EVALUATION OF GEOTHERMAL SYSTEMS IN TWO TECTONIC DEPRESSIONS IN CENTRAL MEXICO

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INTRODUCTION:

Mexico has geothermal resources of high, medium and low temperature. There are around 2000 thermal manifestations (fig. 1), the majority are of low a medium temperature. So that different research have been carried out in any areas of the country (Molina and Banwell, 1970, Torres et al., 1993, Quijano-León Gutiérrez- Negrín, 2003; Martínez et al., 2005; Santoyo-Gutiérrez and Torres Alvarado, 2010). However this information is focused to the high temperature geothermal fields where exist detailed studies about the hydrochemical, geological and geophysical characteristics of them. On the other hand, there exist few literature about the low or medium temperature thermal manifestations, as well as much less information concerning to integral studies of these geothermal systems. So that it´s necessary to carry out multidisciplinary projects focused to provide information to characterize these systems and tool development .

Figure 1 Map of thermal manifestation in Mexico.

OBJECTIVE:

EVALUATE OF THE GEOTHERMAL SYSTEMS PRESENTS IN THE NORTHEAST AREA OF CHAPALA´S GRABEN (CG), JALISCO STATE AND THE SOUTHERN AREA OF VILLA DE REYES´S GRABEN, GUANAJUATO STATE; ACCORDING TO HYDROGEOCHEMICAL CHARACTERISTICS OF THE THERMAL FLUIDS AS WELL AS COMPARE THEIR GEOLOGICAL CONTEXT .

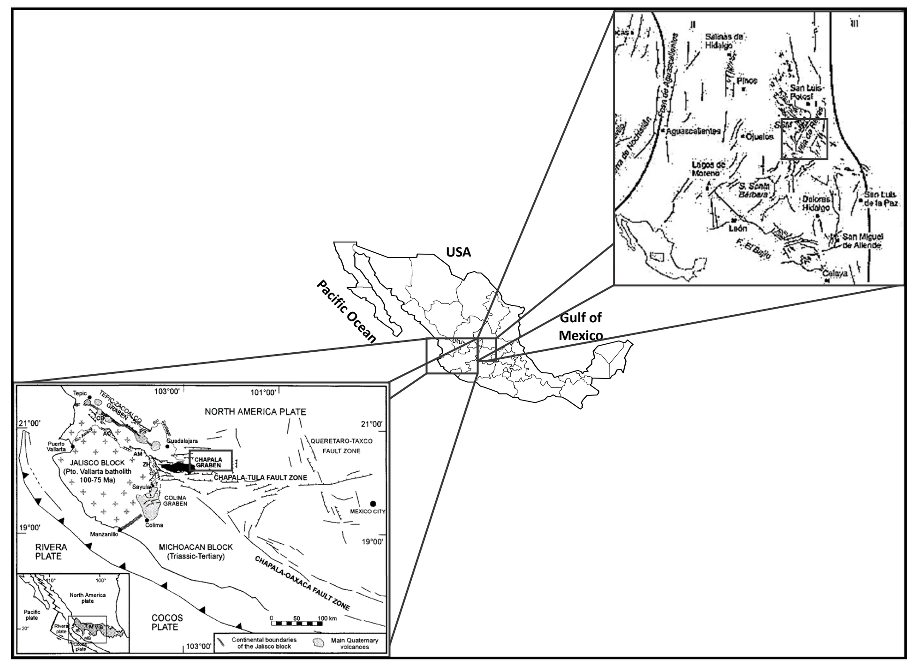

Figure 2 The localization map of the study areas and the tectonic settings

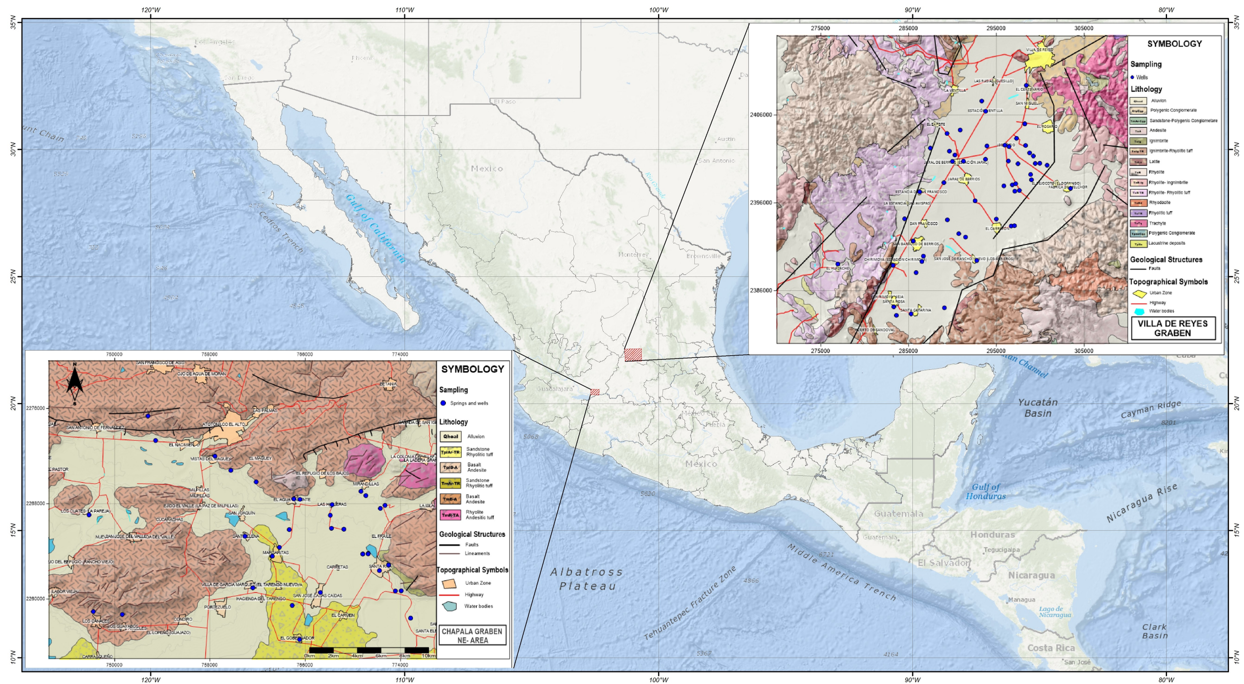

Figure 3 The geologic map of the study areas and the sample zone

GEOLOGICAL SETTINGS:

The study areas are located in the central-north and central-western part of Mexico (fig. 2). The Chapala graben is located in the western part of the physiographic province of the Trans-Mexican Volcanic Belt (TMVB). This is a tectonically active zone and is part of a regional system of grabens and half grabens with an approximate EW orientation. The graben limits to the north by normal faults that form a zone of blocks with a displacement of more than 1000 m representing a greater topographic depression bordered by a volcanic plateau (fig. 2). The zone of study is located in the part of what Rosas Elguera and Urrutia Ficugauchi (1998) denominate as the Paleolake in the Chapala basin in which a sequence of Miocene basalts and lacustrine sediments is found (fig. 3).

The Villa de Reyes graben is located between the NE boundary of the state of Guanajuato and the state of San Luis Potosí (SLP. This is part of a series of tectonic structures present in the physiographic province of the Central Mesa that corresponds to the stage of maximum extension of the area (22-28 Ma). The graben is a tectonic depression of Oligocenic age, limited in its northern portion to two volcanic fields: the Volcanic field of SLP and the volcanic field of the Santa Maria River, and in its southern portion with the volcanic field Sierra de Guanajuato (fig.2); the graben is formed by packages of dacites to rhyolites of 32 at 28 My. The bottom of the basin is formed by exogenous domes of the Latita Portezuelos of 30.6 My with a basement of late Cretaceous marine sediments, this is filled by volcanic and clastic deposits from the early Oligocene to recent age (fig. 3). According to the literature (CNA, 2005) there is a stratified aquifer where it´s present thermalism in deep, which is found in a riodacite rock (Lopez-Loera, Tristán González, 2013).

METHODOLOGY:

For the characterization of geothermal systems, different sampling campaigns were carried out in the dry and rainy season. Where samples of both thermal and cold groundwater were collected from wells and springs (fig. 4); this included the collection of rock samples for the recognition of possible geohydrological units. In situ measurements of physicochemical and chemical parameters (temperature, pH, Eh, CE, STD, HCO_3^-, SiO_2, sulfides) also were carried out. Later in the laboratory were carried out analyzes of chemical of thermal waters and stable isotopes (^{2}H and ^{18}O).

Figure 4 Sampling pictures in the study areas.

RESULTS:

Chemical characteristic of water

The groundwater temperature in wells and springs of the CG ranged from 18° to 75° C. This allow them to be grouped in thermal waters (TW≥36° C) and cold waters (CW<36° C). The first group were a Na^+-K^+-SO_4^{2-} waters associated with higher temperatures and Na^+-K^+-HCO_3^- waters associated with lower temperatures; it´s possible from the mixture of cold and hot groundwater. The second group are Na^+-K^+ to Ca^{2+}-Mg^{2+}-HCO_3^- waters which present possible mixture of groundwater with recent infiltration waters (fig. 5A). In the VRG the groundwater temperature in the wells ranged from 20° to 43° C. The thermal waters type (TW≥30° C) was predominantly Na^+-K^+-HCO_3^-, characteristic of groundwater with a major residence time where ion exchange processes that have been carried out. The cold waters types (CW< 30° C) were from Na^+-K^+-HCO_3^- to Ca^{2+}-Mg^{2+}-HCO_3^-, this represented a mixture of thermal and cold water (fig. 5B); however the concentration of ions didn´t present a direct correlation with the increase in temperature. A characteristic of the zone is that the water shows anomalous concentrations of certain chemical elements like F and U due probably to the boxing rock.

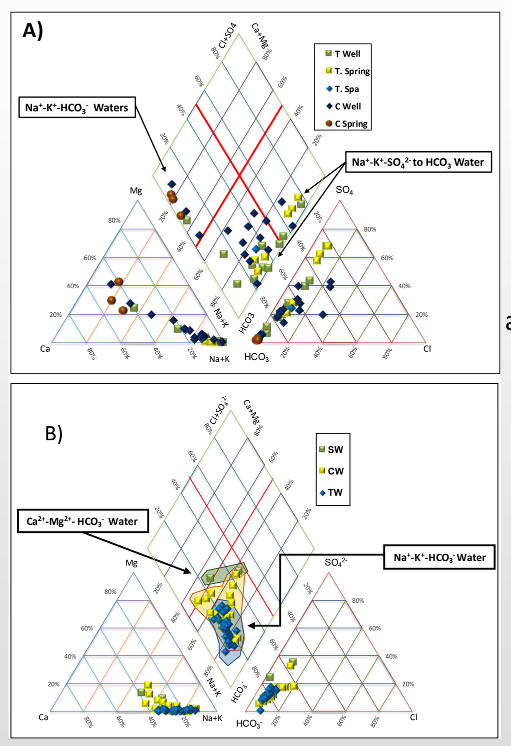

Figure 5 Piper diagram. A) Type of water in CG (thermal well- T well, thermal spring- T Spring, thermal spa- T Spa, cold Well- C Well, cold spring- C spring) **B) Type of water in VRG** (surficial water-SW, cold waters-CW, thermal waters-TW)

Geothermometers

In the CG some of the higher temperature manifestations are in partial equilibrium with the rock according to the Giggenbach diagram (Na^+-K^+-Mg^{2+}). The probable reservoir temperatures range from 140 ° to 160 ° C for the thermal springs and from 80° to 120° C for thermal wells, considering it as a possible medium to high temperature system (fig. 6A). Since in the VRG most of the manifestations are not in equilibrium with the rock and ion exchange processes are carried out, the geothermometers cannot be used to determine the temperature in depth. However, chalcedony geothermometer has been used for groundwater with reservoir temperatures below 150° C. The geothermometer results show a reservoir temperature between 80° and 90° C, this suggests a low temperature geothermal system (fig. 6B).

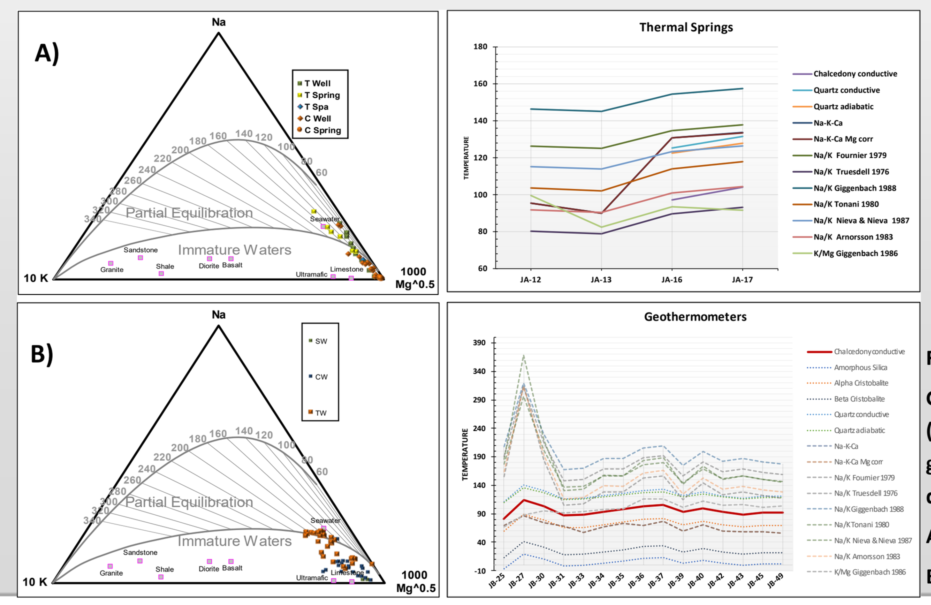

Figure 6 Giggenbach diagram (left) and geothermometer diagram (right): A) CG zone, B) VRG zone.

Stable Isotopes

The stable isotopic values behavior of the $\delta^{18}O$ and δD of the groundwater in CG area show a tendency of evaporation process with respect to Mexican Groundwater Line (MGWL). However some thermal springs and wells present an enrichment in $\delta^{18}O$, suggesting a source of thermal origin while the others probably are a mixture of thermal water and groundwater (fig. 7A).

The $\delta^{18}O$ & δD diagram (fig. 7B) show that the groundwater in the VRG area exhibits behavior similar to the MGWL, this suggests a groundwater origin and possibly existence of two end members: 1)from local to intermediate regime and 2) regional regime .

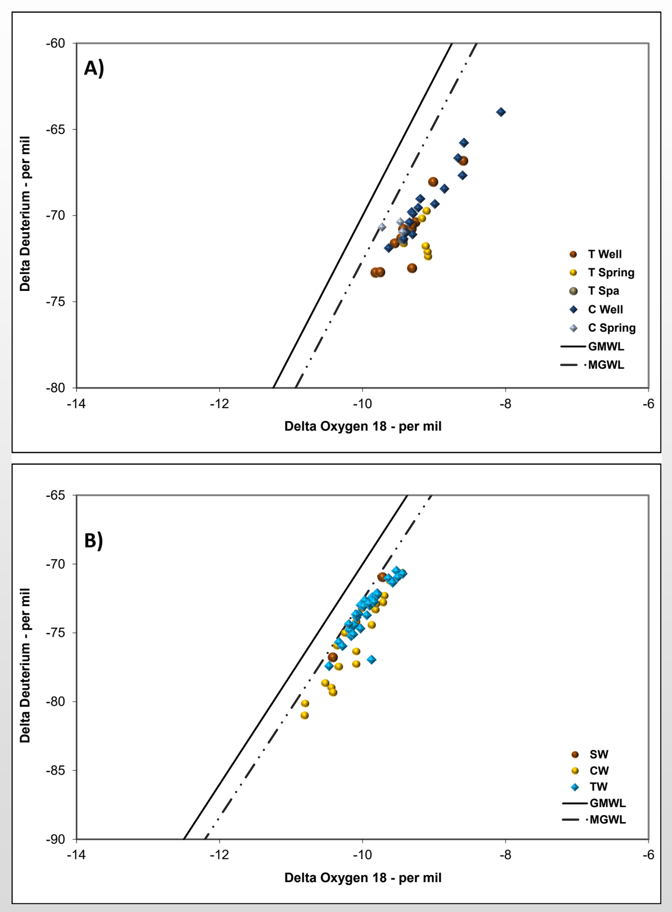

Figure 8 $\delta^{18}O$ & δD diagram of the groundwater in A) CG area and B) VRG area.

Thermalism and geologic context

The higher temperature hydrothermal manifestations in the CG present an NW-SE alignment, which may be associated with depth faults related to the graben's extensional boundary. The temperature of the manifestations decreasing towards SW of the study area and water flow direction (fig. 8A). The highest temperatures in the VRG are in the limits of the basin aligned with faults that limit the graben while in the central part the well water temperature is smaller; this most likely is because the thermal aquifer in this area it's deeper (fig. 8b).

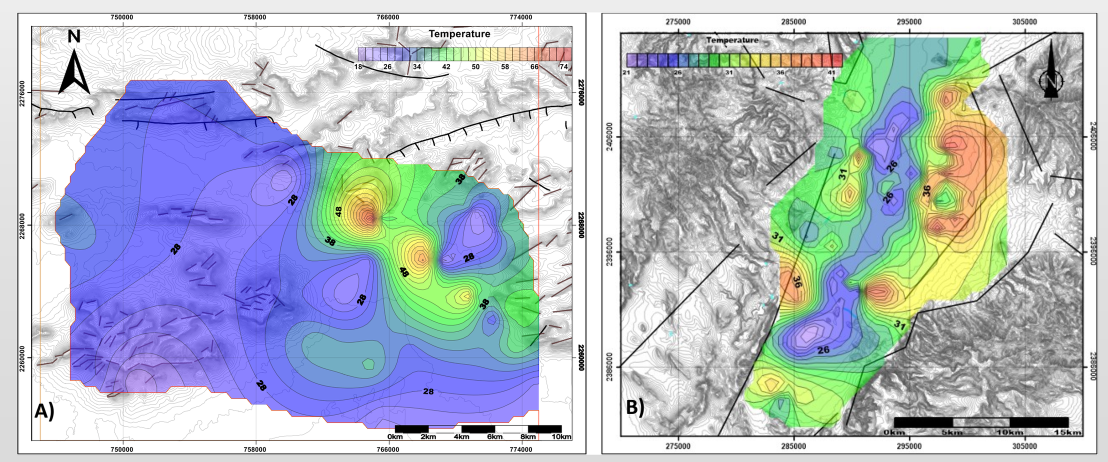

Figure 8 Isothermal map of the: A) wells and springs in the CG area, and B) Wells and springs in the VRG area.

CONCLUSIONS:

In conclusion the thermal system of the area to the NE of Chapala graben is probably a medium to high-temperature geothermal system of extensional domain type due to its geological characteristics in a tectonically active zone with young volcanism (Quaternary-Pliocene); that could be suggested a geothermal potential of interest. Its exploitation can be for direct uses and for indirect use through binary cycle power plants. The thermal system of the southern part of the Valle de Reyes graben is located in a tectonically passive zone with a volcanism older than the previous zone , this is a low temperature system probably due to a regional flow regime with ion exchange processes; however one could think of a possible radioactive thermal origin due to the uranium content . Its thermal and hydrochemical characteristics and its geothermal potential suggests an exploitation for direct uses such as balneology, vegetable drying (since in the area this activity is carried out), heating of greenhouses, etc. Given the above, it would be important to carry out more detailed studies of both zones to determine the specific geothermal potential in the Chapala graben and to determine the origin of the thermalism in the Villa de Reyes graben.

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