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HYDROTHERMAL EXPLOSION DUE TO SEAL EFFECT IN EL HUMAZO GEOTHERMAL MANIFESTATION, DOMUYO VN., NEUQUÉN, ARGENTINA

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ABSTRACT

Two loud explosions accompanied by two successive big dark clouds that would have been 300 metres high, had taken place at El Humazo geothermal manifestation at February 2003. These explosions produced some important geomorphologic and structural changes that were registered in the geothermal area and its surroundings. Among these, it can be mentioned the reactivation of a geothermal manifestation place 1,6 km from El Humazo, called Mallín del Domo. In addition the explosions had yielded stone blocks of breccias up to one tonne, scattered throughout the place.

The mechanism propose for the explosions and disseminated breccias is the local sealing of near-surface discharge channels and the transmission of deeper reservoir pressures to the sealed area by the evolution of a compressible cap of exsolved gas (dominantly CO_2).

INTRODUCTION

The Domuyo geothermal field is located in the northern of the Neuquen Province, 36°63'S and 70º42'W, in the Mines and Chos Malal Departments. It is accessed from the town of Chos Malal across provincial routes 43 and 39 (Figure 1).

The area was originally studied by Groeber (1947). Llambias et al. (1978) studied the petrology and stratigraphic location of the volcanic formations of Domuyo area, and Bravo Muñoz et al. (1989) analysed the structural, geochemical and geocronological characteristics of the Plio-Quaternary volcanism between the 34º-39ºS of the Los Andes Ranges, where Vn. Domuyo lies. The prefeasibility study of the geothermal development in the area has been studied by the JICA-EPEN Project (1983-1984).

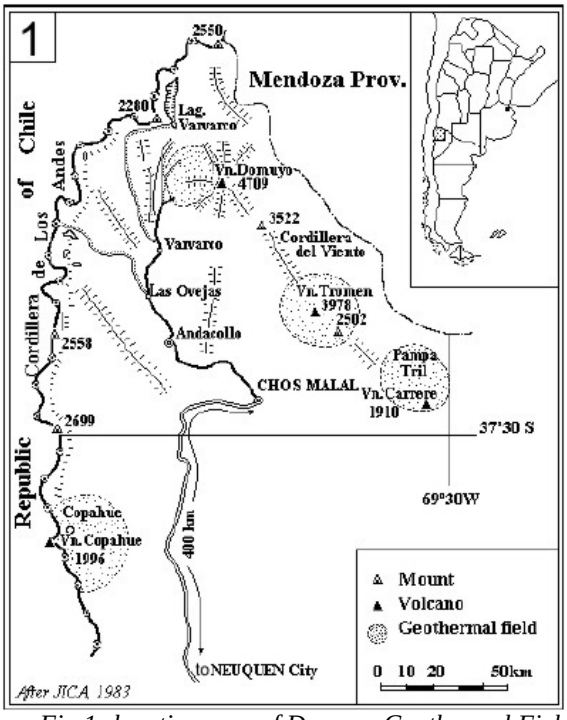

Fig 1: location map of Domuyo Geothermal Field

The Vn. Domuyo is one of a chain of young volcanoes of Plio-Pleistocene age, which also includes the Mt. La Cruzada, and the volcanoes Tromen and Carrere, arranged in NW-SE direction along the Cordillera del Viento. The volcanism has been very intense in the Domuyo area, in the extreme NO, and decreases in intensity towards the SE. The main manifestations of the area are placed in the west and southwest areas of the volcano and are called: Rincón de la Papas, El Humazo, Las Olletas, La Bramadora, Aguas Calientes and Los Tachos (Figure 2). In almost all of them the geothermal activity, as hot springs and fumaroles, flows through the tuffaceous breccias and lava flows that cover the Mesozoic formations and/or the basement rocks.

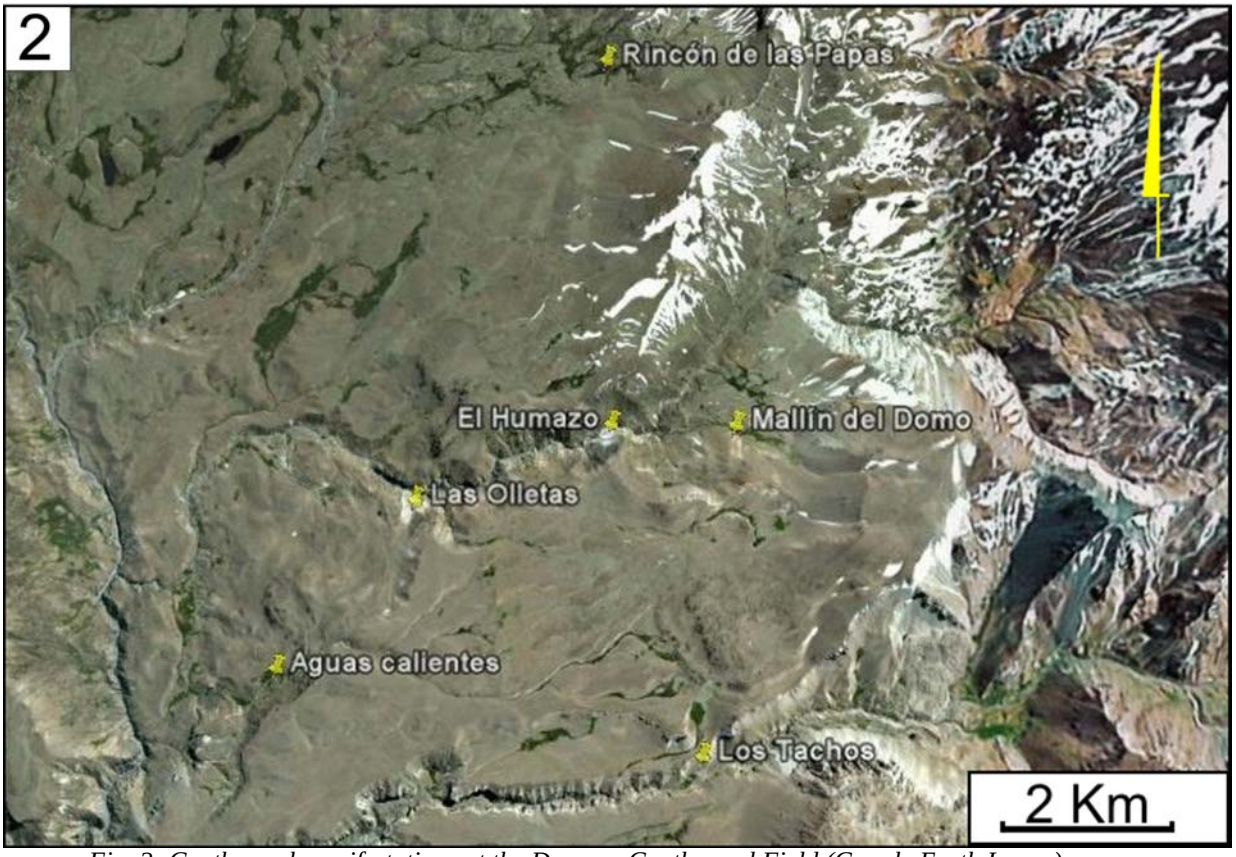

Fig. 2: Geothermal manifestations at the Domuyo Geothermal Field (Google Earth Image)

Only in La Bramadora fluid flows through fissures near the contact with an intrusive body.

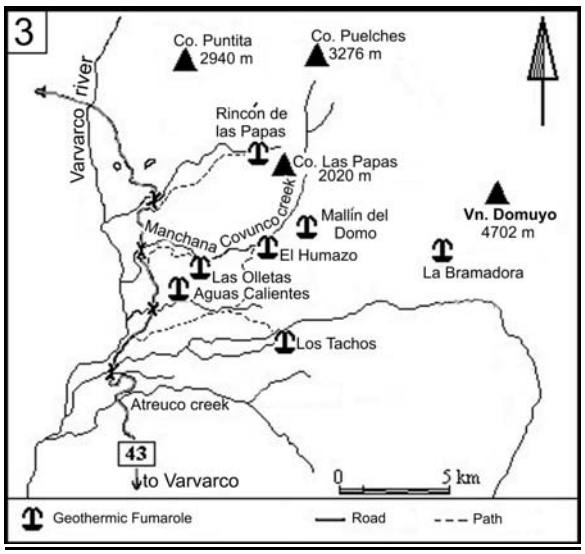

Fig. 3: Geothermal manifestations at the Domuyo Geothermal Field.

EL HUMAZO

El Humazo (*The Big Smoke*) geothermal manifestation is placed at the foot of the Las Papas hill, near of the Manchana Covunco Creek and about 4.8 km east of Las Olletas. It covers an elongated alteration area of NE-SW direction, and shows active emission of steam and gas and numerous fumaroles and some mud pots. In geophysical terms it belongs to an area of high gravity anomaly with some lower anomaly areas (JICA-EPEN, 1983). Although the altered area shows a NE general direction, the hot springs and fumaroles always occurs at the intersections of fractures.

The fluids are of the mixed water-steam type, with an alkali-chloride composition, rich in Na^+ and Cl^-, relatively rich in K^+ and poor in Ca^{2+}. Over 99% of the fumarolic gas is water vapour, and the remaining 1% is mostly gaseous CO_2. The thermometry of gaseous phase of these fluids indicates that the temperature of the underlying reservoir would be greater than 200°C (JICA-EPEN, 1983-84).

Three major alteration areas are presented in El Humazo manifestation:

- The greatest alteration anomaly is represented by an area of 500 x 200m of travertine deposits of up to 50 m thick. The surficial altered rocks in the area are whitish, with a reddish surface mineralization near the main geysers and

fumaroles activity. Rocks in the up welling area are intensively altered to a siliceous porous material made up of the silica polymorphs tridymite and cristobalite, smectites, zeolites and albite. (Mas et al.2000).

- Upstream of the main geothermal area of there is an alteration sector of approximately 100 x 100m, where talus deposits cover the older secondary minerals. Montmorillonite is the main clay mineral, associated to cristobalite, tridymite, and the same zeolites, heulandite and mordenite.

- On a hillside next to El Humazo there is a strong alteration in a bleached area of about 200 x 50m. The predominant minerals are illite, kaolinite and pyrite with subordinate amounts of smectite and interstratified clay minerals. This area has been called Mallín del Domo by the authors.

Current State of El Humazo

On February 28, 2003 at about 19.30 pm, according to the Río Negro newspaper dated March 15th of that year, the residents of the area assured to have heard two loud explosions and observed two successive big dark clouds that would have been high at an altitude of 300 metres and were visible 20 kilometres away. In addition, the explosion "would have yielded stone blocks of up to one tonne that were scattered throughout the place".

They also expressed that after the explosions El Humazo "had changed completely its shape" and added that "since then the column of steam is no longer so great and in the right bank of the stream has formed a crater about 6 meters in diameter where the water, of a turquoise sky blue colour, seems to boil". They added also that the bed of the stream in this sector have changed and "a large lagoon of hot water have been formed".

According to the same information "people who visited the site found small pieces of rocks, mainly of white colour, that were not in the sector before the explosion", adding that "this area was covered with ash and even in some places this material had completely covered the vegetation, consisting of autochthonous species as *piche* and *neneo*, among others".

These changes could be actually confirmed during a campaign that took place the next summer. One of the most conspicuous features observed was the presence of a large number of dispersed pieces of a white, fine grain calcite, ranging in size from few centimetres up to blocks near $1m^3$, scattered in an important area around the geothermal manifestation. There were also blocks of variable size of a breccia, with angular clasts of volcanic rock cemented by the same white material. The photograph of Figure 3 shows scattered fragments in the field and in the photograph of Figure 4 a detail of the breccia. We found no appreciable amounts of ash. The pieces of hydrothermal eruption breccias disseminated around the El Humazo are characterized by variable clast abundance, size, and angularity; a poorly sorted matrix-supported texture; and a variable degree of hydrothermal alteration and brecciation between clasts and deposits.

Fig. 4: a block of breccia at El Humazo

There were also significant changes in the morphology of the site. The main differences observed are:

- The significant increase of the area occupied by the geothermal manifestation, with the formation of a large pool in the spot of greatest activity. The photograph of Figures 5 and b show the hot springs and the nowadays size and shape of the lagoon,

Fig. 5a: lagoon in El Humazo

- The sharp increase in the fracturing of the rocks. The slopes of the hill are more abrupt and very unstable as a result of this fracturing. Fig. 6 shows these features on the surrounding slopes.

Fig. 5b: Nowadays size and shape of the lagoon

Fig. 6: fractures in the talus of El Humazo

- Another important change took place in the Mallín del Domo area, which is located 1,600 m in an easterly direction, 36º 37' 7, 5" S and 70° 32'1, 1" W and a height of 2377 meters above sea level. In this sector a conspicuous increase of the fumarolic activity has occurred, accompanied with sulphur and pyrite deposition around the geysers and fumaroles.

Mallín of Domo is located on a gentle slope, which has begun to show a depressed area due to the alteration of rocks in the field. It presents several small fumarolic centres, lined up in lineaments which together give the typical horseshoe shape of geothermal manifestations (fig. 7).

Fig. 7: Mallín del Domo

In each of the active fumaroles it can be seen the presence of small "nests" of fibrous sulphur formed by the sublimation of the gaseous phase, surrounded by a halo of sulphur and pyrite, with some residual silica, of few centimetres to some decimetres of wide. (fig.8) The alteration along the depressions, and particularly in the areas of upwelling of fluids, consists of varying proportions of kaolinite, usually dominant, illite, and quartz.

Fig. 8: nest of fibrous sulphur

The rock surrounding these fumaroles is also altered, mainly in kaolinite, and between each of the fumaroles alignments there is a hardened crust of reddish coloration, consisting of jarosite in addition to the aforementioned minerals.

This alteration is the result of the action of acid fluids (gas vents and aqueous solutions) over the volcanic rocks of the area. These fluids would be similar to those present at the Humazo and Los Tachos, which are the areas of higher temperatures and lower pH of the field.

The increase in activity in this area might be related to the closing and reopening of fractures as a result of the latest explosions reported in El Humazo, which would have resulted in the revival of other fractures of the area.

DISCUSSION AND CONCLUSIONS

The geyser El Humazo gets its name from the high column of steam and geothermal gas that produces, which is visible from a considerable distance from the site. Although the height of this column is not constant because it depends on weather conditions (it is a rather cold place even in summer) and the amount of water and gas that reaches the surface, it commonly varies within certain limits, which are well known by the few residents of the area. Something similar can be said about the sound it produces, strong, deaf and of continuing nature. Sometimes, however, these conditions change in a sporadic and random way.

The Domuyo Geothermal Field reservoir have been formed by the collapse of intensively faulted and fractured zones in the basement and overlying Mesozoic formations, as it was determined by means of the analytical methods applied during the geophysical prospecting of the (JICA-EPEN, 1983). This structure continue in depth, for the study estimated that the depth of the structural geothermal basement exceed the 800m.

The mentioned explosions and the changes observed in El Humazo might be related to the closing of supplying passages of geothermal hot water by depositions of minerals. This fact increases the pressure in the underlying levels which resulted in the reported explosions.

The increase in activity in the Mallín del Domo area, which NE-SW direction is coincident with the general strike of the El Humazo, would have been the result of the reactivation of some parallels fractures.

The mechanism propose for the explosions and disseminated breccias is the local sealing of near-surface discharge channels and the transmission of deeper reservoir pressures to the sealed area by the evolution of a compressible cap of exsolved gas (dominantly CO_2).

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