

USE OF DEUTERIUM AND OXYGEN-18 IN HYDROLOGICAL PROBLEMS AT DELICIAS VALLEY, CHIHUAHUA, MEXICO

R. Castillo C., P. Morales and A. Cortés

Instituto de Física, UNAM
Apartado Postal 20-364. 01000 - México, D.F.

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ABSTRACT

This paper presents an initial study using stable isotopes at Delicias Valley Chihuahua, where we found an aquifer with two kinds of waters, one of recent infiltration (highly fractionated) and another of more depleted isotope concentration representing precipitation before the construction of the dam and distribution channels.

RESUMEN

Este artículo presenta un estudio preliminar utilizando isótopos estables en el Valle de Delicias, Chihuahua, donde se encontró un acuífero con dos clases de agua, una de infiltración reciente (altamente fraccionada) y otra menos enriquecida en concentración isotópica, que representa la precipitación antes de la construcción de la presa y de los canales de distribución.

INTRODUCTION

In order to support national development of the thermoelectric industry and to give a rational use to natural resources, it is necessary to know the general behavior of the aquifers to be exploited. Therefore our group at IFUNAM collaborated with Federal Commission of Electricity to give more information to establish a more appropriate groundwater model of the area, that will be useful in the future water supply development of thermoelectric plant localized at Delicias Valley. Then this communication presents some preliminary results of a deuterium and oxygen-18 survey in this area.

GENERAL FEATURES

The Delicias Valley is elongated in shape and it is surrounded by little mountains in NW-SE direction. The filling material of the valley comes from the mountain areas forming chaotic and irregular lake deposits. The sets of rocks existing in the area form a stratigraphic column from paleozoic to recent era, mainly of marine and continental sedimentary rocks. Because of the heterogeneous characteristics and the lack of structural cross sections, it is difficult to fix a general sub-soil pattern to support a groundwater model. Using the Geophysical data of Rangel⁽¹⁾, it is possible as a first approximation to consider the aquifer matrix as formed by two layers even though, this are not completely defined horizontally. The first layer has an average depth of 100 m with medium permeability while the second layer ranges in depth from 100 m to more than 400 m and has low permeability.

On the surface, the Delicias Valley appears as a very large semiarid area with a lot of farming, its precipitation values are around 200 to 250 mm per year and it is irrigated as shown in Fig. 1 by two rivers (the Conchos and San Pedro Rivers) and a channel system. Piezometric levels indicate that Conchos river is the natural ground water feed out of the Valley⁽²⁾.

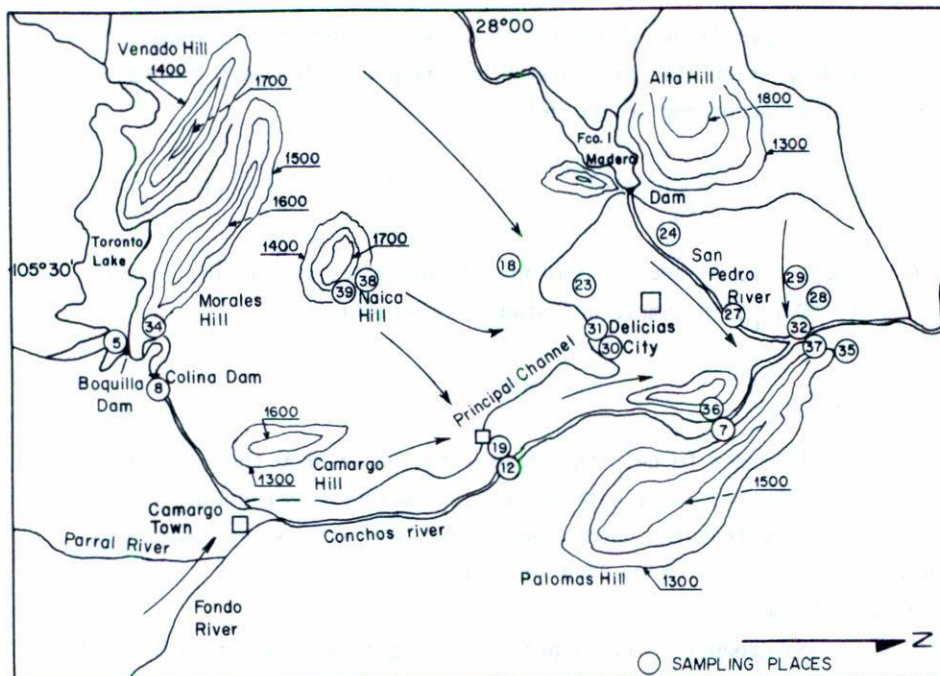
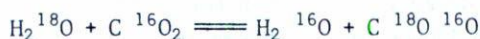


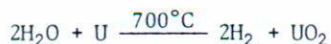
Fig. 1 Schematic diagram of Delicias Valley indicating main hills, rivers and ground water flow lines.

ISOTOPIC ANALYSIS

The Oxygen-18 analysis were prepared according to the Epstein and Mayeda technique⁽³⁾ based in the isotopic analysis of CO_2 , in a triple collector mass spectrometer, previously equilibrated with a sample aliquot according to the following reaction:



Deuterium analysis were done at Krueger Enterprises, Inc. Ma. U.S.A., using the uranium technique based in the isotopic analysis, in a double collector mass spectrometer, of hydrogen gas coming from the following quantitative reaction:



Oxygen-18 and deuterium analysis are reported as usually⁽⁴⁾ in per mil deviation (‰) from a standard sample called SMOW (Standard Mean Ocean Water) according to the definitions

$$\delta D = \left(\frac{R_x - R_s}{R_s} \right) 10^3 \quad \text{and} \quad \delta^{18}O = \left(\frac{R_x - R_s}{R_s} \right) 10^3 ,$$

where the R_x and R_s are the isotopic ratios of corresponding isotopes (D/H or $^{18}O/^{16}O$) in sample and standard respectively.

DISCUSSION

In order to help the interpretation we show the isotopic results in a $\delta D - \delta^{18}O$ plot with the Craig's meteoric water line in Fig. 2, and we can see that the natural waters of Delicias Valley correlates with line $\delta D = 5.14 \delta^{18}O - 23.9$ (correlation = 0.94) and it is composed by two subgroups:

Subgroup I are samples belonging to deep waters from wells of more than 200 m depth or hot springs, in some cases with temperatures of more than 40°C, and they are around $\delta^{18}O = -7.5\%$ and $\delta D = -63\%$. Saline content was not high, the mean value of ionic sums is around 13.5 m eq/l.

Subgroup II are samples coming from shallow waters clearly belonging to evaporated waters, since their correlation line has a slope quite below 8^(5,6), having a strong evaporative process and their origins at the large reservoirs. Toronto lake (sample 5) shows the greater enrichment in the area, having a logical position in the evaporative-mixing line since it seems to undergo the most evaporative process in the area, probably due to a long residence time with semiarid conditions. On the other hand Francisco I. Madero Reservoir (not plotted in Fig. 2) shows very different values, $\delta^{18}O = -6.2\%$ and $\delta D = -76\%$, due to different type of run off recharge and probably shows an isolated event since this reservoir seems to have a very short residence time.

It is interesting to note that the mean value at meteoric water as determined by I.A.E.A.⁽⁷⁾ shows no relation to groundwater in the area,

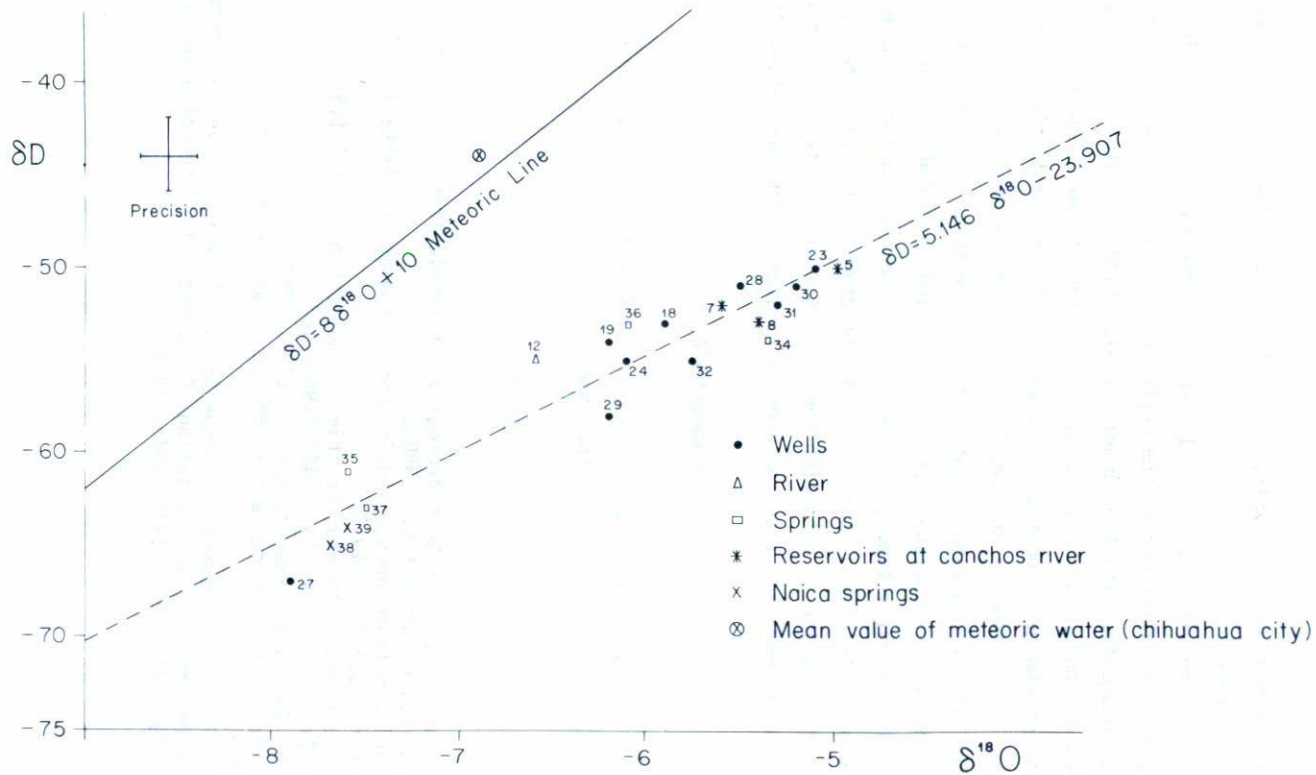


Fig. 2 Isotope composition of ground at Delicias Valley.

confirming that meteoric waters have little contribution to the recharge of the aquifer⁽¹⁾.

Even with the scarce information everything seems to indicate that Delicias Valley has at the depth that we can reach with existing wells, an aquifer with two closely related kinds of water. First the shallow one having its origins at Toronto lake through Conchos River and irrigation channels located in the upper and more conducting part of the aquifer (the influence of Francisco I. Madero reservoir was not determined). The second kind of water, the deep water, is located in the lower and less conducting part of aquifer and is probably product of infiltration in early times, long before the dam construction. Anyhow it is necessary to have a strong research program in this area, mainly a deeper exploration to establish the existence of a deeper aquifer in limestone formations, like the general geology of the area suggests.

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