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USE OF DEUTERIUM AND OXYGEN-18 IN HYDROLOGICAL PROBLEMS AT VILLA DE REYES, S.L.P. MEXICO

Pedro Morales and Rolando Castillo Caballero

Instituto de Física, UNAM

P.O. Box 20-364. Delegación Alvaro Obregón

01000 - México, D.F.

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ABSTRACT

This paper presents a survey of an initial study in order to understand the general behavior of ground water at Villa de Reyes, S.L.P. Mexico. Deuterium and oxygen results are discussed and two geothermometers were used in order to search for a geothermal area.

RESUMEN

Este artículo presenta una visión general del estudio realizado en Villa de Reyes, S.L.P. México, cuyo objetivo fue entender el comportamiento del agua subterránea. En este estudio se utilizaron geotermómetros químicos con el fin de buscar áreas geotérmicas y se discuten los resultados de los análisis de deuterio y oxígeno-18.

INTRODUCTION

In order to support the national development of thermoelectric industry, it is necessary to know the behavior of aquifers to be exploited to give a rational use of natural resources. Therefore our group collaborated with C.F.E. (Comisión Federal de Electricidad, Federal Commission of Electricity) in order to initiate a research program in the area around Villa de Reyes, San Luis Potosí State (approx. 22°00' to 21°30' N and 100°40' to 101°20' W, Fig. 1). This communication presents a survey of an initial study using deuterium and oxygen-18 isotopes in ground water samples, in order to understand the general behavior of ground water in this area.

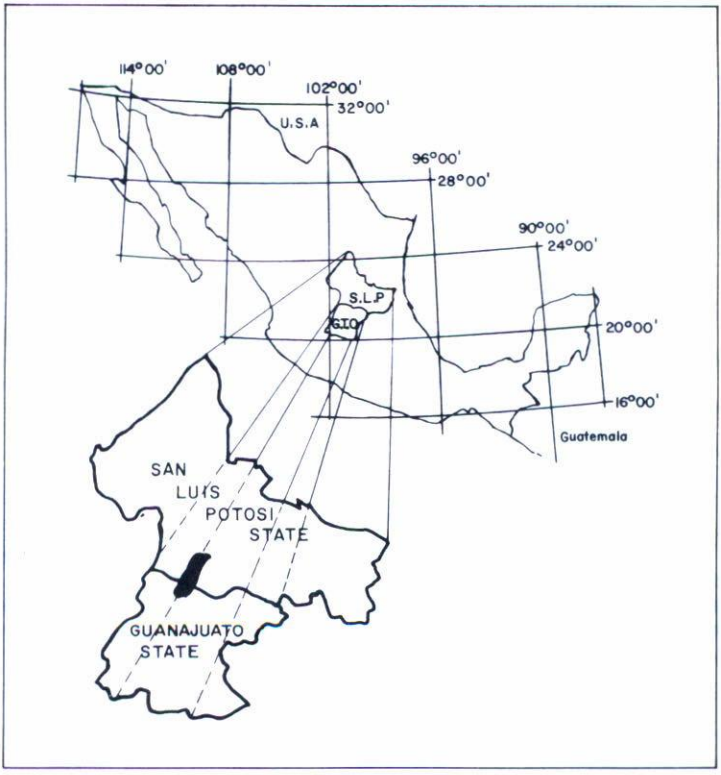

Fig. 1 Approximate localization of Villa de Reyes Valley.

GEOLOGICAL FEATURES

Using data obtained from drilling a few wells, geological and topographycal maps[1], we made several cross sections of the area (Fig. 2) which indicate that the Villa de Reyes Valley is an hydrological basin formed on top of a rhyolite basement which is filled with gravel, sand and clay produced by erosion of igneous rocks.

The scarce piezometric level data all seem to indicate that ground water flows from South to North or Northeast from Villa de Reyes town[2].

DEUTERIUM AND OXYGEN ANALYSIS

Oxygen-18 analysis was performed according to a slight modification of Epstein and Mayeda[4] technique, consisting of equilibrating in a vaccum line 1 ml of water sample with a known quantity of CO_2 in order to reach the isotopic equilibrium:

$$H_2\,{}^{18}O + C\,{}^{16}O_2 \longrightarrow H_2\,{}^{16}O + C\,{}^{16}O\,{}^{18}O \quad .$$

After this operation and before a drying process, this equilibrated CO_2 is compared with other CO_2 previously equilibrated with a standard water sample, in a three collector mass spectrometer with a Mc Kinney inlet system, in order to find the value $\delta^{18}O = \left(\frac{R_{sample} - R_{std}}{R_{std}} \right) 10^3$, where R is the isotopic ratio $^{18}O/_{16}O$.

Deuterium analysis was done partly at Krueger Enterprises Inc. Mas., U.S.A. and partly at Teledyne Isotopes, N.J., U.S.A., both using the well-known uranium technique consisting of carrying out the complete reduction of a 5 µl water sample over uranium, at 750°C and comparing the isotopic composition of this resulting hydrogen gas with other gas coming from a standard water sample, in a double collector mass spectrometer in order to find the value $\delta D = \left(\frac{R_{sample} - R_{std}}{R_{std}} \right) 10^3$, where R is the isotopic ratio $^{D}/_{H}$.

All data from ground water are plotted relative to Craig's Me-

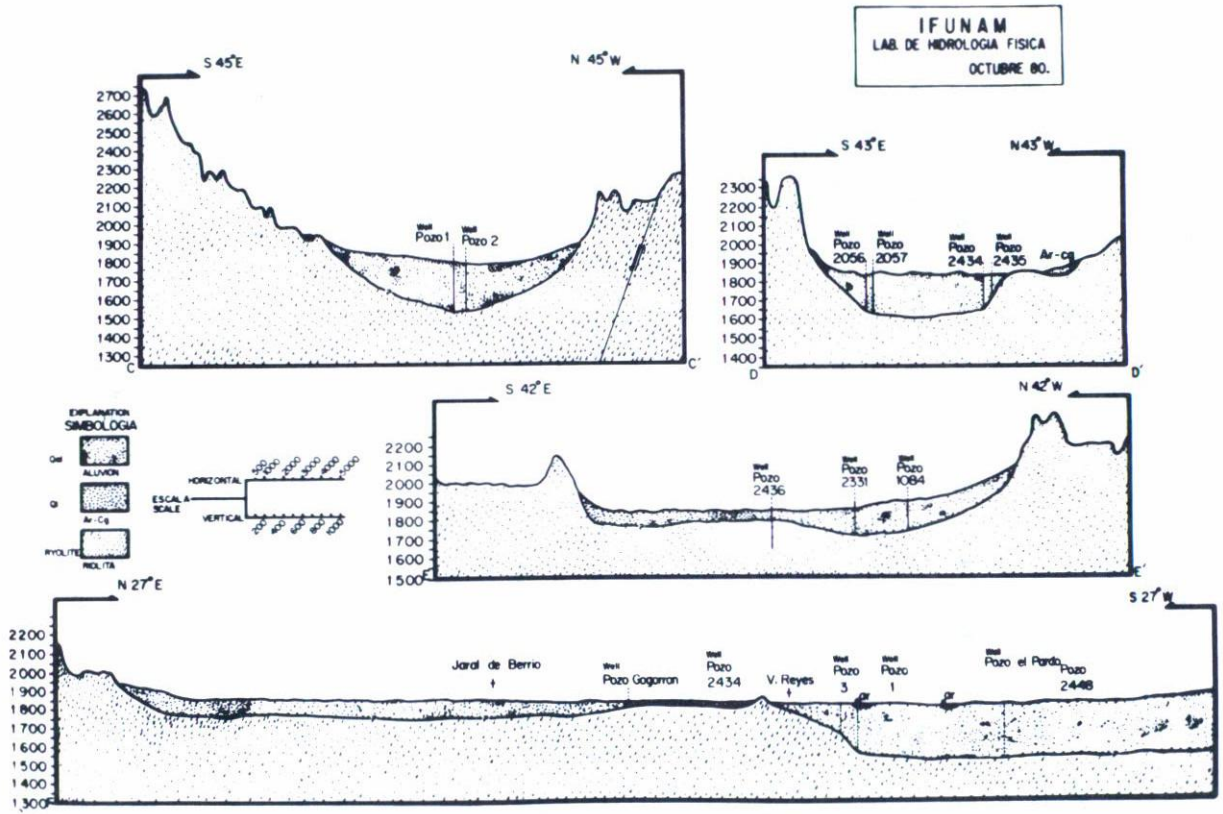

Fig. 2 Cross sections showing the main geological features of the studied area.

teoric water line in Fig. 3, where standard is V-SMOW.

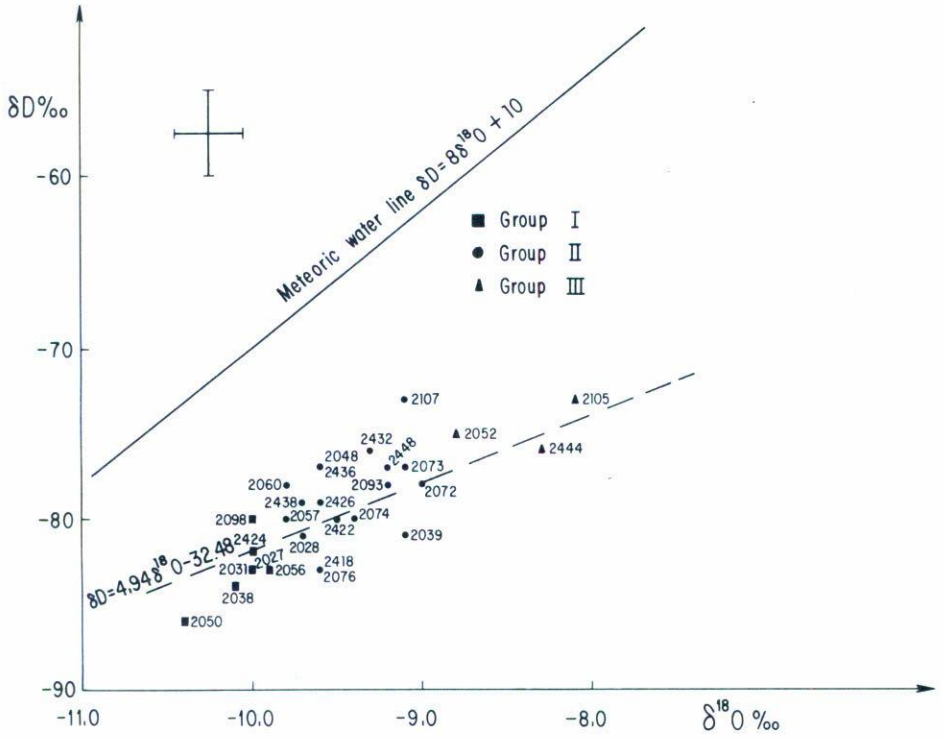

Fig. 3 Diagram showing the isotopic content of Villa de Reyes Valley's ground water in permil desviation from S.M.O.W. (the cross indicates precision).

USE OF GEOTHERMOMETERS

Since there are several wells producing hot water (above 35°C) in the area, we determined the temperature of last water-rock interaction in order to look for a new geothermal area. For this purpose we used the Fournier and Truesdell Geothermometer[3] (Table I).

T A B L E I

WELL	DEPTH (m)	TEMPERATURE IN SITUO (°C)	TEMPERATURE LAST ROCK WATER INTERACTION (°C)	$\delta\ ^{18}O$
2374	270	40.6	142	---
2381	400	39.4	138	9.7
2418	60	38.6	138	9.6
2422	175	26.9	114	9.5
2426	---	39.3	140	9.6
2428	83	26.2	197	9.4
2432	246	28.0	172	9.3
2436	411	41.8	142	9.6
2438	377	39.7	141	9.7

DISCUSSION

a) Waters from wells near mountains have depleted isotopes values: around - 10‰ for oxygen and -83‰ for hydrogen. These waters form group I in Fig. 3. Meteoric water in the Valley is around $\delta\ ^{18}O$ of -10.4‰, hence these waters appear to be derived directly from meteoric water through infiltration with only minor evaporation.

b) Going away from the mountains towards the center of the valley water becomes more enriched in heavy isotopes. These water can be classified into two groups: Group II with isotopic values around $\delta\ ^{18}O$ = -8.4‰ and δD = -74.6‰.

c) The above mentioned groups, in Fig. 3 fall along the correlation line $\delta D = 4.94\ \delta^{18}O - 32.48$. The slope of this line is tipically of waters that have undergone evaporation[6], because is less than 8 and greater than 0, and all of this is consistent with values of ionic sum determined by chemical analysis (not shown); that is, the greater the

enrichment the greater the salinity (and hence evaporation). There is no correlation of oxygen-18 content and well depths (not shown).

d) Such an evaporative pattern can be originated by the following mechanisms:

1) Evaporation of recharge waters in low areas before infiltration. Climatic conditions are typical for semiarid areas (average rainfall about 420 mm, temperature extremes -5°C and 38°C).
2) Evaporation of water in large reservoirs built for farming, which after infiltration mix with ground-water (as an example, oxygen-18 content in one reservoir was determined to be +1.9‰).
3) Mixing ground water with water provided by wells, evaporated in channels and farming fields prior to infiltration. It is important to note that areas with the greatest enrichment in the Valley coincide with farming areas. Bad irrigation techniques resulting in large losses of water have been used here for the last two hundred years.

e) The area of hot water is probably the result of an intrusive hot body which warms the ground water; however, the temperature is too low to be of much industrial importance now (there is no correlation of oxygen-18 water-rock exchange and wells with hot water in Fig. 3).

CONCLUSION

All indications are the Villa de Reyes Valley behavior like a normal unconfined aquifer recharging mainly from meteoric waters at the sides of the basin, with the ground water flowing from South to North or Northeast from Villa de Reyes town. All these features are influenced by the strong evaporative processes of a semiarid area with wasteful irrigation techniques.

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