Received: 9 May 2026 • **Accepted**: 11 Oct. 2026
Published online: 1 Nov. 2026 • **eISSN:** 2594-0694
DOI: https://doi.org/10.22201/igg.25940694e.2026.2.142

Terra Digitalis
Artículos con mapas
Vol. 10 **No.** 2 (2026) **Pages**: 1-7

terra digitalis
international journal of interactive maps

National Inventory of Thermal Springs in Mexico: An integrated geospatial database for scientific research and sustainable tourism☆

Inventario Nacional de Manantiales Termales en México: Una base de datos geoespacial integrada para la investigación científica y el turismo sostenible

Alejandra Selene Membrillo-Abad* [a], Joseph Tadeo Almazan-Valencia [b], Jerjes Rigoberto Pantoja-Irys [c], María Jesús Puy-Alquiza [d], Miguel Ángel Sánchez-Romero [e], Sebastian Ali Ortiz-Rosillo [e], Marcela Margarita Errasti-Orozco[e], Christian Santillanes-Gutiérrez [c], Aarón David González-Ortega[e], Raúl Pacheco-Ayala [e], Rosa María Prol-Ledesma [f]

[a] *Universidad Nacional Autónoma de México, Posgrado en Ingeniería, Ciudad de México, México*
[b] *Universidad Nacional Autónoma de México, Posgrado en Ciencias de la Tierra, Ciudad de México, México*
[c] *Corporación Ambiental de México S.A. de C.V. (CAM), Monterrey, Nuevo León, México*
[d] *Universidad de Guanajuato, Departamento de Ingeniería en Minas, Metalurgia y Geología, Guanajuato, México*
[e] *Universidad Nacional Autónoma de México, Facultad de Ingeniería, Ciudad de México, México*
[f] *Universidad Nacional Autónoma de México, Instituto de Geofísica, Ciudad de México, México*

Abstract

Thermal springs are expressions of geothermal systems. They can provide information about structural geology, tectonic activity, hydrothermal circulation, and water-rock interaction. In Mexico, some thermal areas have been studied for electricity generation, but there are many areas less documented, despite their importance for direct-use applications, research, and sustainable tourism. Nature-based tourism (NBT) can promote economic development and community wellbeing while supporting biodiversity conservation. NBT should be encouraged in thermal spring areas with limited economic activity.

This study presents a national geospatial database of 1,881 thermal spring records in Mexico, compiled from scientific literature, institutional reports, geothermal projects, historical records, and geospatial datasets. The database integrates spatial, physical and territorial variables, including location, temperature, pH, source, accessibility, population proximity, and tourism-related infrastructure. A relative thermal criterion based on mean annual temperature was applied to identify thermal springs. The inventory provides a national-scale tool for geothermal exploration, sustainable ecotourism, territorial planning, and conservation.

Keywords: thermal springs; geothermal resources; geospatial database; Mexico; nature-based tourism; GIS

Resumen

Los manantiales termales son expresiones superficiales de sistemas geotérmicos, y pueden proporcionar información sobre su geología estructural, actividad tectónica, circulación hidrotermal e interacción agua-roca. En México, algunas áreas termales han sido estudiadas para generación eléctrica, pero muchas otras se encuentran menos documentadas, a pesar de su importancia para los usos directos, la investigación y el turismo sostenible. El turismo basado en la naturaleza puede promover el desarrollo económico y el bienestar de las comunidades, al mismo tiempo que favorece la conservación de la biodiversidad. Este tipo de turismo debe promoverse en áreas de manantiales termales con actividad económica limitada. Este estudio presenta una base de datos geoespacial nacional con 1,881 registros de manantiales termales en México, compilados a partir de literatura científica, reportes institucionales, proyectos geotérmicos, registros históricos y datos geoespaciales. La base de datos incluye variables espaciales, físicas y territoriales como ubicación, temperatura, pH, fuente, accesibilidad, proximidad a poblaciones e infraestructura turística. Además, aplica un criterio térmico relativo basado en la temperatura media anual para identificar manantiales termales. El inventario constituye una herramienta nacional para la exploración geotérmica, la planeación territorial, la conservación y el ecoturismo sostenible.

Palabras clave: manantiales termales; recursos geotérmicos; base de datos geoespacial; México; turismo basado en la naturaleza; SIG

1. Introduction

Thermal springs are surface expressions of groundwater flow and geothermal systems. They occur when groundwater reaches the surface through geological structures such as faults, fractures, lithological contacts, or permeable zones. These conduits facilitate the ascent of geothermally heated fluids, often enriched with dissolved minerals. These hydrothermal manifestations provide insights into subsurface heat flow, tectonic activity, magmatic processes, hydrothermal circulation, and water-rock interaction. In some cases, fluids precipitate minerals at the surface and generate distinctive deposits that provide geochemical evidence of subsurface conditions (Waring et al., 1965). For this reason, they can be considered natural probes of the Earth's geodynamic activity and accessible indicators of geothermal direct use (Waring et al., 1965; Pentecost et al., 2003; Tamburello et al., 2022).

For centuries, these systems have been part of human life. They have been used for bathing, health activities, cultural practices, and local economic activities. Currently, they also represent a key resource for sustainable development. Natural hot and mineral springs are relevant for health, wellness, and recreational tourism, and they are frequently linked to cultural heritage and local identity (Erfurt, 2011).

In the context of the global energy transition, geothermal energy is gaining importance because of its minimal or null CO_2 emissions. Unlike other renewable sources, geothermal energy can be a reliable base-load energy source.

Mexico has several geothermal fields under exploitation (Castillo-Reyes et al., 2024), as well as significant geothermal potential (Palacios et al., 2024; Prol-Ledesma, 2025). Thermal springs are the most evident and accessible surface expressions of subsurface reservoirs, especially in areas where deep wells, geophysical surveys, or detailed geothermal studies are not available.

Thermal springs have a strong social and economic impact. Many thermal springs in the world are used for recreation and tourism (Medai et al., 2022; Ding, 2024). They attract visitors, support local economies, and preserve cultural heritage. This creates a direct link between geoscience and sustainable tourism. Some springs are associated with developed spas, recreational facilities, or nearby services, while others remain in rural or remote areas where nature-based tourism and conservation may be more appropriate.

Despite their importance, thermal spring data are often scattered. Information is stored in reports, scientific papers, academic theses, local records, government documents, and previous research projects. Many sources are difficult to access, are not georeferenced, or lack standardized attributes. In Mexico, there are several important reports and studies, but they are often regional, thematic, or focused on high-temperature geothermal fields. There is no published unified national database integrating scientific data with territorial and tourism variables.

That gap limits both research and application. It restricts geothermal exploration, reduces opportunities for sustainable tourism, and limits territorial planning. It also makes it difficult to identify accessible sites, remote areas, potential ecotourism resources, and springs that may require environmental protection or field verification.

This study addresses this limitation by presenting a national inventory of thermal springs in Mexico. The database integrates scientific, spatial, hydrogeochemical, and territorial variables. It provides a tool for research, energy assessment, ecotourism planning, conservation, and sustainable development. Thermal springs are not only geological features, but also strategic resources that connect Earth processes, human use, local economies, cultural value, and future energy systems.

The aim of this research is to disseminate the existing data on the georeferenced database of thermal springs in Mexico, facilitating a more robust understanding of their geotectonic controls and their potential for scientific research, geothermal assessment, and sustainable economic development.

1.1. State of the art

Early compilations such as Waring et al. (1965) provided one of the first global inventories of thermal springs. These studies organized dispersed information and defined key variables such as location, temperature, flow rate, chemical composition, associated rocks, and references. They demonstrated the importance of compiling scattered information into structured datasets, even when many locations were originally presented in analog maps without numerical coordinates.

Recent work has digitized historical datasets. Tamburello et al. (2022) georeferenced approximately 6,000 geothermal spring areas from the original work of Waring et al. (1965) and analyzed their relationship with global geological and environmental factors. Their results showed that thermal springs are strongly influenced by terrestrial heat flow, topography, volcanism, and extensional tectonics.

Regional studies have also contributed important information. Digital geological maps have integrated thermal spring data with geological units and tectonic structures, supporting the interpretation of geothermal potential in regions such as the southeastern Sierra Madre Occidental (Ferrari et al., 2018). Hydrogeological studies have shown that groundwater exploitation can reduce spring flow and affect associated ecosystems, highlighting the need to consider conservation and water management in spring inventories (Orozco-Uribe et al., 2021).

Relevant projects and sources for Mexico include CeMIE-Geo files, SENER geothermal programs, geothermal exploration DGAPA-UNAM projects, CONAGUA and CFE records, academic theses, technical reports, and scientific publications (e.g., Torres-Rodríguez et al., 1993; Martínez-Estrella et al., 2005; Torres et al., 2005). However, all of the data are dispersed and with only limited connection between scientific variables, territorial context, accessibility, and tourism infrastructure.

☆This is an Open Access article distributed under the terms of a Creative Commons Attribution License

**E-mail address:* alejandra@igeofisica.unam.mx

Thermal spring databases are vital tools for geothermal research, sustainable development, and the identification of geothermal potential in regions like Mexico. They facilitate classification, spatial analysis, and applications in tourism, energy planning, and territorial decision-making (Martínez-Estrella et al., 2005; Torres et al., 2005; Flores-Espino et al., 2017).

1.2. Objective

The objective of this study is to develop a national geospatial database of thermal springs in Mexico to support spring identification, geothermal potential, Nature-based tourism (NBT) opportunities, and territorial planning.

The specific objectives are to compile and digitize historical and recent data, standardize key variables such as geographic location, temperature, pH, source, and tourism-related attributes, apply a relative thermal criterion based on mean annual temperature, integrate the database into a GIS environment, evaluate ecotourism potential, classify the territorial context of spring locations, and provide general geochemical characteristics such as pH and temperature.

2. Data and methods

2.1. Data sources

As mentioned before, data were obtained from scientific literature, publicly available CeMIE-Geo reports, SENER datasets, academic theses, technical reports, historical records from technical reports from CONAGUA and CFE, open access databases, and geospatial datasets from INEGI.

DENUE (*Directorio Estadístico Nacional de Unidades Económicas*) database from INEGI (Instituto Nacional de Estadística y Geografía, 2025) was used to identify economic units related to tourism, recreation, services, and local infrastructure, like private fitness centers, private water parks and spas, public fitness centers, private sports clubs, caves, natural parks and other national cultural heritage sites, public water parks and spas, professional sports teams, private botanical gardens and zoos, and golf courses. Population and territorial layers were used to evaluate the spatial context of each spring.

The complete database used in this study is included as a Supplementary Information file. This table contains the compiled thermal spring records used for the national map and spatial analysis, as well as the source and references for each record.

2.2. Data recovery and digitization

As part of the PAPIIT research projects, one of the academic activities was the compilation and recovery of reliable, previously published information. The student co-authors participated in this activity, including the recovery of thermal spring databases used as input data for geothermal Play Fairway Analysis, and extracted the available metadata (geographic location, surface temperature, pH, reference, locality name, and relevant geological or hydrogeochemical parameters).

Some data were digitized from printed maps, analog materials, or non-georeferenced documents. These records were converted into digital spatial information using GIS tools such as ArcGIS, QGIS and Excel. When coordinates were missing or inconsistent, locations were reviewed using the original source, locality names, geographic references, and expert validation.

All information was standardized and integrated into a GIS database. The coordinate systems, temperature units, pH values, source names, state and municipality names, locality names, and attribute fields were reviewed and standardized. Duplicate records were reviewed using spatial proximity, name similarity, source information, and expert input.

2.3. Variables

The compiled database includes variables critical for both scientific analysis and tourism assessment (source, author, data origin, tourist use, territorial context), as well as qualitative indicators related to infrastructure, accessibility, and potential for recreational or therapeutic use, allowing a more complete evaluation of the NBT potential of each spring (Table 1).

Table 1: Main variables included in the thermal springs database of Mexico. / Tabla 1: Variables principales incluidas en la base de datos de manantiales termales de México.

Variable	Type	Use
Geographic coordinates	Spatial	GIS analysis and mapping
State	Categorical	Administrative classification
Municipality	Categorical	Administrative classification
Locality or site name	Categorical	Site identification
Temperature	Continuous	Thermal classification
pH	Continuous	Basic hydrogeochemical analysis
Source/author	Categorical	Traceability
Tourism use	Categorical	NBT assessment
Population proximity	Spatial	Territorial classification
DENUE economic units	Spatial/ categorical	Tourism and service context

The availability of each variable depends on the information reported in the original source; therefore, complete information is not available for all records. The variables with the most

consistent coverage are location, temperature, pH, and source reference.

2.4. Thermal spring definition

A spring was considered thermal when its water temperature was more than 5 °C higher than the mean annual air temperature of its location:

$$T_{\text{spring}} > T_{\text{mean annual}} + 5\ ^{\circ}\text{C} \quad (1)$$

where T_{spring} is the spring temperature and $T_{\text{mean annual}}$ is the mean annual temperature at the spring location (White, 1957; Prol-Ledesma, 1988; Luijendijk et al., 2020).

Mean annual temperature was obtained from CONABIO (Cuervo-Robayo et al., 2015).

This relative criterion allows comparison between different climatic regions. It avoids the limitations of using a fixed temperature threshold, because a spring that is anomalously warm in a cold mountain region may have a lower absolute temperature than a spring in a tropical region. This approach improves the identification of geothermal anomalies across diverse environments and supports national-scale comparison.

2.5. Workflow for the construction of the thermal spring database

The construction of the thermal spring database followed a structured workflow comprising data collection, data recovery, digitization, standardization, validation, thermal classification, spatial analysis, territorial classification, integration with economic data, mapping, pattern analysis, and interpretation (Figure 1).

Analog materials were digitized and georeferenced using GIS tools such as QGIS. Units and formats were standardized. Records were validated for consistency, duplicates, and location accuracy with expert input. Thermal classification was performed using the temperature criterion. The database was integrated with spatial layers including geology, DEM, population data, and economic units. Territorial classification was performed using distance buffers. The final dataset was mapped and interpreted in relation to geology, geothermal potential, tourism, and territorial planning.

2.6. Territorial classification

Spatial classification was based on distance to populated areas. This approach provides a first approximation of accessibility and territorial context (Table 2).

Table 2: Territorial classification based on distance to populated areas. / Tabla 2: Clasificación territorial basada en la distancia a las áreas pobladas.

Distance	Class
0–5 km	Urban
5–20 km	Rural
>20 km	Remote

Urban class may be associated with developed tourism, existing infrastructure, recreational facilities, or direct-use opportunities. Rural and remote springs may be associated with NBT or conservation value. However, this classification should be interpreted as a planning tool, because field verification is required to evaluate access conditions, land tenure, environmental sensitivity, safety, and current use.

2.7. GIS integration

All data were integrated into a GIS environment. The spatial layers include spring locations, temperature, population proximity and DENUE economic units. Spatial querying through PostgreSQL tools can be performed in the following platform: `https://cam-mx.maps.arcgis.com/apps/dashboards/1cdca73ab90047109caca4a92d8ca8f1`

The GIS integration allows the visualization of national and regional patterns, the identification of clusters, the evaluation of accessibility, and the comparison between spring locations and geological or territorial variables.

3. Results

A total of 1,881 thermal spring records were mapped across Mexico. All of them meet the thermal criterion defined in Equation (1), that is, their water temperature is more than 5 °C higher than the mean annual temperature at their location. The initial compilation included more than 2,000 manifestations reported as thermal, some of which did not meet this criterion; one of the aims of this work was to clean and standardize this information in order to identify the records that actually satisfy the thermal condition. These records form the spatial basis of the national inventory.

The main distribution is associated with the Trans-Mexican Volcanic Belt, where high relief, volcanic activity and faults/fractures allow groundwater circulation, and with the extensional area of the Gulf of California. Thermal springs show strong relations with volcanic, relief and tectonic features, correlating to major geological structures (Plate 1).

Plate 1 shows the national distribution of 1,881 thermal spring records compiled in the geospatial database, which is included as Supplementary material in an Excel file. This file contains the compiled thermal spring records used for the national map and for the spatial analysis presented in this work. The table includes the available attributes for each record, including location, temperature, pH, source information, and additional variables when available. As shown in Plate 1, several thermal springs are not associated with active volcanism in Northeastern Mexico. Instead, they may be linked to deep circulation systems, crustal heat sources, regional structures, or fault-controlled groundwater flow. These findings suggest the possible presence of unconventional or non-volcanic geothermal systems of low temperature.

The distribution of springs provides a first-order spatial guide for identifying areas where additional geological, geophysical, and hydrogeochemical studies may be useful.

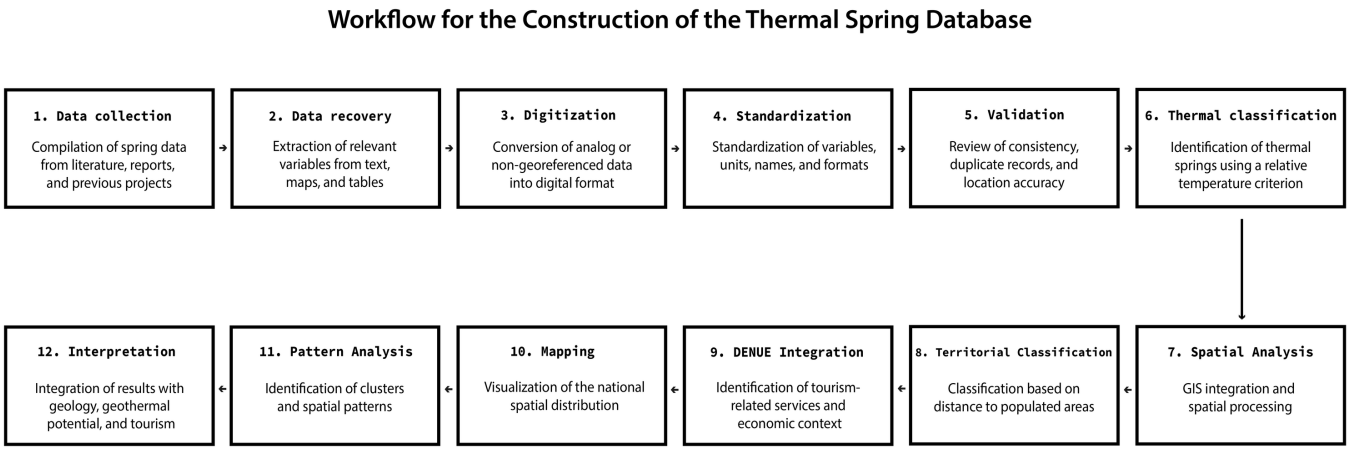


Figure 1: Workflow for the construction of the thermal spring database. / Figura 1: Flujo de trabajo para la construcción de la base de datos de manantiales termales.

The integration with population and economic data shows that many springs are located near populated areas, recreational activities, or service infrastructure. These sites have high accessibility and potential for developed tourism and direct-use applications. Developed tourism refers to springs located near cities, spas, recreational facilities, hotels, restaurants, sports centers, or other services. These sites may be suitable for sustainable tourism strategies if water quality, environmental conditions, and local management are properly evaluated. NBT mostly involves travelling to natural areas like springs located in unpopulated areas. These sites may attract visitors seeking natural landscapes and less developed environments. However, remote springs may also have higher conservation value or environmental sensitivity. Their use should be evaluated carefully through field verification, community consultation, and environmental criteria.

The territorial classification shows that a significant number of springs are located in urban and peri-urban contexts. These areas may have potential for tourism, education, monitoring, and direct-use applications. Other springs are in rural or remote areas that may be important for conservation, hydrogeological studies, or future geothermal exploration despite their difficult access. The integration with DENUE economic units provides a preliminary evaluation of the relationship between spring locations and tourism-related infrastructure.

4. Conclusion

The results confirm the importance of integrating dispersed information into a unified geospatial database. Thermal spring data in Mexico have historically been scattered across several diverse sources. By organizing this information into a single database, the inventory preserves and shares information collected through years of research. The integration of basic variables, especially temperature and pH, is an added value to the database.

From a tourism perspective, the database provides information that can support sustainable tourism planning, since thermal springs have recreational, cultural, therapeutic, and economic values. However, their use requires responsible management. Springs located near populated areas may be more accessible and suitable for developing tourism, whereas rural and remote springs may require conservation rules, environmental monitoring, and local community participation. Distinction between developed tourism and nature-based tourism is useful for planning. Urban springs may be used for recreation, local businesses, and educational activities while rural and remote springs may support NBT, environmental education, and conservation.

The inventory contributes to preserving and sharing information collected through years of research. It transforms dispersed data into an accessible geospatial resource and provides a foundation for future studies on geothermal potential, conservation, NBT, and regional planning. This work shows that thermal springs are not only natural features. They are strategic resources that connect scientific knowledge with economic and social applications. They also link Earth processes, groundwater flow, cultural practices, local economies, and future energy systems.

Software and data

The database and map were prepared using ArcGIS, ArcMap, QGIS, Microsoft Excel, and PostgreSQL. These tools were used for data cleaning, spatial processing, map design, and database organization. The database is provided as supplementary material in Excel and shapefile formats. The shapefile contains point geometry in Geographic Coordinate System WGS 1984, datum WGS84, spheroid WGS84, EPSG:4326.

The database includes location, coordinates, temperature, pH, source information, population proximity, and tourism-related attributes. Empty fields indicate unavailable

or unverified information, and positional accuracy may vary according to the original source.

Map design

The main map shows the national distribution of thermal springs in Mexico. The springs are represented with blue points, and state boundaries are included as geographic reference. This simple design was selected to show the spatial pattern clearly and to avoid visual saturation.

The coordinate system is Geographic Coordinate System WGS 1984, datum WGS84, spheroid WGS84. The map was prepared in ArcMap. Because the database was compiled from different sources, the positional accuracy may vary among records. For this reason, the map should be used as a national-scale inventory and visualization tool. Field verification is recommended for detailed local studies.

Acknowledgments

The authors thank the Programa de Apoyo a Proyectos de Investigación e Innovación Tecnológica (PAPIIT), DGAPA-UNAM, for the support provided through projects IN107223, *"Implementación del análisis de Play Fairway para la identificación de zonas geotérmicas en las provincias de vulcanismo intraplaca,"* and IN106726, *"Mapa de generación de calor por elementos radioactivos para la evaluación regional de recursos geotérmicos."* These projects supported the research activities and the participation of students in the compilation and analysis of the information used in this study.

References

Castillo-Reyes, O., Prol-Ledesma, R. M., Corbo-Camargo, F., and Rojas, O. (2024). Geothermal resources in Latin America and their exploration using electromagnetic methods. *Geothermal Energy*, 12(1):34. https://doi.org/10.1186/s40517-024-00314-5.

Cuervo-Robayo, A. P., Téllez-Valdés, O., Gómez-Albores, M. A., Venegas-Barrera, C. S., Manjarrez, J., and Martínez-Meyer, E. (2015). *Temperatura media anual en México (1910–2009), escala 1:1000000*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México.

Ding, L. (2024). Tourist choice of sustainable hot springs tourism under post-COVID-19 pandemic period: A case in Colorado. *International Journal of Tourism Research*, 26(1):e2619. https://doi.org/10.1002/jtr.2619.

Erfurt, P. J. (2011). *An assessment of the role of natural hot and mineral springs in health, wellness and recreational tourism*. PhD thesis, James Cook University.

Ferrari, L., Castillo-Reynoso, J. C., Orozco-Esquivel, T., and Silva-Fragoso, A. (2018). Digital geologic map and geochronologic, geochemical and geothermal database of the south-eastern part of the Sierra Madre Occidental, Mexico. *Terra Digitalis*, 2(2):1–6. https://doi.org/10.22201/igg.25940694.2018.2.53.

Flores-Espino, F., Booth, S., and Graves, A. (2017). Mexico's geothermal market assessment report. Technical report, National Renewable Energy Laboratory, Golden, CO. https://doi.org/10.2172/1349719.

Instituto Nacional de Estadística y Geografía (2025). Directorio estadístico nacional de unidades económicas. INEGI, México.

Luijendijk, E., Winter, T., Köhler, S., Ferguson, G., von Hagke, C., and Scibek, J. (2020). Using thermal springs to quantify deep groundwater flow and its thermal footprint in the Alps and a comparison with North American orogens. *Geophysical Research Letters*, 47(22):e2020GL090134. https://doi.org/10.1029/2020GL090134.

Martínez-Estrella, J. I., Torres, R. J., and Iglesias, E. R. (2005). A GIS-based information system for moderate- to low-temperature Mexican geothermal resources. In *Proceedings World Geothermal Congress 2005*, Antalya, Turkey. 24–29 April 2005, paper 1725, 8 pp.

Medai, N., Okamoto, N., Ogasawara, Y., and Hihara, K. (2022). Factors contributing to tourism demand at major Japanese hot springs. *PLOS ONE*, 17(9):e0274681. https://doi.org/10.1371/journal.pone.0274681.

Orozco-Uribe, L. C., Ortega-Guerrero, M. A., Cantoral-Uriza, E. A., Domínguez-Cortázar, M. Á., and Rodríguez-Gutiérrez, E. (2021). Cambio de las manifestaciones de agua subterránea y características de los ecosistemas asociados en el semiárido mexicano. *Hidrobiológica*, 31(1):1–15. https://doi.org/10.24275/uam/izt/dcbs/hidro/2021v31n1/Orozco.

Palacios, A., Koon-Koon, R., Miranda-Flores, G., Lewis, S., Castro-Olivera, P. M., Cordova-Lizama, A., and Hernandez-Garcia, A. I. (2024). A Monte Carlo-based approach for the evaluation of Mexico's geothermal potential. *Renewable Energy*, 223:120006. https://doi.org/10.1016/j.renene.2024.120006.

Pentecost, A., Jones, B., and Renaut, R. W. (2003). What is a hot spring? *Canadian Journal of Earth Sciences*, 40(11):1443–1446. https://doi.org/10.1139/e03-083.

Prol-Ledesma, R. M. (1988). *El calor de la Tierra*. Fondo de Cultura Económica, México.

Prol-Ledesma, R. M. (2025). Past, present and future of geothermal energy in Mexico. In *3rd EAGE Workshop on Geothermal Energy in Latin America*, pages 1–5. EAGE Publications BV. https://doi.org/10.3997/2214-4609.202586013.

Tamburello, G., Chiodini, G., Ciotoli, G., Procesi, M., Rouwet, D., Sandri, L., Carbonara, N., and Masciantonio, C. (2022). Global thermal spring distribution and relationship to endogenous and exogenous factors. *Nature Communications*, 13(1):6378. https://doi.org/10.1038/s41467-022-34115-w.

Torres, R. J., Martínez-Estrella, J. I., and Iglesias, E. R. (2005). Database of Mexican medium- to low-temperature geothermal resources. In *Proceedings World Geothermal Congress 2005*, Antalya, Turkey. 24–29 April 2005.

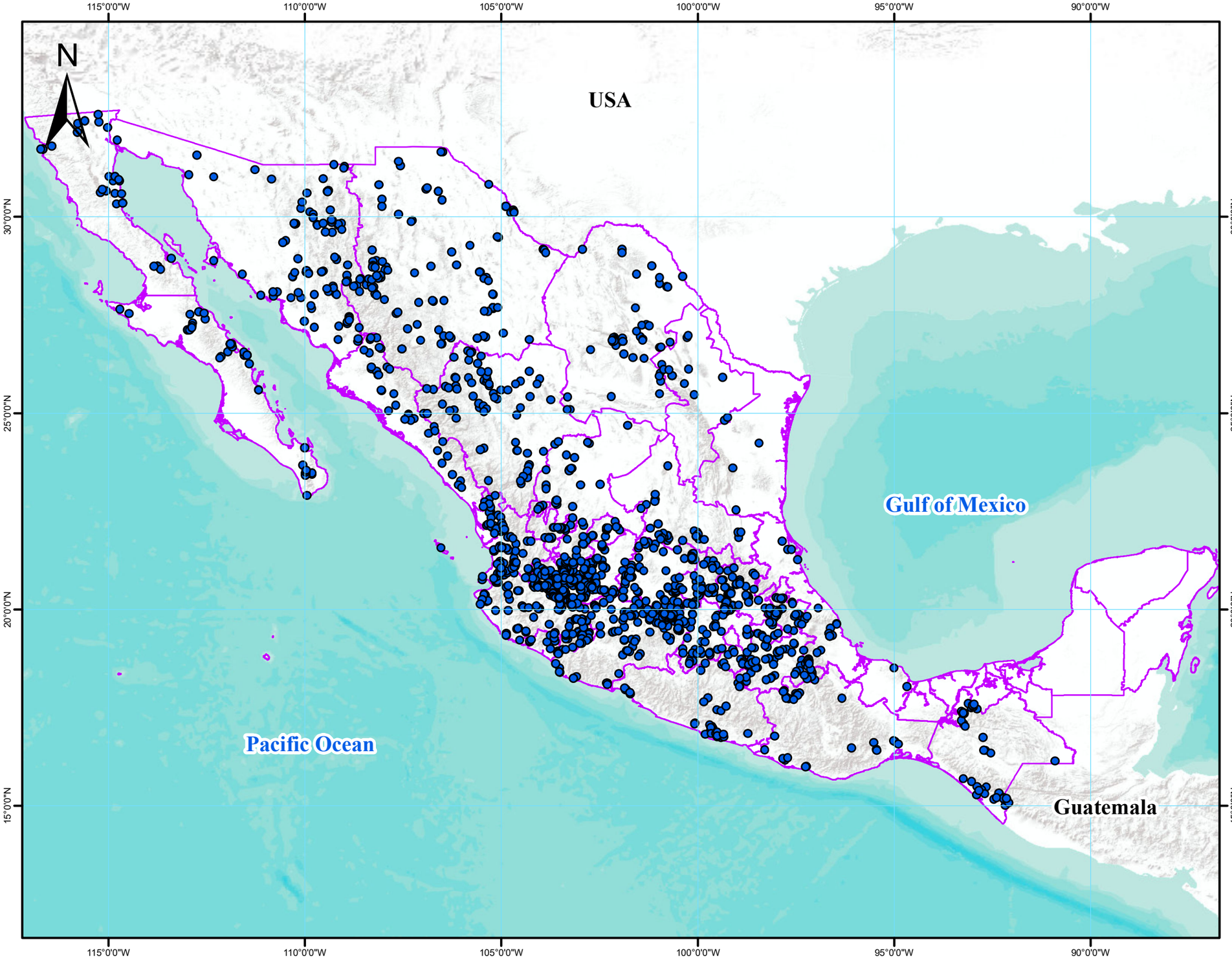
Torres-Rodríguez, V., Venegas-Salgado, S., Herrera-Franco, J. J., and González-Partida, E. (1993). Manifestaciones termales de la República Mexicana. In Torres-Rodríguez, V., editor, *Geotermia en México*, pages 31–78. Programa Universitario de Energía, Universidad Nacional Autónoma de México, México.

Waring, G. A., Blankenship, R. R., and Bentall, R. (1965). Thermal springs of the United States and other countries of the world; a summary. Professional Paper 492, U.S. Geological Survey, Washington, DC. 383 pp. https://doi.org/10.3133/pp492.

White, D. E. (1957). Thermal waters of volcanic origin. *Bulletin of the Geological Society of America*, 68(12):1637–1658. https://doi.org/10.1130/0016-7606(1957)68[1637:TWOVO]2.0.CO;2.

This article describes the following material:

Interactive map: 10.22201/igg.25940694e.2026.2.142.272
Supplementary material: 10.22201/igg.25940694e.2026.2.142.278



National Inventory of Thermal Springs in Mexico: An integrated geospatial database for scientific research and sustainable tourism

Inventario Nacional de Manantiales Termales en México: Una base de datos geoespacial integrada para la investigación científica y el turismo sostenible

Membrillo-Abad, A.S.(a), Almazan-Valencia, J.T.(b), Pantoja-Irys, J.R.(c), Puy-Alquiza, M.J.(d), Sánchez-Romero, M.A.(e), Ortiz-Rosillo, S.A.(e), Errasti-Orozco, M.M.(e), Santillanes-Gutiérrez, C.(c), González-Ortega, A.D.(e), Pacheco-Ayala, R.(e), Prol-Ledesma, R.M (f).

(a)UNAM, Posgrado en Ingeniería, CDMX, México
(b)UNAM, Posgrado en Ciencias de la Tierra, CDMX, México
(c)CAM S.A. de C.V., Monterrey, Nuevo León, México
(d)UG, Departamento de Ingeniería en Minas, Metalurgia y Geología, Guanajuato, México
(e)UNAM, Facultad de Ingeniería, CDMX, México
(f)UNAM, Instituto de Geofísica, CDMX, México

Data source: Springs database compiled by the authors
GIS processing: ArcMap

Positional accuracy (x,y): Variable according to the original source
Vertical accuracy: Not applicable

Coordinate System:
Geographic Coordinate System (GCS)
Datum: WGS84
Spheroid: WGS84

Symbology

- Spring (point feature) / Manantial (elemento puntual) (1,881)
- State boundary / Límite estatal

terra digitalis
international journal of interactive maps

Scale: 1:12,600,000

0 100 200 400 600 800 km