THE USE OF HYDROCHEMISTRY AND ENVIRONMENTAL ISOTOPES TO IDENTIFY GROUNDWATER FLOW SYSTEMS IN COAHUILA STATE, MEXICO.

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Introduction

The Eagle Ford Formation in southern Texas is nowadays one of the fast growing oil and gas fields on the planet. The shales of the Eagle Ford Formation from south Texas continues to Coahuila state in northern Mexico, some shale gas/oil exploration wells drilled by PEMEX close to the USA border showed moderate results. Coahuila state has a semi-arid condition (precipitation 300-400 mm/year), and groundwater is the main source for population and agricultural use.

Objective

Geochemical groundwater flow systems characterization with isotopes ($\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{3}H$, $\delta^{13}C$ and $\delta^{14}C$), major elements and trace elements in the southern region of the Coahuila state, including a karstic regional aquifer developed into carbonates rocks of the Coahuila Platform.

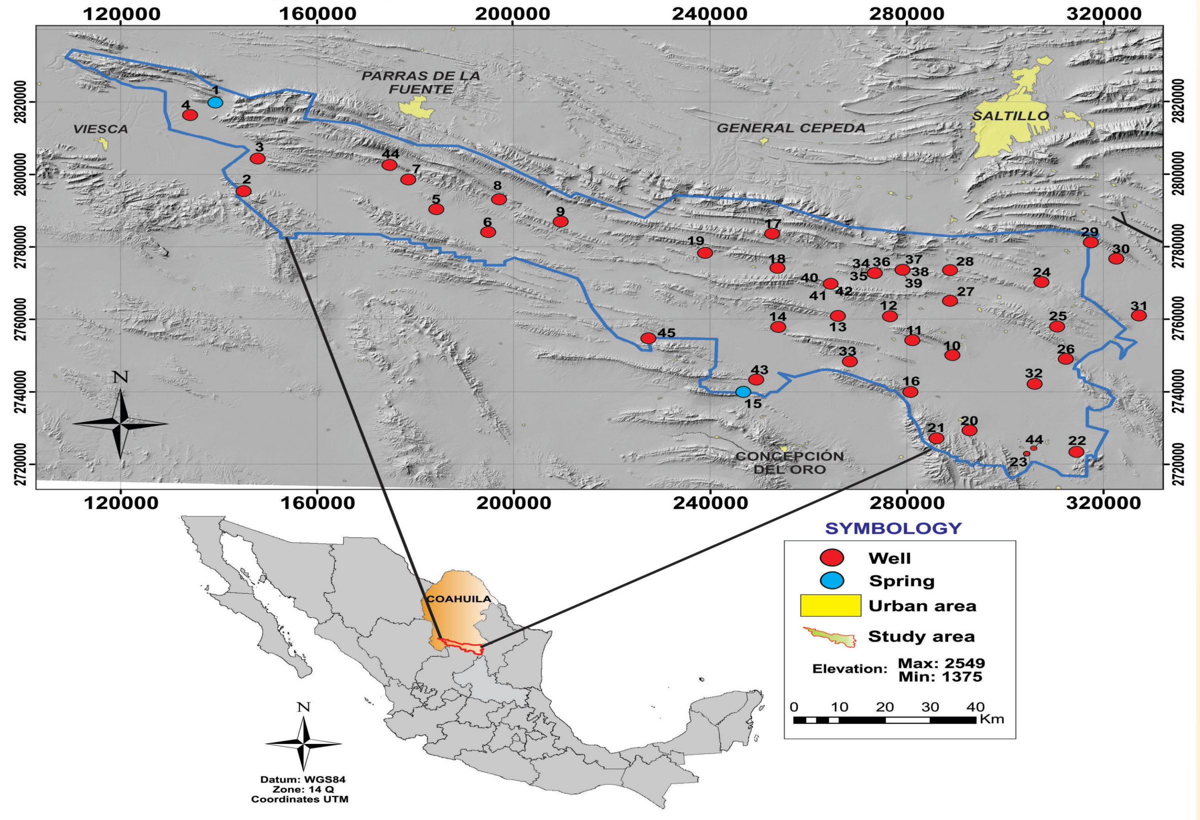

Fig 1. Location of the aquifer Saltillo Sur, Coahuila, Mexico.

Methods

Bibliographic analysis

Fig 2. Information compilation

Fieldwork

Fig 3. A) Sampling vessels, B) Groundwater sampling

Laboratory work

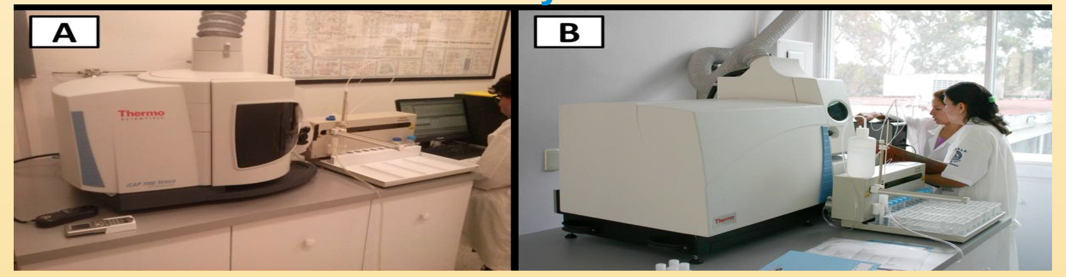

Fig 4. A) ICP-OES "Thermo Scientific", model: ICAP 700, B) ICP-MS "Thermo Scientific" model: X-Serie II

Results and discussion

Statistic analysis

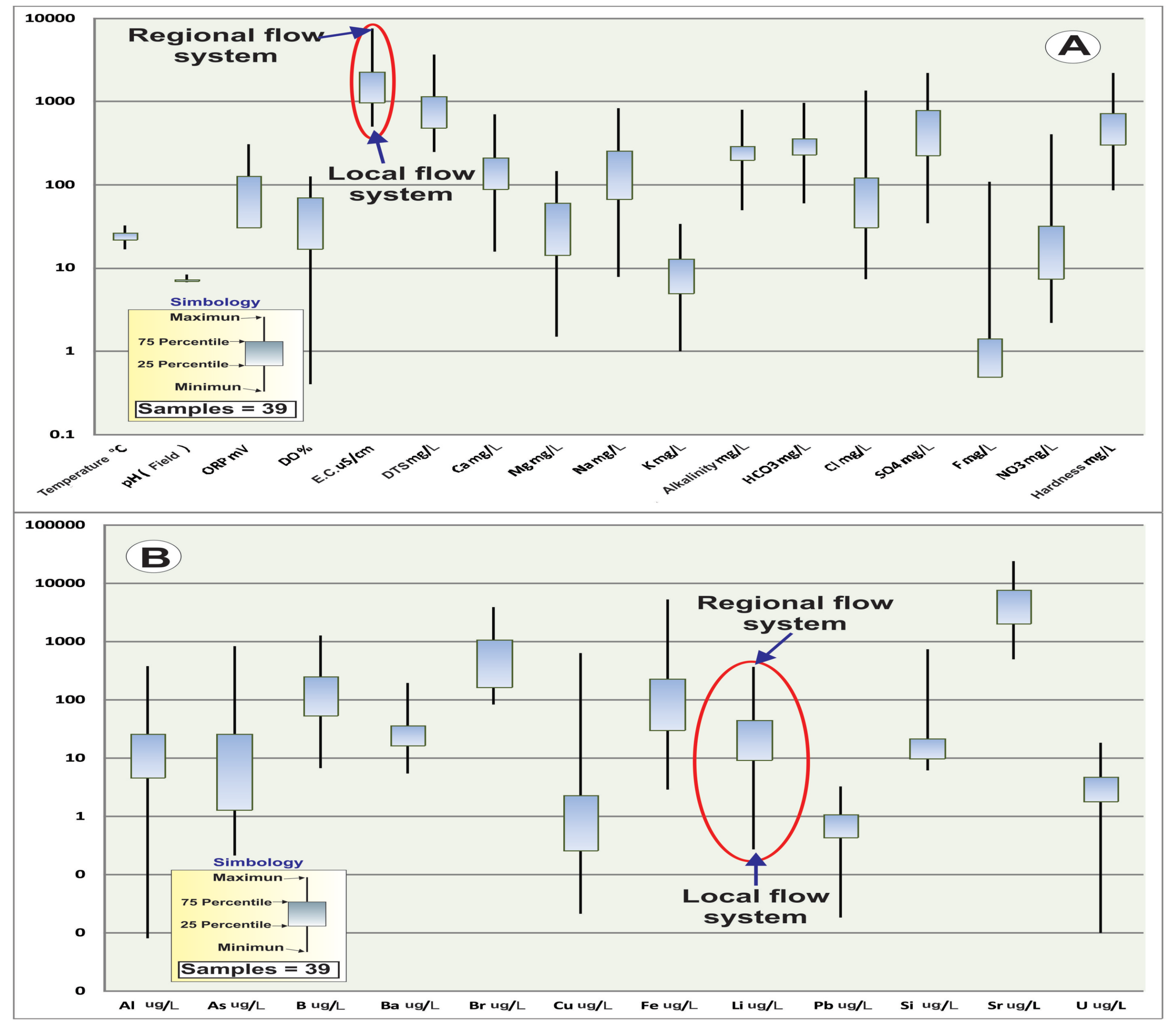

Fig 5. Box plots representing the statistical analysis for wells: A) major elements; B) trace elements.

Piper diagram

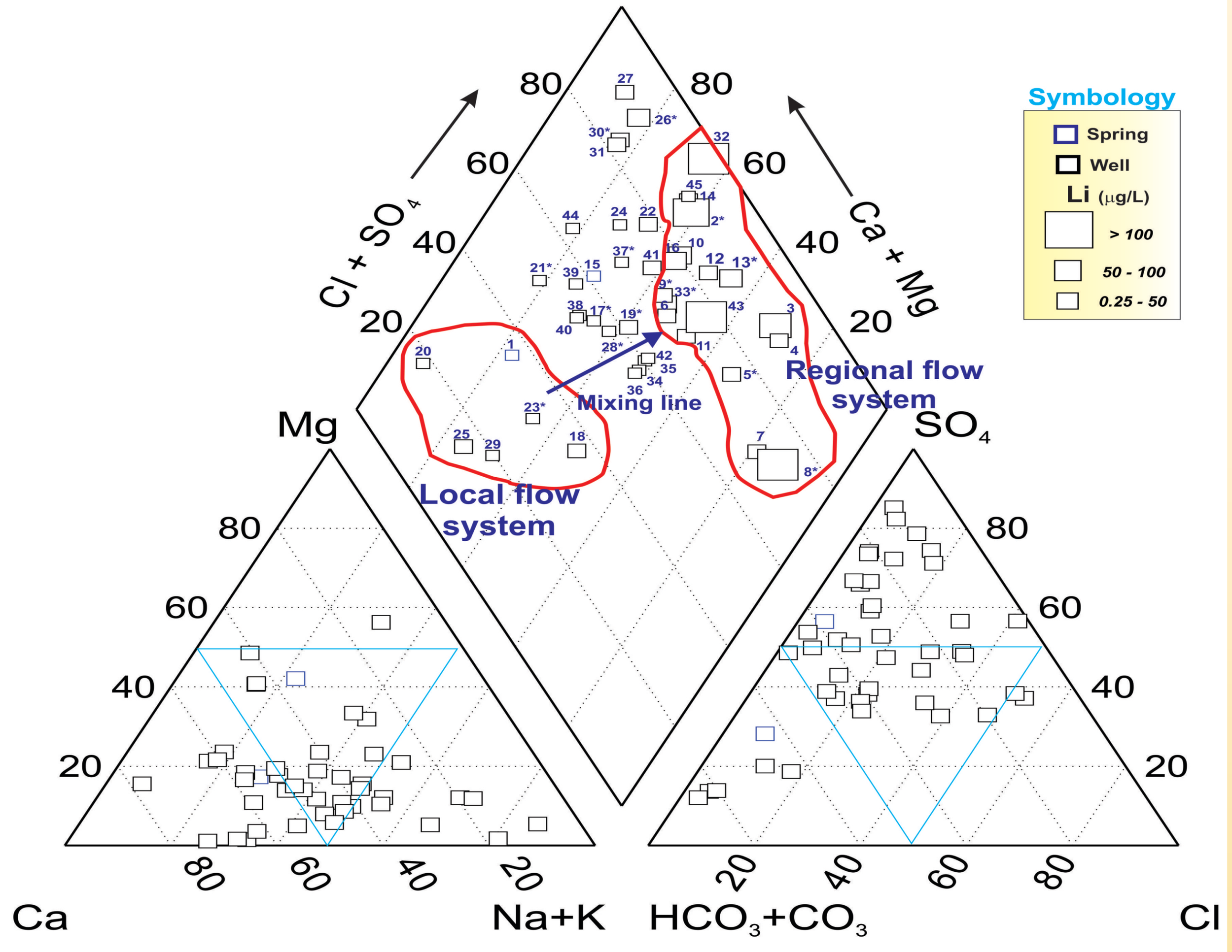

Fig 6. Piper diagram showing chemistry of wells from Saltillo Sur Aquifer (Piper, 1944).

Stiff diagrams

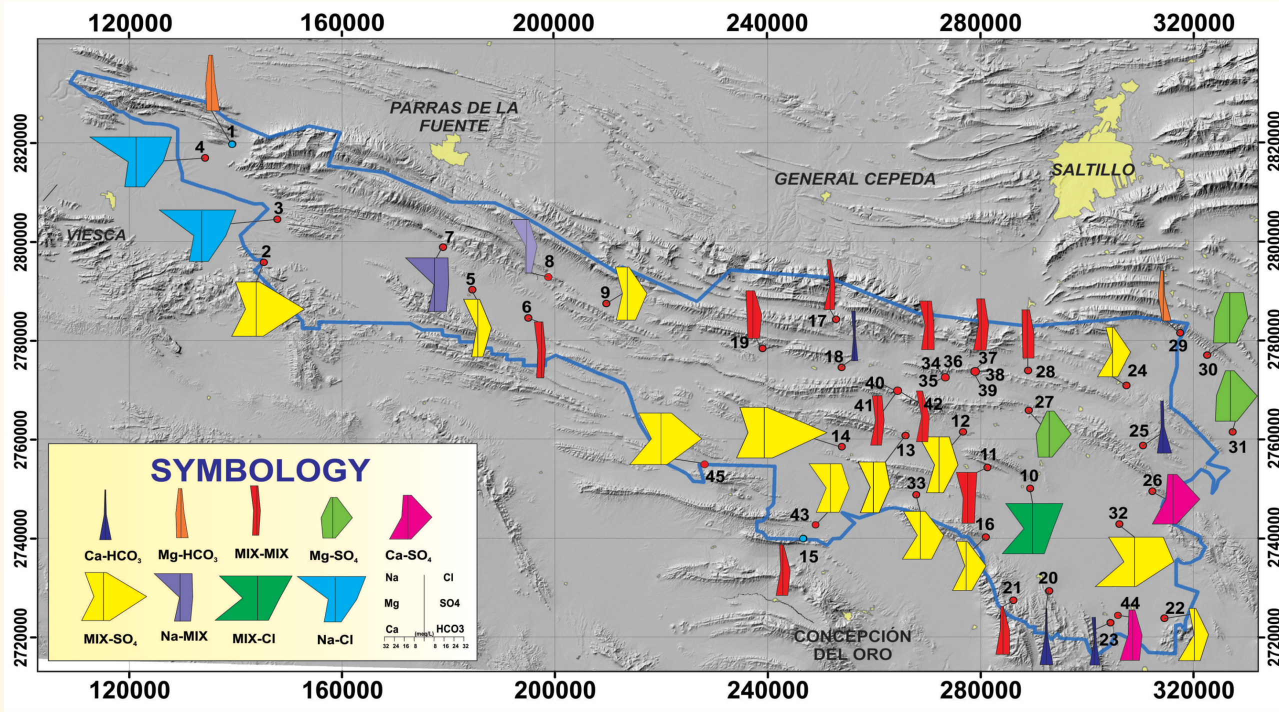

Fig 7. Distribution of Stiff diagrams for Saltillo Sur Aquifer.

Li vs B

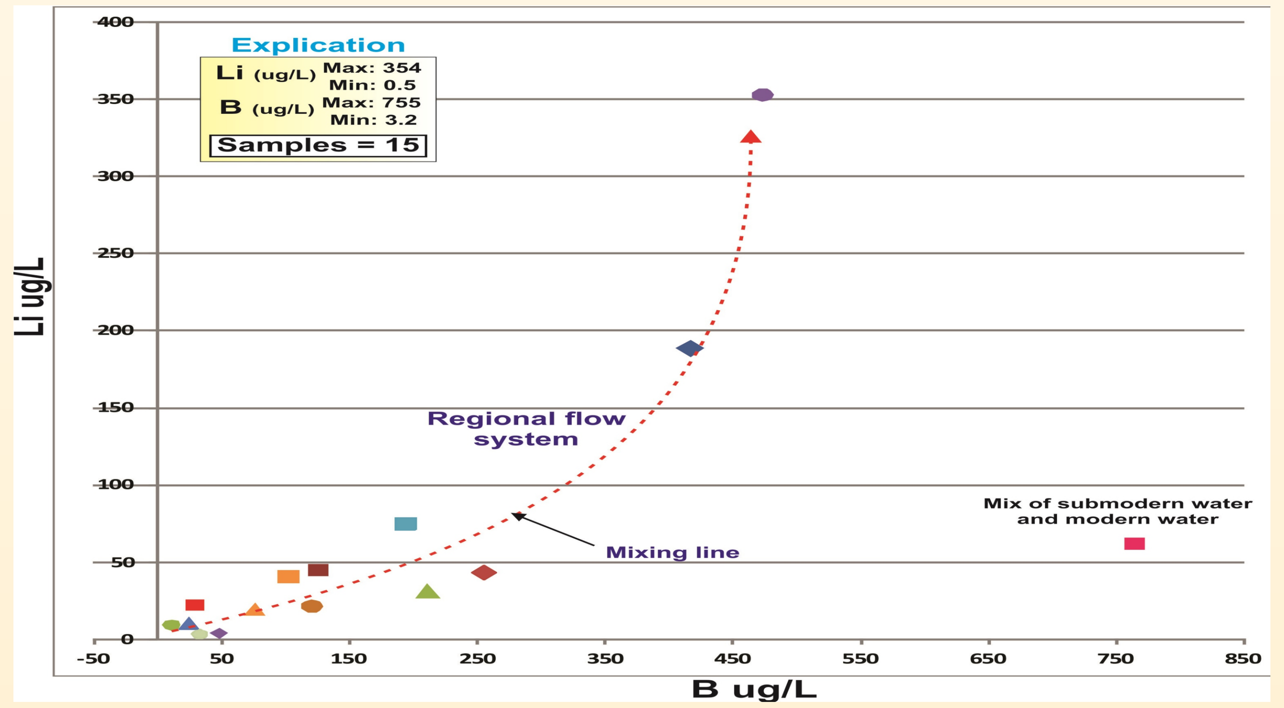

Fig 8. Li vs B concentration.

Isotopes $\delta^{18}O$ and $\delta^{2}H$

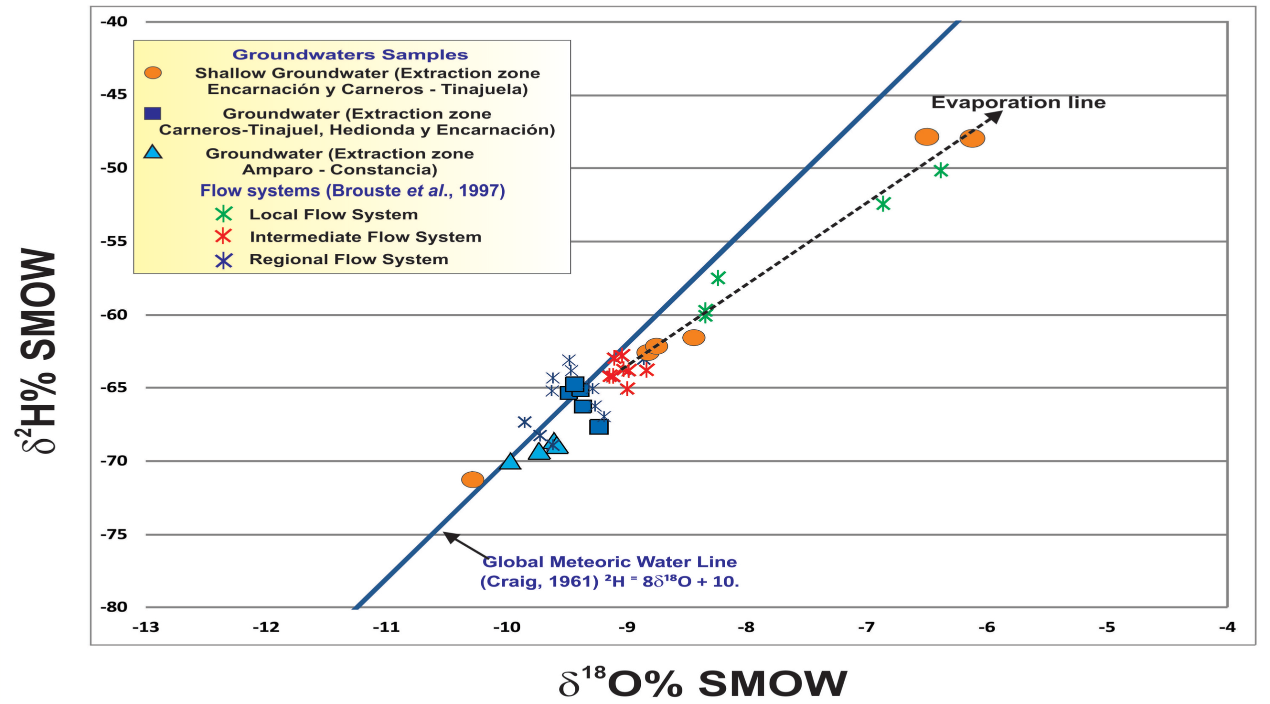

Fig 9. Concentration of $\delta^{18}O$ vs $\delta^{2}H$.

Isotopes $\delta^{34}S$

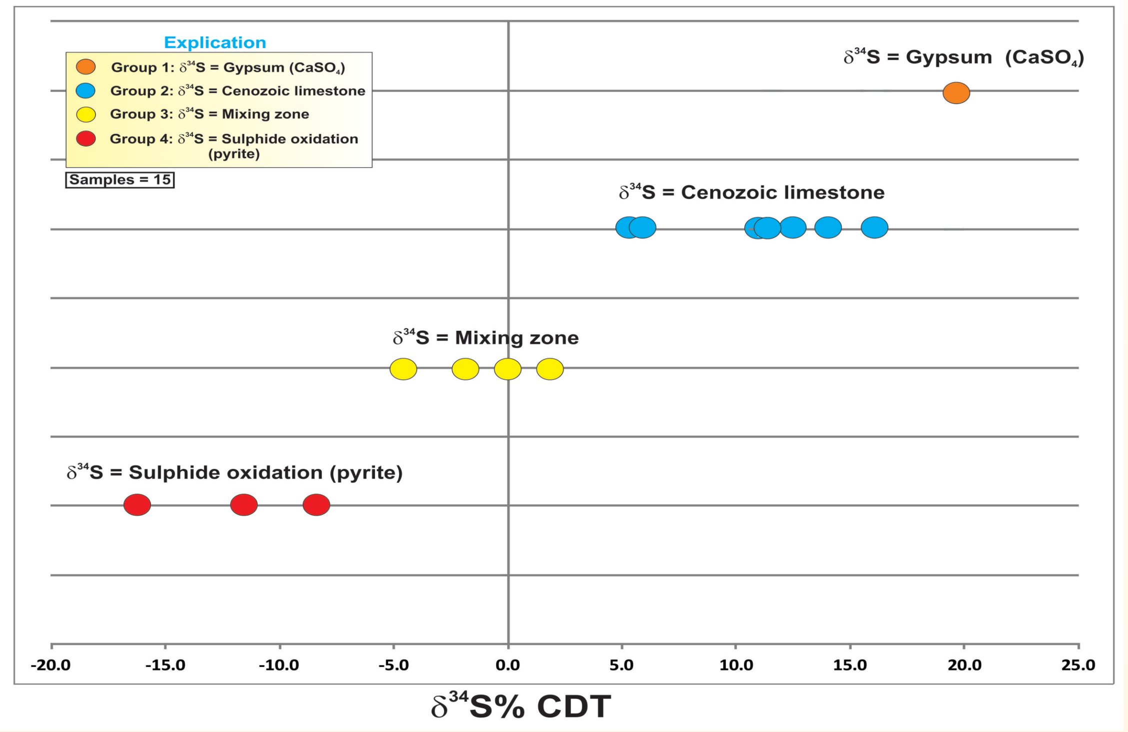

Fig 10. Results of the ^{34}S in wells of the Saltillo Sur Aquifer compared to the sulfur cycle.

$\delta^{13}C$ vs ^{14}C

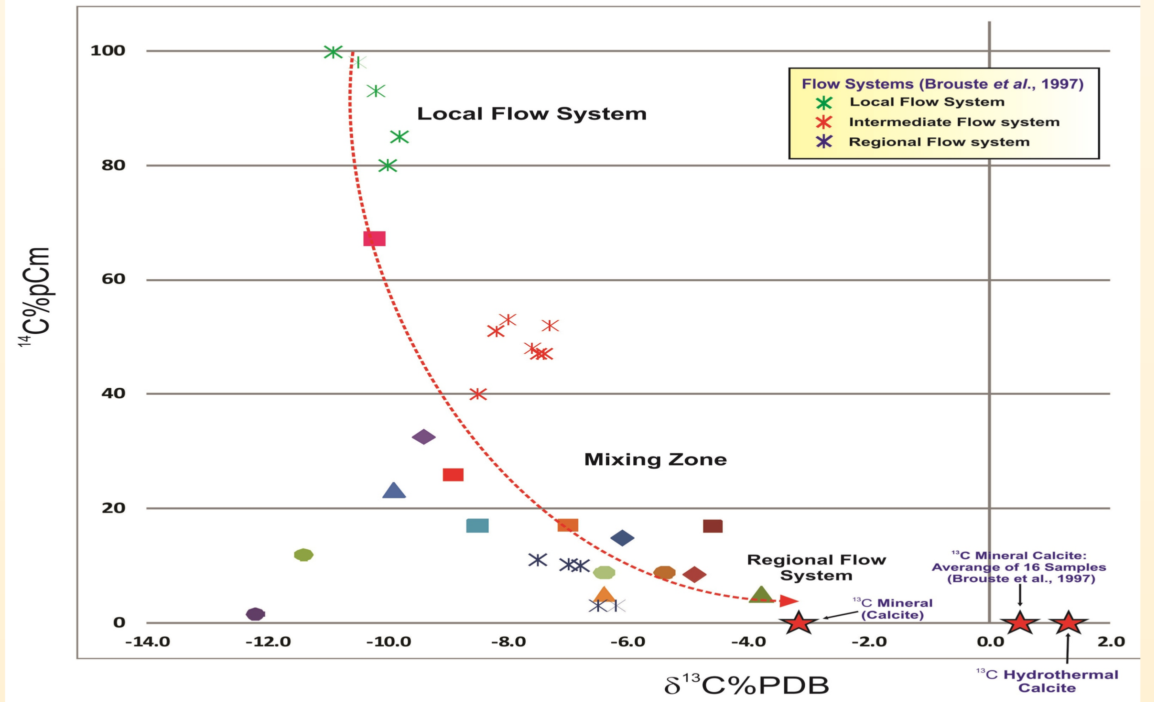

Fig 11. $\delta^{13}C$ VS ^{14}C concentration.

The $\delta^{13}C$ mixing model

The $\delta^{13}C$ mixing model allows the incorporation of active ^{14}C DIC during the dissolution of the carbonate under open system conditions and the subsequent dilution of ^{14}C under closed system conditions, whereby this correction method gives results with greater certainty (Clark, 2015).

$$q = \frac{\delta^{13}C_{DIC} - \delta^{13}C_{rock}}{\delta^{13}C_{rech} - \delta^{13}C_{rock}}$$

Where:

- $\delta^{13}C_{DIC}$ = Measured ^{13}C in groundwater.
- $\delta^{13}C_{recharge}$ = Measured ^{13}C in groundwater during recharge.
- $\delta^{13}C_{rock}$ = ^{13}C of the calcite being disolved.

Isotopes ^{3}H and ^{14}C

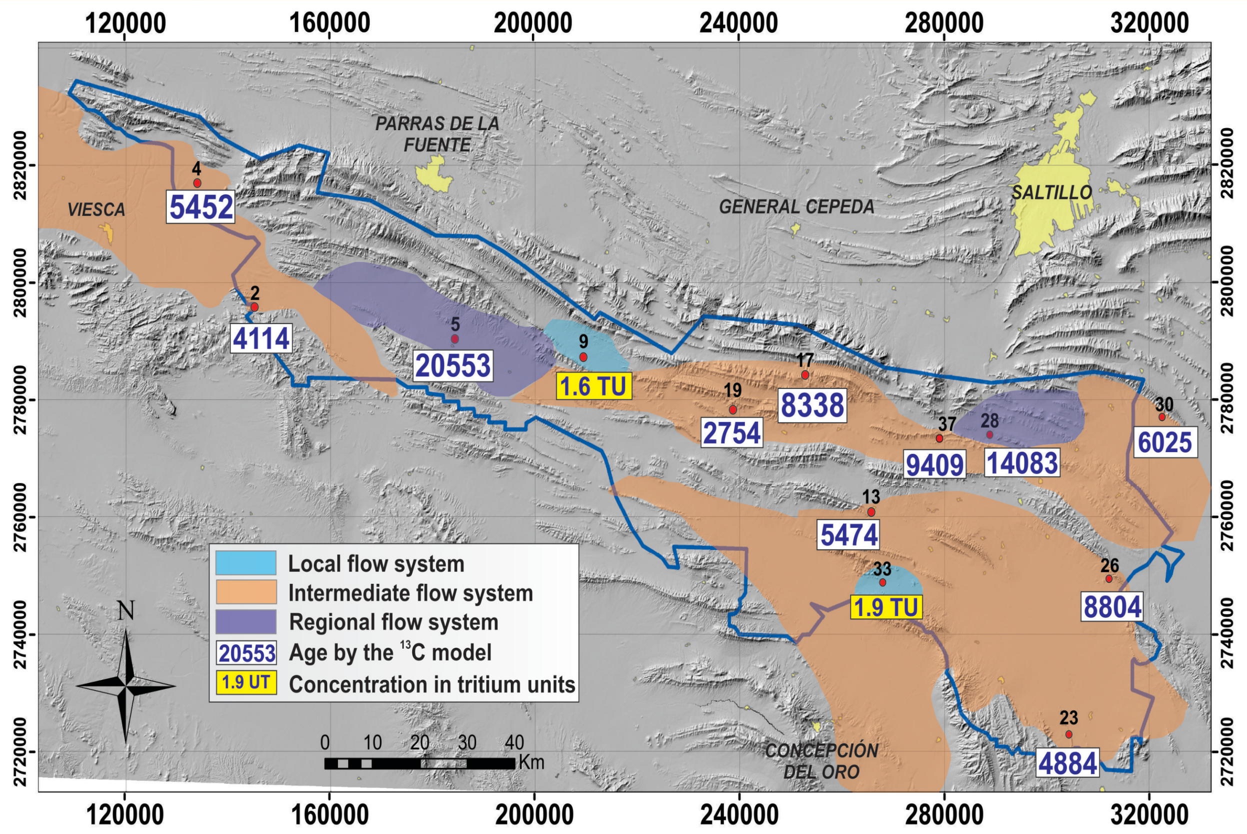

Fig 12. Geographic distribution of the groundwater ages calculated by the method of mixing ^{13}C in the wells of the Saltillo Sur Aquifer.

Conclusions

- Local flow systems, circulation depth is restricted to less than 150 m, HCO_3-Ca nature and 21.5 °C, high dispersion of ^{18}O and ^{2}H values reflecting different recharge elevation, measureable (1.6-1.9 TU) and high C-14 (67 pmC).
- The intermediate flow systems, have a circulation depth up to 200 m, the water types are HCO_3-Ca and HCO_3-Mg, with about 23 °C, have a wide deviation of ^{18}O and ^{2}H values, are tritium free (<0.5 TU), and a C-14 corrected age between 5,000-6,000 years BP. A second group of groundwater flow systems shows a longer travel path as indicated by a Mixed and Mg-SO_4water type, temperature of 26 °C, and a narrower range of ^{18}O and ^{2}H values, they are also tritium free; and a C-14 corrected age between 6,000-12,500 years BP.
- Deep wells (>200 m) in karstic conditions tapping regional groundwater flow systems, with water 28 °C, long and deep travel paths are confirmed by ^{18}O and ^{2}H values with a very small deviation and C-14 corrected age between 12,500-25,000 years BP.

Future work: Water level measurements for groundwater flow delineation, geophysical techniques and pumping tests for aquifer geometry and hydraulic properties.

Acknowledgments

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