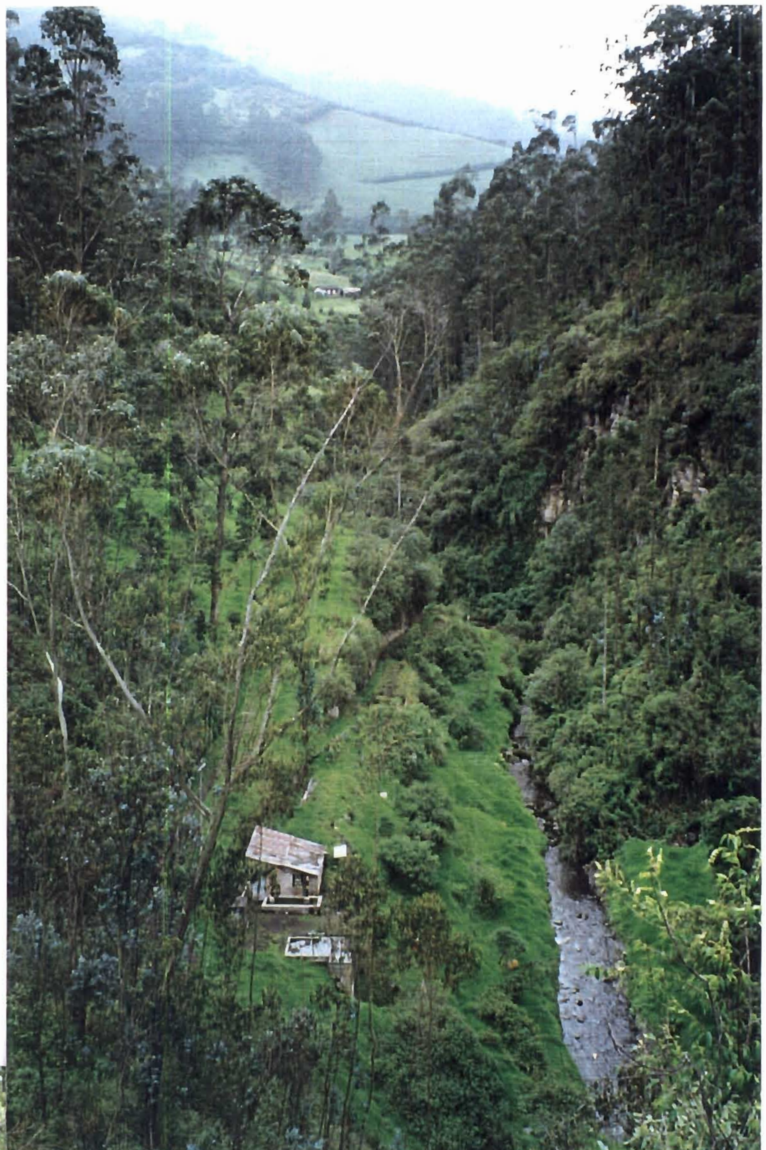
Picture 13.
Concrete separator of Alborada A. Collapsed separator tank in foreground.

Picture 14.
Flow from well Alborada B. Note two PVC casing strings and gas in the throat.

Picture 15. *San Andres on the flats well near the plant. Two abandoned wells in background.*

Picture 16.
Effluent channel from Tatatambo B. Temperature being measured.

Picture 17.
Río San Piedro Booster pump 1 by Tatatambo in the gully.



Picture 18. *Booster pump 1. Note concrete header on suction side (also on discharge side).*

Appendix

Quito 14.11.1997

Activity report of Sverrir Thorhallsson, Ecuador November 8th-17th 1997

Day	Description of the days activity
Nov. 8th	Departure Iceland FI-615 at 15:00 and continuing to Quito EU-815 at 23:00.
Sunday Nov. 9th	Arrived Quito 12:00 noon after a stopover in Guayaquil and landing at an alternative airport at Latacunga (2hr. drive from Quito). Door-to-door Reykjavik-Quito uninterrupted travel time was 27 hours.
Monday Nov. 10th	Mr. Clemis Miki AGA SA General Director brought me to the office where we had a short discussion of the plans for the week, followed by a meeting and introduction to Mr.José Sosa Director of Production and Logistics, Mr. José Bazurto AGA Guayaquil Plant Mgr. and Mr. Alvaro Montalvo Chief of Engineering. Accompanied by Mr. Bazurto and Mr. Montalvo we drove to Agua y Gas de Sillunchi SA (29 km south of Quito) where we had an all day meeting with Mr. Patricio Tamayo Flores Plant Mgr., Mr. Cruz Elías Terán and Ing. Angel Brito Head of Qual. Contr. The check list I had sent was used to obtain the available information on the well design, production characteristics, chemical analysis, flow tests and gathering system (see list of documents). Arriving at the AGA office at 17:00 we prepared diagrams of the past two year's monthly flow tests and well information, in reparation for to-morrows field inspection. The evening was spent in the hotel refining the diagrams and preparing notes.
Tuesday Nov. 11th	Left hotel at 8:15 to go to the AGA office and to the field with Mr.José Sosa and Mr. Alvaro Montalvo. At Agua y Gas de Sillunchi SA we were met by Mr. Cruz Elías Terán who showed us the following sites: San Guillermo Alto and Bajo, Tatatambo Alto, A and B, Booster station #1, Margarita, San Andrés, and Booster station #2. At San Guillermo I intended to sample the gas for H2S but only had NH3 sampling tubes with me. The gas was sampled for NH3 and was not detected. At the header of Booster station #1 I took two gas samples for analysis at Orkustofnun and I also used the H2S sampling tubes (1-150 ppm). No H2S was detected in the gas, nor was there any smell of H2S. The water flow from Margarita and San Guillermo was measure in the rectangular weir overflows. Arrived back at the office 16:30 where I met Mr. Alexander Camara the AGA Project Director for Brasil who is here to evaluate the gas plant. Late afternoon spent drawing diagrams of the field installation. They brought back good maps and aerial photographs and production data for the past week.
Wednesday Nov. 12th	Spent the day in AGA Quito office preparing the report and data. Mr. Camara , Mr. Montalvo, Mr. Bazurto went to the field to inspect the plant.
Thursday Nov. 13th	The second day spent in the office discussing the data with Mr. Camara, Mr. SOS, Mr. Bazurto and Mr. Montalvo and working on the report. Draft copies were circulated and comments made. In the evening I was asked to give a verbal presentation to the AGA management that has arrived in Quito. Present at the meeting were Mr. Clemis Miki, Mr. Mats Eivinson VP Business Area Process Ind., Mr. Hans Mirch Business Controller Process Ind., Mr. Hakan Rindborg Finance Mgr. Quito. I described the findings to date of my work and showed diagrams of the field installation, and measurements. Then I described what is known about the output characteristics of the wells and their present capacity and the general lack of good data to base a resource assessment on. Finally I described the need for additional surveys and drilling to insure future supplies to the plant and for a possible expansion.
Friday Nov. 14th	Starting from the hotel at 7:15 I worked in the office on polishing the report and arrange photographs and appendix content. Handed in the field report.
Nov. 15th	Departure planned from Quito at noon EU 812 for the return trip via New York..

Sverrir Thorhallson, Orkustofnun

Clemis Miki, AGA Ecuador SA

AGUA Y GAS DE SILLUNCHI S. A.
GAS CARBONICO

MEMORANDUN

Para : Sr. Sverrir Thorthallson
De : Patricio Tamayo Flores
JEFE DE FABRICA
Fecha : Noviembre 10 , de 1997
Asunto : Informe de Producción

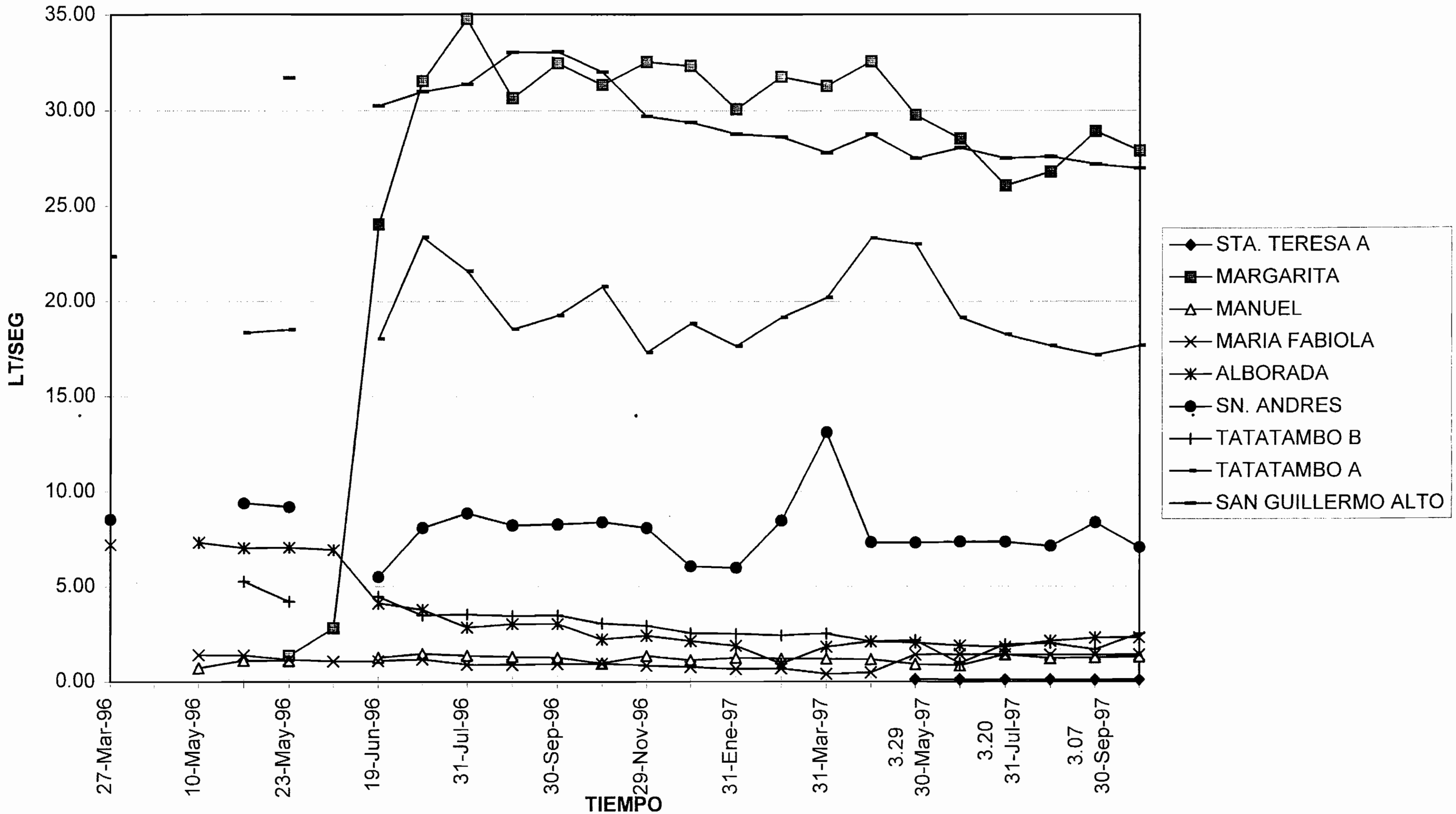
MES	AÑO 1995 Producción	Hrs	AÑO 1996 Producción	Hrs	AÑO 1997 Producción	Hrs		
Enero	364.063		502.829		436.359	729		
Febrero	293.431		490.575		407.358	651	0.6 T/h.	15 T/day.
Marzo	327.313		501.166		397.347	675	0,58	14,1
Abril	364.741		466.838		375.179	720	0,52	12.5
Mayo	403.193		468.588		426.531	711	0.6	14.3
Junio	381.719		415.380		438.500	683	0,64	15.4
Julio	416.406		478.317		391.490	701	0,56	13.4
Agosto	404.323		412.082		462.545	743	0.62	14.9
Septiembre	376.073		343.482		465.111	689	0.67	16.2
Octubre	413.061		377.040		498.835	699.	0.7 T/h.	17 T/day
Noviembre	381.908		360.754					
Diciembre	446.135		375.344					
Totales								

→ LIQ + DRY ICE
(185 [illegible])

Con atento saludo

PATRICIO TAMAYO FLORES
JEFE DE PLANTA

AFORAMIENTOS DE LAS FUENTES



COMPARACION DE AFORAMIENTO DE TODAS LAS FUENTES

MES	STA. TERESA B	STA. TERESA A	MARGARITA	MANUEL	MARIA FABIOLA	ALBORADA	SN. ANDRES	TATATAMBO B	TATATAMBO A	SAN GUILLERMO ALTO
27-Mar-96						7.21	8.53		22.34	
01-Abr-96										
10-May-96				0.70	1.38	7.33				
17-May-96				1.10	1.37	7.04	9.39	5.28	18.33	
23-May-96			1.35	1.09	1.15	7.07	9.20	4.21	18.50	31.70
30-May-96			2.79		1.06	6.94				
19-Jun-96			24.04	1.26	1.08	4.11	5.51	4.47	18.02	30.25
01-Jul-96			31.54	1.45	1.16	3.78	8.10	3.48	23.36	30.98
31-Jul-96			34.76	1.36	0.89	2.83	8.85	3.53	21.59	31.37
30-Ago-96			30.64	1.29	0.88	3.02	8.23	3.43	18.52	33.03
30-Sep-96			32.47	1.25	0.91	3.02	8.28	3.47	19.24	33.06
31-Oct-96			31.32	0.97	0.94	2.22	8.40	3.05	20.76	32.01
29-Nov-96			32.55	1.35	0.84	2.40	8.10	2.93	17.32	29.70
31-Dic-96			32.33	1.12	0.77	2.13	6.07	2.55	18.82	29.38
31-Ene-97			30.06	1.26	0.67	1.88	6.00	2.51	17.64	28.77
28-Feb-97			31.75	1.20	0.69	0.94	8.48	2.42	19.14	28.61
31-Mar-97			31.28	1.21	0.42	1.84	13.12	2.53	20.19	27.79
30-Abr-97			32.57	1.16	0.48	2.10	7.35	2.10	23.33	28.76
30-May-97	3.29	0.13	29.77	0.91	1.41	2.04	7.32	2.17	23.01	27.51
30-Jun-97	3.28	0.13	28.53	0.85	1.44	1.89	7.38	0.96	19.14	28.05
31-Jul-97	3.20	0.12	26.07	1.42	1.42	1.81	7.36	1.94	18.26	27.51
29-Ago-97	3.18	0.12	26.80	1.21	1.40	2.13	7.15	2.01	17.66	27.60
30-Sep-97	3.07	0.11	28.91	1.27	1.41	2.30	8.39	1.68	17.17	27.19
31-Oct-97	3.05	0.10	27.89	1.29	1.40	2.30	7.08	2.51	17.66	26.98

AGUA Y GAS DE SILLUNCHI S.A.

AFORAMIENTO DE FUENTES EN LTS/SEG.

FUENTES:	PATRON	29-ago-97	%	31-oct-97	%	OBSERVACIONES
SANGUILLERMO ALTO	33.15	27.60	-16.74	26.98	-2.25	
TATATAMBO A	18.33	17.66	-3.66	22.06	24.92	
TATATAMBO B(TQ.METALICO)	3.43	2.01	-41.40	2.51	24.88	
MARCELA	5.36	3.78	-29.48	3.52	-6.88	DESCONECTADA
SAN ANDRES	9.39	7.15	-23.86	7.08	-0.98	
ALBORADA A	0.65	1.32	103.08	1.12	-15.15	DESCONECTADA
ALBORADA B(TQ.METALICO)	3.02	2.13	-29.47	2.30	7.98	DESCONECTADA
MARIA FABIOLA	0.88	1.40	59.09	1.40	0.00	DESCONECTADA
MANUEL	1.10	1.21	10.00	1.29	6.61	DESCONECTADA
MARGARITA	31.54	26.8	-15.03	27.89	4.07	
SANTA TERESA A	0.13	0.12	-7.69	0.10	-16.67	DESCONECTADA
SANTA TERESA B	3.29	3.18	-3.34	3.05	-4.09	DESCONECTADA
TATATAMBO ALTO				4.99		DESCONECTADA
TOTAL AGUA AFORADA	110.27	94.36		104.29		
PORCENTAJE AFORADO PATRON	100%	83.14%		94.27%		
PORCENTAJE AFORADO MES ANTERIOR		100%		109.52%		

REALIZADO POR:
ING. Angel Brito
JEFE DE CONTROL DE CALIDAD

Tgo. Patricio Tamayo
JEFE DE FABRICA

AGUA Y GAS DE SILLUNCHI S.A.

REPORTE DIARIO DE CONTROL DE CALIDAD

FECHA	1997-11-04	DIA	Martes	HORA	7h10

ANALISIS DE PUREZA EN PROCESO

	PRESION	%
FUENTE LINEA A	0,49 bar	98,45%
FUENTE LINEA B	—	—
FUENTE LINEA C	—	—
SECADORES A	21,8 bar	98,4%
SECADORES B	—	—
SECADORES C	—	—
CONDENSADOR 1	19,8 bar	93%
CONDENSADOR 2	310 psi	75%
CONDENSADOR 3	21,2 bar	98,3%
CONDENSADOR B	—	—
CONDENSADOR C	—	
TANQUE 100 TON.	20,8 bar	89%
TANQUE 50 TON.	285 psi	91%
TANQUERO 2	130 psi	95,2%
TANQUERO 3	-	-
TANQUERO 4	—	—

REPORTE OPERACIONAL

	%
REGULACION ROOTS TATATAMBO	73%
REGULACION ROOTS FABRICA	92%
REGULACION ROOTS B	—
BANCO DE HIELO	95%
PRECOOLER B	—
PRECOOLER C	—
REMANENTE GAS FUENTES	100%
EVALUACION PURGAS DE AGUA	97%
EVALUACION PURGAS DE CO2	96%
FUGAS DE AMONIACO	0%

ESTADO FISICO DEL AGUA REFRI:

NIVEL =	BAJO	
TURBIEDAD =	CERO	
DUREZA ABLANDADOR =	120	ppm.
DUREZA SISTEMA =	300	ppm.
DUREZA COND.EV.1 =	310	ppm.
DUREZA COND.EV.2 =	310	ppm.

PUNTO DE ROCIO EN PROCESO

	PRESION	TEMP. oF	ppm H2O
DESHUMIFICADOR	0,49 bar	+25°	18.078
PRECOOLER B	—	—	—
PRECOOLER C	—	—	—
SECADORES A	21,8 bar	-100°	1
SECADORES B	—	—	—
SECADORES C	—	—	—
TANQUE 100 TON	20,8 bar	-103°	0
TANQUE 50 TON.	285 psi	-103°	0

REPORTE DE TEMPERATURAS

	TEMP. oC
AGUA DESHUMIFICADOR	18°
AMBIENTE	14°
LICUEFACCION COND.1	-11,6°
LICUEFACCION COND.2	-22,0°
LICUEFACCION COND.3	13,1°
LICUEFACCION COND.B	—
LICUEFACCION COND.C	—

OBSERVACIONES: Pureza de fuentes tiene 98,45% y la presión 0,49 bar. Alta humedad en fuentes disminuye la pureza del tanque de 100 ton a 89% y del tanque de 50 ton a 91%. Hay dureza en el ablandador, se regenera la resina

NOTA: La presión se reporta en psi: Factor=14.5

A=PLANTA 1000 KG/H
B=PLANTA 225 KG/H
C=PLANTA 100 KG/H

REALIZADO POR: ANGEL BRITO

ANALIZADO POR: [signature]

APROBADO POR: [signature]

AGUA Y GAS DE SILLUNCHI S.A.

REPORTE DIARIO DE CONTROL DE CALIDAD

FECHA	1997-11-05		DIA	Miércoles	HORA	7:10			
ANALISIS DE PUREZA EN PROCESO			**REPORTE OPERACIONAL**			**PUNTO DE ROCIO EN PROCESO**			
	PRESION	%			%		PRESION	TEMP.oF	ppm H2O
FUENTE LINEA A	0,48 bar	98,45%	REGULACION ROOTS TATATAMBO		72%	DESHUMIFICADOR	0,48 bar	+20°	8984
FUENTE LINEA B	–	–	REGULACION ROOTS FABRICA		93%	PRECOOLER B	–	–	–
FUENTE LINEA C	–	–	REGULACION ROOTS B		–	PRECOOLER C	–	–	–
SECADORES A	20,8 bar	98,45%	BANCO DE HIELO		96%	SECADORES A	20,8 bar	-80°	3
SECADORES B	–	–	PRECOOLER B		–	SECADORES B	–	–	–
SECADORES C	–	–	PRECOOLER C		–	SECADORES C	–	–	–
CONDENSADOR 1	20,2 bar	82%	REMANENTE GAS FUENTES		100%	TANQUE 100 TON	20,5 bar	-103°	0
CONDENSADOR 2	303 psi	72%	EVALUACION PURGAS DE AGUA		97%	TANQUE 50 TON.	295 psi	-103°	0
CONDENSADOR 3	20,8 bar	98,4%	EVALUACION PURGAS DE CO2		95%				
CONDENSADOR B	–	–	FUGAS DE AMONIACO		0%				
CONDENSADOR C	–	–	**ESTADO FISICO DEL AGUA REFRI:**			**REPORTE DE TEMPERATURAS**			
TANQUE 100 TON.	20,5 bar	88%	NIVEL =	BAJO			TEMP. oC		
TANQUE 50 TON.	295 psi	92,5%	TURBIEDAD =	CERO		AGUA DESHUMIFICADOR	2°		
TANQUERO 2	150 psi	95,2%	DUREZA ABLANDADOR =	20	ppm.	AMBIENTE	15°		
TANQUERO 3	–	–	DUREZA SISTEMA =	235	ppm.	LICUEFACCION COND.1	-12,8°		
TANQUERO 4	–	–	DUREZA COND.EV.1 =	240	ppm.	LICUEFACCION COND.2	-22,0°		
			DUREZA COND.EV.2 =	250	ppm.	LICUEFACCION COND.3	13,1°		
						LICUEFACCION COND.B	–		
						LICUEFACCION COND.C	–		

OBSERVACIONES:

Pureza de fuentes tiene 98,45% y la presión 0,48 bar. Hay humedad en fuentes

Disminuye la pureza del tanque de 100 ton a 88% y del tanque de 50 ton a 92,5%

Hay un pozo de dureza en el ablandador.

NOTA: La presión se reporta en psi: Factor=14.5

A=PLANTA 1000 KG/H B=PLANTA 225 KG/H C=PLANTA 100 KG/H	REALIZADO POR: ANGEL BRITO	ANALIZADO POR: [signature]	APROBADO POR: [signature]

AGUA Y GAS DE SILLUNCHI S.A.
REPORTE DIARIO DE CONTROL DE CALIDAD

FECHA	1.997-11-06	DIA	Jueves	HORA	7h10

ANALISIS DE PUREZA EN PROCESO

	PRESION	%
FUENTE LINEA A	0,47bar	98,4%
FUENTE LINEA B	—	—
FUENTE LINEA C	—	—
SECADORES A	21,2bar	98,45%
SECADORES B	—	—
SECADORES C	—	—
CONDENSADOR 1	20,6bar	81%
CONDENSADOR 2	302 psi	72%
CONDENSADOR 3	20,8bar	98,35%
CONDENSADOR B	—	—
CONDENSADOR C	—	—
TANQUE 100 TON.	20,3bar	89%
TANQUE 50 TON.	300psi	93%
TANQUERO 2	150psi	95,2%
TANQUERO 3	—	—
TANQUERO 4	—	—

REPORTE OPERACIONAL

	%
REGULACION ROOTS TATATAMBO	72%
REGULACION ROOTS FABRICA	93%
REGULACION ROOTS B	—
BANCO DE HIELO	98%
PRECOOLER B	—
PRECOOLER C	—
REMANENTE GAS FUENTES	100%
EVALUACION PURGAS DE AGUA	97%
EVALUACION PURGAS DE CO2	98%
FUGAS DE AMONIACO	0%

ESTADO FISICO DEL AGUA REFRI:

NIVEL	= COMPLETO	
TURBIEDAD	= CERO	
DUREZA ABLANDADOR	= 165	ppm.
DUREZA SISTEMA	= 230	ppm.
DUREZA COND.EV.1	= 235	ppm.
DUREZA COND.EV.2	= 240	ppm.

PUNTO DE ROCIO EN PROCESO

	PRESION	TEMP.oF	ppm H2O
DESHUMIFICADOR	0,47bar	115°	5.890
PRECOOLER B	—	—	—
PRECOOLER C	—	—	—
SECADORES A	21,2bar	-90°	1
SECADORES B	—	—	—
SECADORES C	—	—	—
TANQUE 100 TON	20,3bar	-103°	0
TANQUE 50 TON.	300psi	-104°	0

REPORTE DE TEMPERATURAS

	TEMP. oC
AGUA DESHUMIFICADOR	3°
AMBIENTE	14°
LICUEFACCION COND.1	-12,6°
LICUEFACCION COND.2	-22,1°
LICUEFACCION COND.3	9,8°
LICUEFACCION COND.B	—
LICUEFACCION COND.C	—

OBSERVACIONES:

Pureza de fuente tiene 98,4% y la presión 0,47bar
Mejora un poco la pureza del tanque de 100 ton a 89% y del tanque de 50 ton a 93%
La dureza en el ablandador, se regenera la resina

NOTA: La presión se reporta en psi; Factor=14.5

A=PLANTA 1000 KG/H
B=PLANTA 225 KG/H
C=PLANTA 100 KG/H

REALIZADO POR: ANGEL BRITO

ANALIZADO POR: [signature]

APROBADO POR: [signature]

AGUA Y GAS DE SILLUNCHI S.A.

REPORTE DIARIO DE CONTROL DE CALIDAD

FECHA	1.997 - 11 - 07		DIA	Viernes	HORA	7h10		
ANALISIS DE PUREZA EN PROCESO			**REPORTE OPERACIONAL**		**PUNTO DE ROCIO EN PROCESO**			
	PRESION	%		%		PRESION	TEMP. oF	ppm H2O
FUENTE LINEA A	0,47 bar	98,45%	REGULACION ROOTS TATATAMBO	72%	DESHUMIFICADOR	0,47 bar	+17°	6.841
FUENTE LINEA B	—	—	REGULACION ROOTS FABRICA	92%	PRECOOLER B	—	—	
FUENTE LINEA C	—	—	REGULACION ROOTS B	—	PRECOOLER C	—	—	—
SECADORES A	19,8 bar	98,45%	BANCO DE HIELO	97%	SECADORES A	19,8 bar	-80°	3
SECADORES B	—	—	PRECOOLER B	—	SECADORES B	—	—	—
SECADORES C	—	—	PRECOOLER C	—	SECADORES C	—	—	—
CONDENSADOR 1	20,6 bar	92,5%	REMANENTE GAS FUENTES	100%	TANQUE 100 TON	19,3 bar	-103°	0
CONDENSADOR 2	285 psi	78%	EVALUACION PURGAS DE AGUA	97%	TANQUE 50 TON.	285 psi	-103°	0
CONDENSADOR 3	19,7 bar	98,45%	EVALUACION PURGAS DE CO2	98%				
CONDENSADOR B	—	—	FUGAS DE AMONIACO	0%				
CONDENSADOR C	—	—	**ESTADO FISICO DEL AGUA REFRI:**		**REPORTE DE TEMPERATURAS**			
TANQUE 100 TON.	19,3 bar	93%	NIVEL = completo			TEMP. oC		
TANQUE 50 TON.	~~295 psi~~	93%	TURBIEDAD = cero		AGUA DESHUMIFICADOR	6°		
TANQUERO 2	320 psi	99,98%	DUREZA ABLANDADOR = 20	ppm.	AMBIENTE	15°		
TANQUERO 3		—	DUREZA SISTEMA = 180	ppm.	LICUEFACCION COND.1	-13,0°		
TANQUERO 4	—	—	DUREZA COND.EV.1 = 190	ppm.	LICUEFACCION COND.2	-22,4°		
			DUREZA COND.EV.2 = 190	ppm.	LICUEFACCION COND.3	12,5°		
					LICUEFACCION COND.B	—		
					LICUEFACCION COND.C	—		

OBSERVACIONES:

Pureza de fuentes tiene 98,45% y la presión 0,47 bar.
Mejora la pureza del tanque de 100 ton a 93% y del tanque de 50 ton a 93%
Hay un poco de dureza en el ablandador.

NOTA: La presión se reporta en psi: Factor=14.5

A=PLANTA 1000 KG/H
B=PLANTA 225 KG/H
C=PLANTA 100 KG/H

REALIZADO POR: ANGEL ARIZO

ANALIZADO POR:

APROBADO POR:

AGUA Y GAS DE SILLUNCHI S.A.

REPORTE DIARIO DE CONTROL DE CALIDAD

FECHA	1997-11-10	DIA	Lunes	HORA	7h10

ANALISIS DE PUREZA EN PROCESO

	PRESION	%
FUENTE LINEA A	0,47bar	98,45%
FUENTE LINEA B	–	–
FUENTE LINEA C	–	–
SECADORES A	20,5bar	98,45%
SECADORES B	–	–
SECADORES C	–	–
CONDENSADOR 1	20,6bar	94%
CONDENSADOR 2	290 psi	73%
CONDENSADOR 3	20bar	98,45%
CONDENSADOR B	–	–
CONDENSADOR C	–	–
TANQUE 100 TON.	19,6bar	90%
TANQUE 50 TON.	245 psi	94,1%
TANQUERO 2	200 psi	95,2%
TANQUERO 3	–	–
TANQUERO 4	300 psi	99,98%

REPORTE OPERACIONAL

	%
REGULACION ROOTS TATATAMBO	72%
REGULACION ROOTS FABRICA	92%
REGULACION ROOTS B	–
BANCO DE HIELO	98%
PRECOOLER B	–
PRECOOLER C	–
REMANENTE GAS FUENTES	100%
EVALUACION PURGAS DE AGUA	97%
EVALUACION PURGAS DE CO2	95%
FUGAS DE AMONIACO	0%

ESTADO FISICO DEL AGUA REFRI:

NIVEL	=	COMPLETO	
TURBIEDAD	=	CERO	
DUREZA ABLANDADOR	=	170	ppm.
DUREZA SISTEMA	=	270	ppm.
DUREZA COND.EV.1	=	275	ppm.
DUREZA COND.EV.2	=	280	ppm.

PUNTO DE ROCIO EN PROCESO

	PRESION	TEMP.oF	ppm H2O
DESHUMIFICADOR	0,47bar	+15°	5.890
PRECOOLER B	–	–	–
PRECOOLER C	–	–	–
SECADORES A	20,5bar	-98°	1
SECADORES B	–	–	–
SECADORES C	–	–	–
TANQUE 100 TON	19,6bar	-104°	0
TANQUE 50 TON.	245 psi	-103°	0

REPORTE DE TEMPERATURAS

	TEMP. oC
AGUA DESHUMIFICADOR	6°
AMBIENTE	13°
LICUEFACCION COND.1	-13,9°
LICUEFACCION COND.2	-22,9°
LICUEFACCION COND.3	9,2°
LICUEFACCION COND.B	–
LICUEFACCION COND.C	–

OBSERVACIONES:

Pureza de fuente tiene 98,45% y la presión 0,47bar.
Disminuyo un poco la pureza del tanque de 100ton a 90% y del tanque de 50ton a 94,1%
Hay dureza en el ablandador, se regenera la resina.

NOTA: La presión se reporta en psi: Factor=14.5

A=PLANTA 1000 KG/H
B=PLANTA 225 KG/H
C=PLANTA 100 KG/H

REALIZADO POR:	ANALIZADO POR:	APROBADO POR:
ANGEL BRITO	[signature]	[signature]

GAS DE SILLUNCHI S. A.
GAS CARBONICO

PARA: Lcdo. Santiago Vel

AGUA Y GAS DE SILLUNCHI S.A.
DEPARTAMENTO DE CONTROLDE CALIDAD
ANALISIS DE AGUA

FUENTE SAN ELOY
Fecha: 21 de Abril 1.997

ANALISIS FISICO:

pH	6,9	
Conductividad	1800	microsiemens/cm a 25 oC

ANALISIS QUIMICO:

Carbonatos	0	ppm.
Bicarbonatos	1160	ppm.
Cloruros	260	ppm.
Cloro	0	ppm.
Hierro	trazas	ppm.
Alcalinidad Total	950	ppm.
Dureza Total	650	ppm.
Nitritos	0	ppm.
Fosfatos	2	ppm.

CAUDAL = 0,81 lts/seg

CONDUCTIVIDAD DE FUENTES:

Fuente Alborada A	1900	usiemens/cm
Fuente Alborada B	1925	usiemens/cm
Fuente San Andres	2950	usiemens/cm
Fuente Margarita	3650	usiemens/cm
Fuente Marcela	3325	usiemens/cm
Fuente Tatatambo A	3725	usiemens/cm
Fuente Tatatambo B	3225	usiemens/cm
Fuente San Guillermo bajo	4650	usiemens/cm
Fuente San Giuillermo bajo	7900	usiemens/cm
Fuente San Guillermo	7750	usiemens/cm
Fuente Maria Fabiola	1400	usiemens/cm

Realizado por Ing. Angel Brito

ANALISIS DE PUREZA DEL CO_2

- EPN, METODO: CROMATOGRAFIA DE GASES
  (NO EXISTEN ESTANDARES O PROCEDIMIENTOS COMUNES APROBADOS)

- AGUA Y GAS DE SILLUNCHI REALIZA ACTUALMENTE EL SIGUIENTE ANALISIS:

  ANALISIS DE PUREZA : METODO ZAHM & NAGEL
  CONTENIDO DE HUMEDAD : (PUNTO DE ROCIO)

- LA EMPRESA SGS REALIZO UN ANALISIS RECIENTE AL CO_2 DE SILLUNCHI CON LOS SIGUIENTES RESULTADOS (95-07)

  PUREZA = 99.9% V/V
  HUMEDAD = 1.2 ppm

- LIQUID CARBONIC ANALIZO EL CO_2 DE SILLUNCHI (89) CON EL SIGUIENTE RESULTADO:

  PUREZA = 99.92 % V/V
  CH4 = 9.8 ppm
  EL RESTO = N/D (<1 ppm)

Analisis Fisico Quimico De Aguas.

Silloncha 23 - junio - 97.

(1). Fuente Santa Teresa A. Teresa B 3416/g.

Analisis Fisico

Nueva

	Teresa A	Teresa B	
PH.	6.5	6.7	
Conductividad	3.725	3.750	µsiemens/cm 25 °C 1.700

Analisis Quimico

	Teresa A	Teresa B		
Carbonatos	0	0	PPM	
Bicarbonatos	3.013	3.050	PPM	
Cloruros	210	230	PPM	
Cloro	0	0	"	
Hierro	5 ✓	7.5 ✓	"	— 0
Alcalinidad Total	2.470	2.500	"	
Dureza Total	1.680	1.700 ✓	"	
Nitritos	0	0	"	
Silice	85	100	"	
Fosfatos	2	2.5	"	— 1,0
Aforamiento	0.13	3.29	Lts/seg.	

Realizado por Ing. A. Brito

9 M gal capacidad
345 m³

Pepsi - Guayaquil
Ing Wilmer Castro
258 138
214 329
329 966
04 4250033/531/141