GEOTHERMAL RESOURCES IN PERU

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Starting from the unforeseen increasing of oil price that took place in 1973, a favorable attitude at international level toward the examination of an eventual substitution of this fuel was taken regarding the exploitation of other alternating and Renewable Energetic Sources as the GEOTHERM, a present resource existing in Peru.

In fact , the Peruvian territory is part of the Pacific Fire Circle, Characterized by the occurrence of seismic movements, tectonic phenomena, a high concentration of geothermal caloric flow and the presence of vast volcanic rock deposits, some of them of recent age that make evident a latent magmatic activity.

More than 400 thermal water manifestations between 40 – 89°C, had been identified at Peruvian territory, situated preferently along the Occidental Cordillera, and in less proportion at inland valleys and Oriental zone.(Fig N°1). This has permitted the determination of six (06) Geothermal Regions (Fig N° 2)

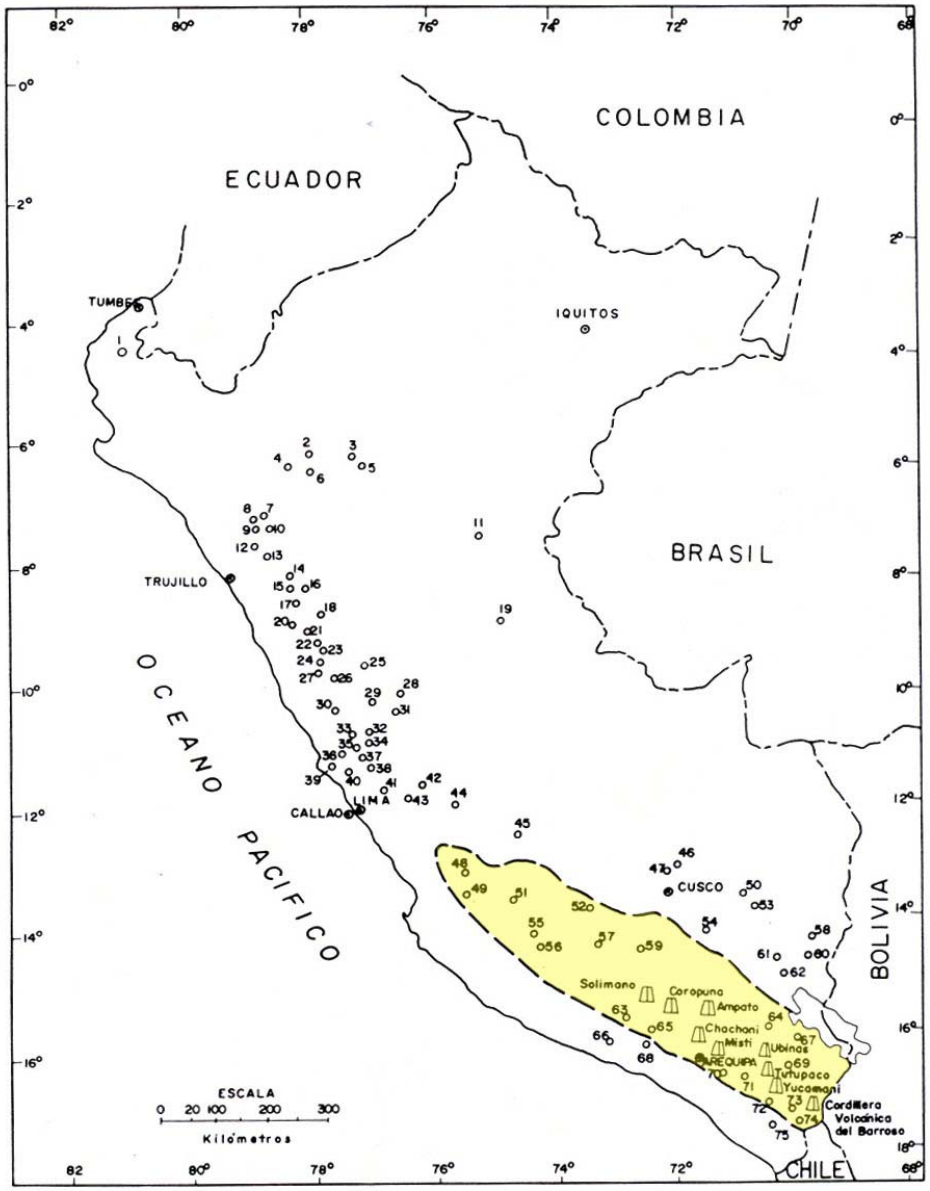


Fig. 1. Manifestations of thermal waters and approximate limit of Tertiary and Quaternary volcanism. Principal volcanoes.

Fig. N° 2

GEOTHERMAL REGION SOUTH

The recogniton research made at **V REGION, Volcanic** range, has permitted to establish geothermal areas of interest with the denomination of **GEOTHERMAL FIELDS.**

A) FIELD TUTUPACA – CALACOA GEOTHERMAL

The TUTUPACA – CALACOA geothermal field is also located on the southern part of Peru.. **Calacoa area** is at the inlands of Moquegua, and TUTUPACA is on Tacna and a portion of Moquegua (Fig N° 3).

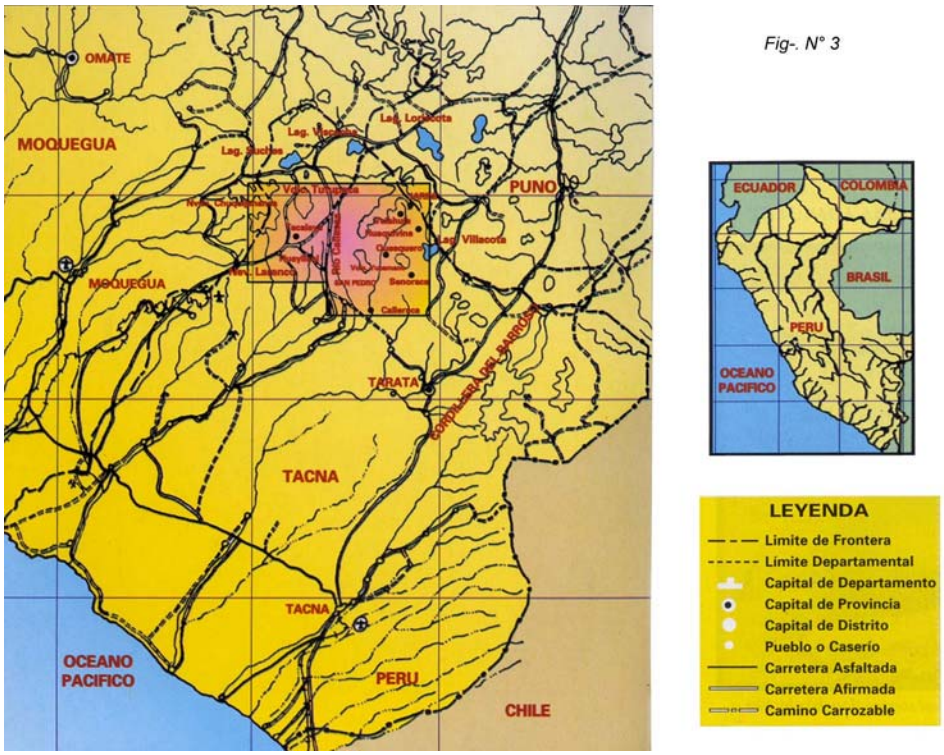


Fig-. N° 3

THERMAL MANIFESTATIONS

In Calacoa area, the thermal manifestations are mainly associated with the Quaternary Volcanism, and they are shown as flows, fumaroles and geysers **(Photo N° 1)**. The emergent temperatures are between 54° and 94°C


Photo N° 1

At TUTUPACA area, the Thermal activity is shown mainly along the fracturements related with the settings of a recent volcanism. The emergent temperature of main flows are between 40° and 92°. Some of them exceed the boiling point and are located the boiling point and are located mainly in **QUEBRADA AZUFRE (Photo N° 2).**


Photo N° 2

The Chemical analysis for CALACOA area,classify in under **SODIC CHLORIDE** type, and for **TUTUPACA** the classification follows under SODIC and **CALCIC SULFATE** type, pH too acid

GEOTHERMOMETRY
CALACOA AREA

SiO2 : 110- 160°C
Na/k : 180 – 190°C

TUTUPACA AREA

SiO2 :180°C
Na/K :240° C

VULCANOLOGY

At CALACOA area ,there are volcanic apparatus of central type with explosive phases to the base and effusive to the top.The presence of exogen domos is noted at Ticsani volcano, and these domos are related to a volcanic structure ligtly collapsed. The age of these domos is 190,000 by K-Ar method, and it shows active magmatic chambers.

At TUTUPACA, the most evident strucuture is **TUTUPACA VOLCANO (Photo N° 3)** ,and exogen domos of dacitic composition present in cerro **San Francisco (Photo N° 4)**, which shows the existence of active and non-deep magmatic chambers.

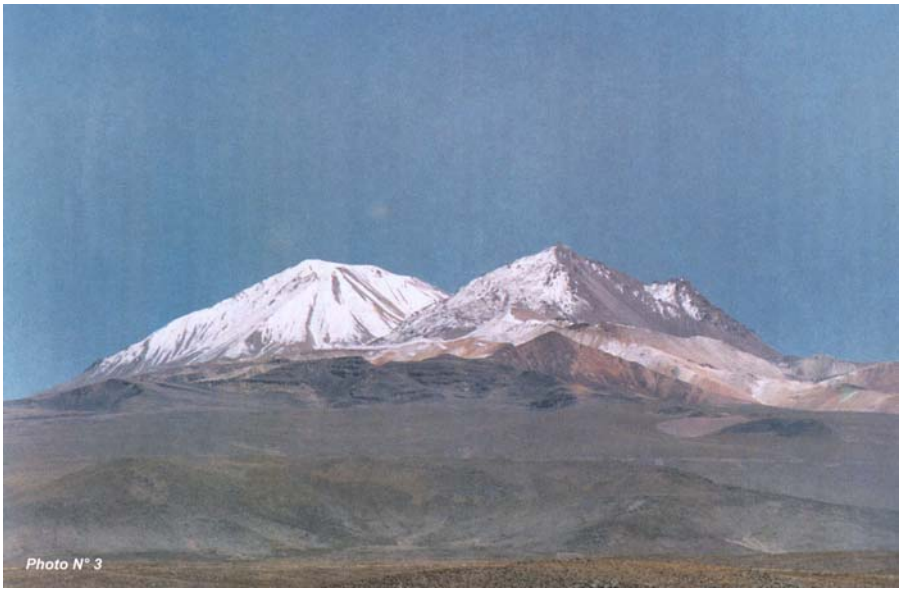
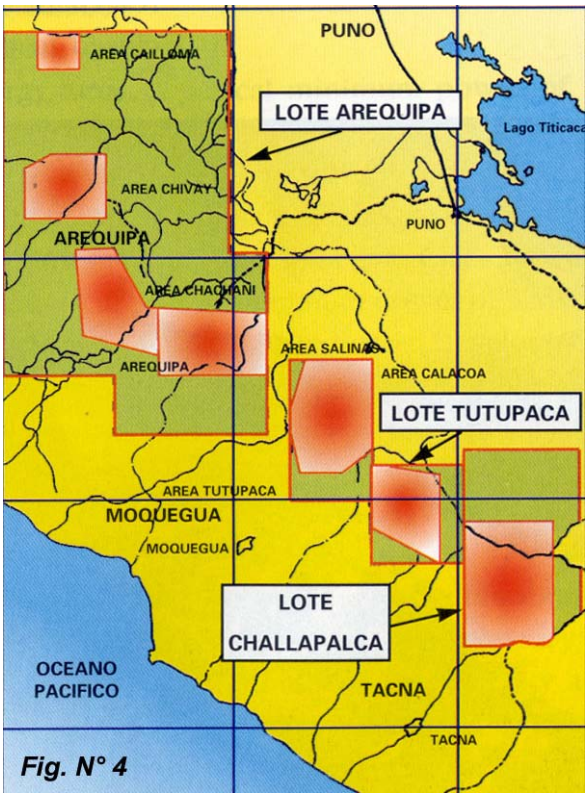


Photo N° 3

B) FIELD CHALLAPALCA GEOTHERMAL

This field is situated on the southern part of Peru, at the altiplanic region of Tacna and a portion of Puno (Fig. N° 4)



Thermal Manifestations

Thermal activity on above mentioned areas, consists of hot water flows and fumaroles with an emergency temperature upto 90°C 0ver 4000 m.s.n.m.

Chemical analysis classify water of Sodium Chloride type, with a high content of Boron, that is between 1,412 and 8,70 mol/l.

Isotopic data reveal that thermal waters are possibly a result of a mixture with different percentages, between fluids of deep source and superficial waters.

Geothermometry

The temperatures calculated on a Geothermomeeter basis, are the following:

Si02	: 192°C
Na/K	: 182-232°C
Na/k/Ca	: 184- 212°C
Na/K/Ca/Mg	: 44 – 179 °C
Na/Li	: 204- 240°C
K/Mg	: 87- 183 °C

Vulcanology

The existence of a Caldron structure. Puts on evidence the presence of a non- deep heat source, which is confirmed by the existence of domic forms that in Challapalca area are called **DOMOS PURPURUNI,** of exogen nature and andesitic composition (Photo N° 5)

The recent fracturation is the north south direction system, which is correlationed to the main geothermal manifestation with a temperaturer of 89°C (Photo N° 6).This Fracturation also has an effect on DOMOS and on recent morrainic soils (Quaternary), showing that there is a non deep magmatic activity.

Photo N° 6

Radiometric Data made on samples taken from DOMOS, report an age of 100,000 years, therefore it refers to a young vulcanism, at the plain and middle part of **CALDRON OF MAURE,(Fig. N° 5)** a litte volcano named **TITIRE,** can be observed, confirming the reactivation of Magmatic Chamber, still active (Photo N° 7)

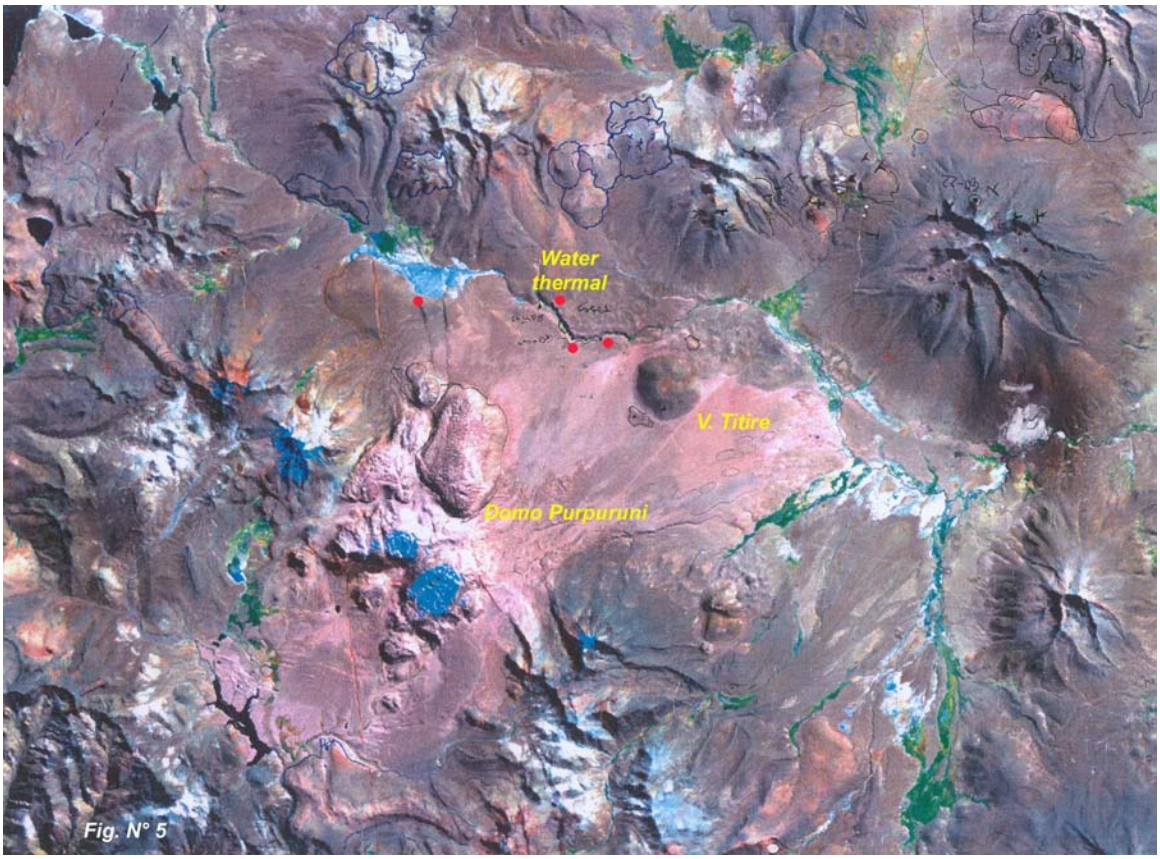


Fig. N° 5

PROJECT BENEFITS

The Geothermal development foreseen for the Challapalca area is enclosed to the southern part of the country , a zone in which surrounds, are located important charging centers of difficult covering, with an increasing demamd of electrical energy,future industrial and mining centers and other infrastructural developments that could burden the country´s economy with a conventional energetic attention of a high expensive operation,so,the following centers could get benefits partially covering their requirements::

- Electrical System of Tacna – Moquegua , actually in deficit.
- Toquepala Mining Complex, which electrical generation dependes very much on hydrocarbons.
- The further mining expansion of Cuajone which development foresees an electrical minimum power of 13 MW.
- The further mining expansion OF Quellaveco,which development Programs for future investements at the region.

PLANNED ACTIVITIES

To achieve the utilization of this resource, is necessary to continue with Feasability and Development studies, by means of the contribution from International Cooperation or with the participation of Private entities for its exploitation

C) FIELD GOETHERMAL AREQUIPA

The geothermal field in Arequipa, was defined of high priority because of its great geothermal potential according to the RECOGNITION research made by AQUATER-INGEMMET on 1978 –1979, under auspices of OLADE and with financial aid from the European Economic Community.

This gothermal field is located in Arequipa, a Departament in the southern part of Peru (Fig. N° 6)

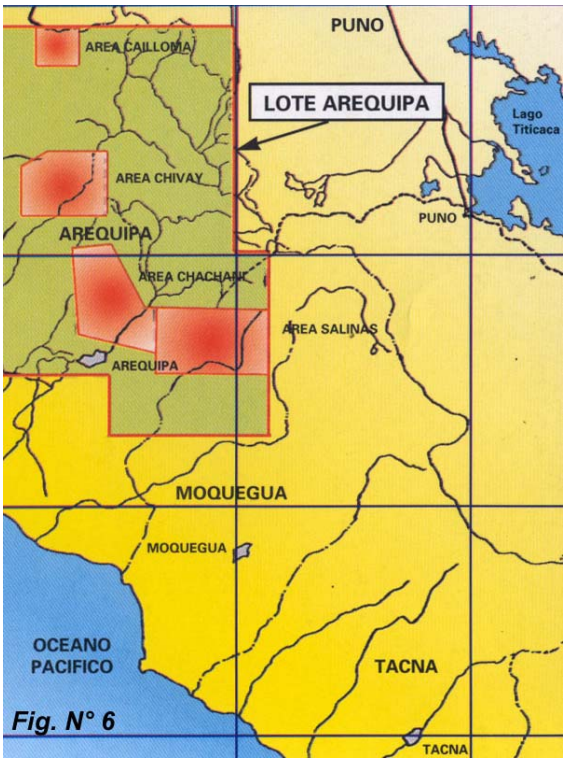


Fig. N° 6

The following geothermal areas are located in this area:

- Laguna Salinas – Chachani
- Chivay
- Caylloma

Termal Manifestations

Generally, the thermal manifestations are on an average between 30 – 65°C. At LagunaSalinas – Chachani, thermal waters have a temperature of 30 –35 °C. At Chivay, in a place named la CALERA, thermal waters have a temperature between 54 – 65°C. , and **geiser of Pinchollo** (Photo N° 8) and thermal water 70°C. At caylloma, these thermal waters go up to 70°C.

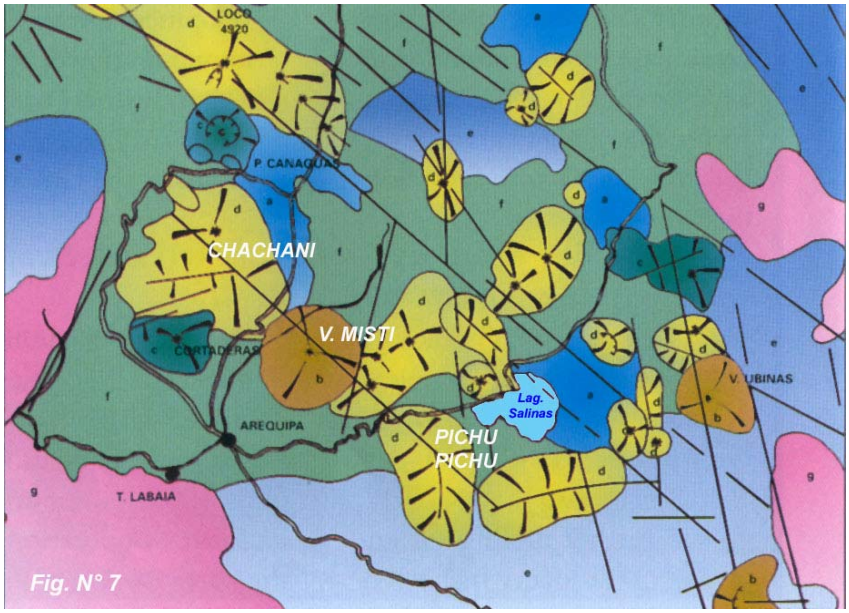
Geotermometry

The geeothermometers have given the following results:

- Chivay : SiO2 170°C
- SALINAS : SiO2 190°C

Vulcanology

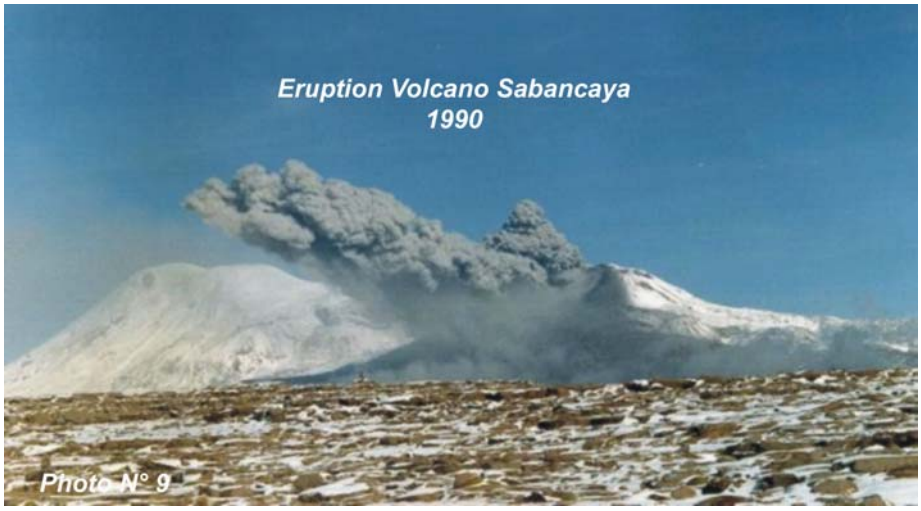
This zone is characterized by the presence of numerous central composed apparatuses as MISTI and UBINAS. Sometimes these central apparatuses are toget incomplex volcanic systems, as it occurs with PICHU PICHU and CHACHANI (Fig. N° 7)



The most beautiful volcanic unit of all this covered by with Caylloma and they have an age of 80,000 years and for Chivay area an age of 70,000 is reported.

Important volcanic structure as **CAYLLOMA CALDRON**, had been determined with the presence of volcanic apparatus of clinker nature, domos.

At Chivay area,there are volcanic domos and at Laguna Salinas – Chachani the presence of domos and volcanic structures show favorable evidences for existence of Magmatic nondeep and active chambers. The activity that shows **SABANCAYA** volcano is one these evidences.(Photo N° 9).



GEOTHERMAL PROJECT CENTRE NORTH

In 1983 work began on assessing the geothermal potential of **REGIONES 1 – 4 (Fig N° 2)** And the identification of promising areas.
This study was carried out with the technical-economical cooperation of the Italian Goverment through Cesen Co.
The results of the exploratory work led to the selection of six areas of interest (Fig. N° 8):
Group A: consisting of Callejonde Huaylas whitch has been divided into the following sub –zones, from north to south (Fig. N° 8), accoording to priority: Corongo , Caraz and Huaraz

Group B: Otuzco and La Grama (Aguas calientes).
Group C: Cajamarca – Baños del Inca.

The Field Corongo is very important the area Aquilinas Baños because has the spring with the highest temperatur of 90°C and the geothermometer indicates high temperatures:

Na-K : 220 . 290 °C
Na- Cl: 240 . 280°C.