Geothermal Play Fairway Analysis in the Central Intraplate Volcanism Province, center of Mexico

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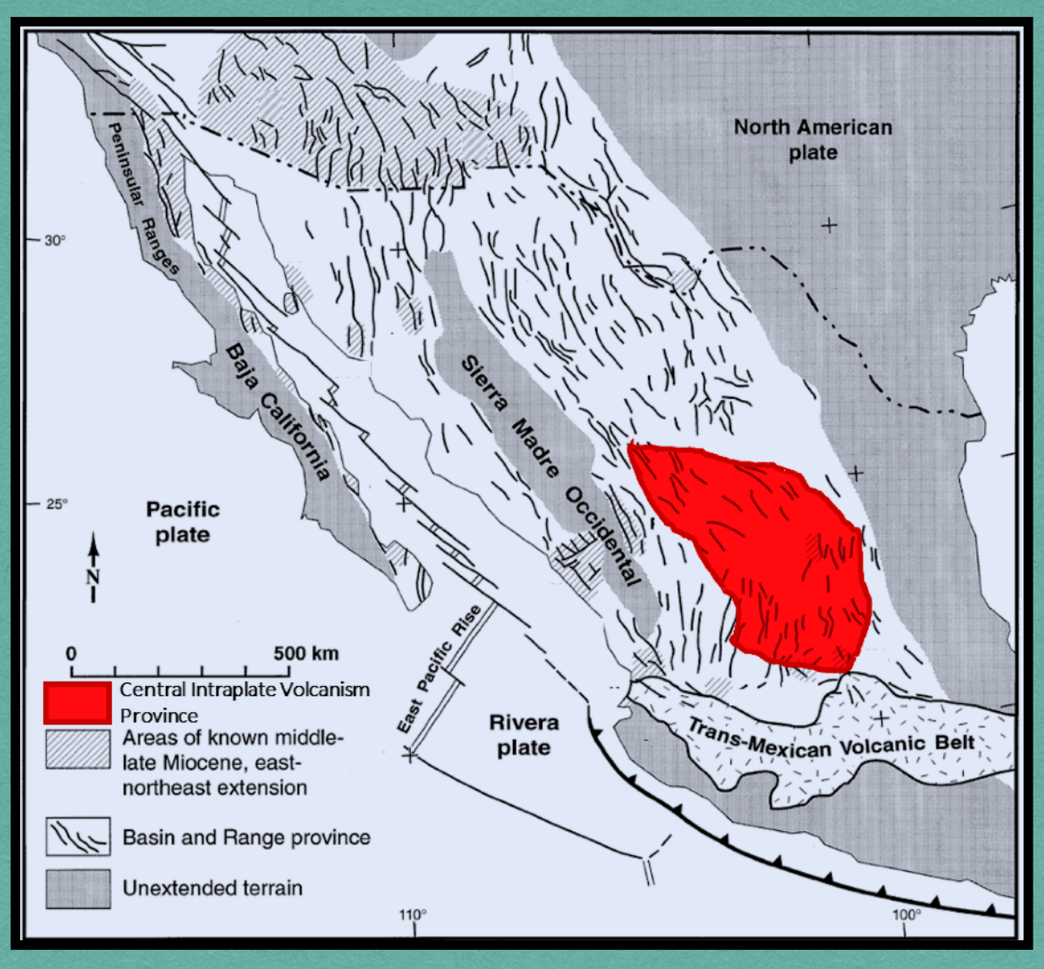
Central Intraplate Volcanism Province

The Central Intraplate Volcanism Province (CIVP) is characterized by recent intra-plate volcanism (Late Oligocene-Quaternary), sometimes aligned with regional normal faults. It is located in the southern part of the Basin and Range province, which is the result of extensional tectonics associated to the Farallon Plate ceased subduction under North America Plate (Aranda-Gómez et al., 2000).



CIVP defined by Prol-Ledesma and Morán-Zenteno (2019). Modified from Henry and Aranda-Gómez (2000)

Play Fairway Analysis

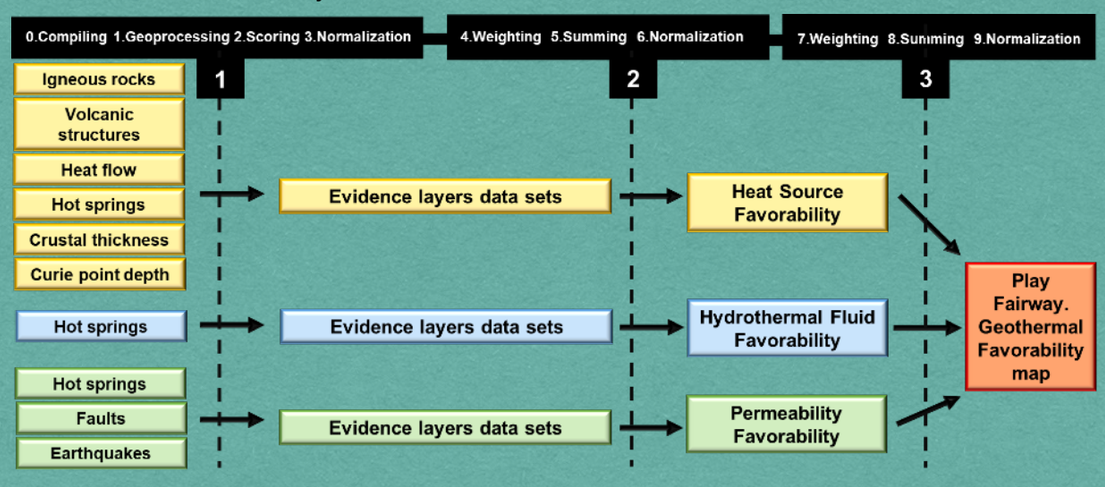
The Play Fairway Analysis (PFA) comes from the Oil & Gas industry and is considered a flexible, scalable, and effective method for the integration of multiple datasets considering their relative importance to the occurrence of a certain geothermal play type (Lindsey et al., 2021).

	Volcanic field type	Plutonic type	Extensional domain type
2	*Java-Kamojang*	*Larderello*	*Bradys (Basin and Range)*
3	Magmatic arcs Mid oceanic ridges Hot spots	Young orogens Post-orogenic phase	Metamorphic core complexes Back-arc extension Pull-apart basins Intracontinental rifts
	Magma chamber, intrusion	Young intrusion+extension	Thinned crust → elevated heatflow
4	Active magmatism (volcanism)	Recent plutonism	Active extensional domain
5	Convection dominated systems		
6	+	Fault controlled Magmatic	+

Convection dominated geothermal play systems. 1.Play type, 2.Typus locality, 3.Plate tectonic setting, 4.Geologic habitate of potential geothermal reservoirs, 5.Heat transfer type, 6.Geologic controls. From Moeck, 2014

Work Flow

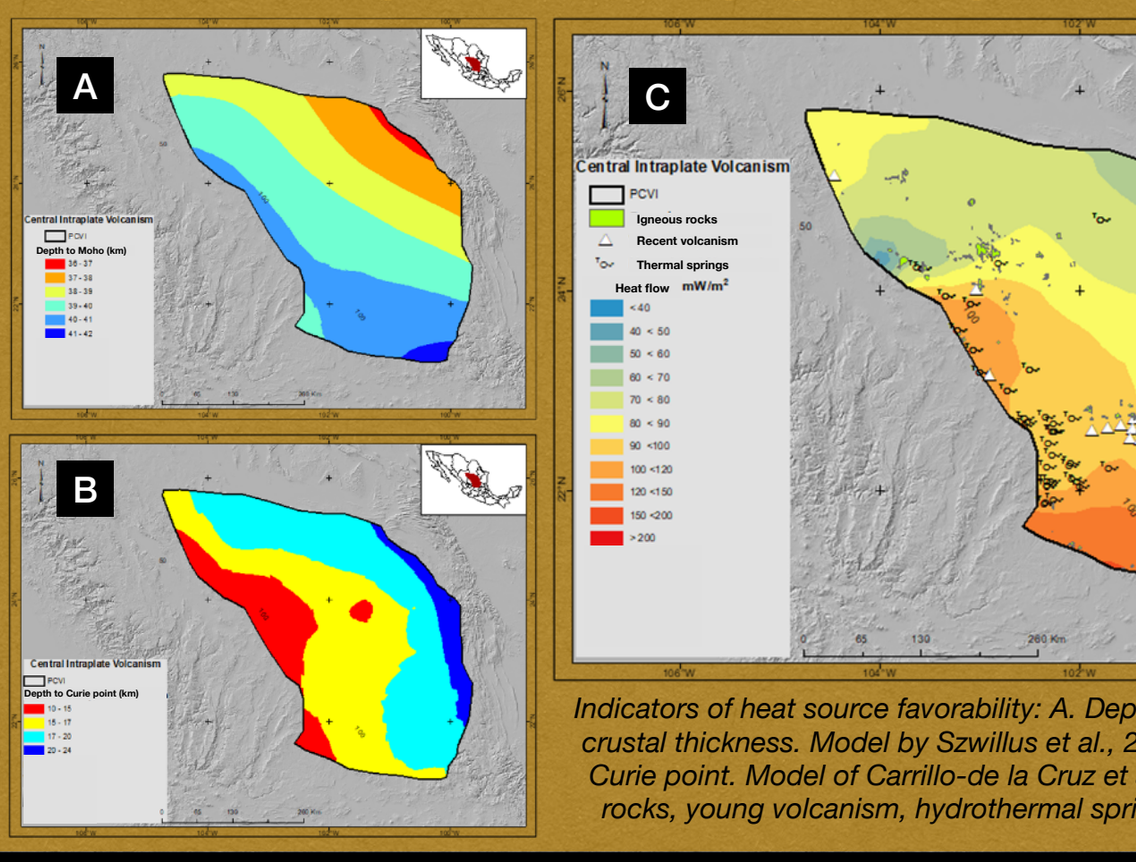
When evaluating the geothermal potential of an area, three basic geological attributes must be defined: heat source, hydrothermal fluid, and the necessary permeability to allow its flow (Lindsey et al., 2021; Faulds et al., 2021). The conceptual model proposed for the CIVP aims to evaluate the individual and joint occurrence of these three indicators.



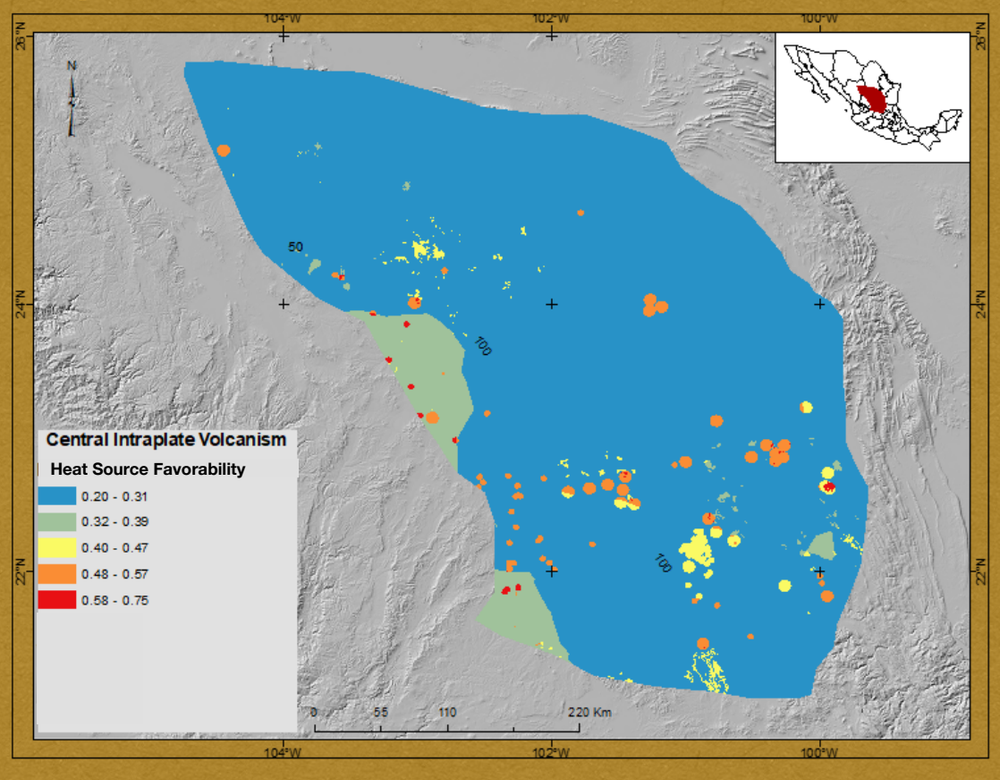
Workflow and data layers used for the Geothermal PFA. Three main weighting stages: 1.Scoring inside each evidence layer, 2.Weighting layers inside each individual model, 3.Weighting individual models

Heat Source

The datasets were integrated into a geographic information system and then three individual favorability models and a final Play Fairway model were developed. The proposed integration method is weighted sums, and the weighting at each stage was carried out following a knowledge-driven approach.

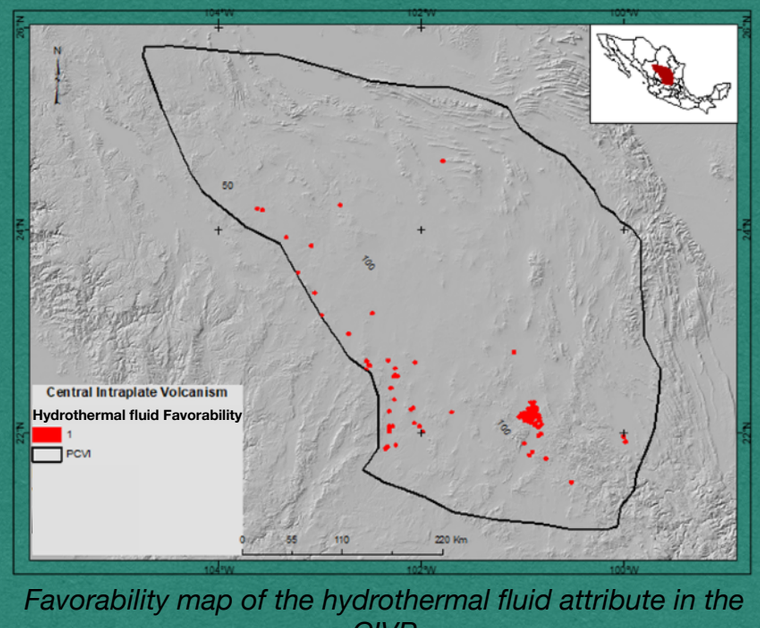


Indicators of heat source favorability: A. Depth to Moho, proxy for crustal thickness. Model by Szwillus et al., 2019. B. Depth to the Curie point. Model of Carrillo-de la Cruz et al., 2021.C. Igneous rocks, young volcanism, hydrothermal springs, and heat flow.



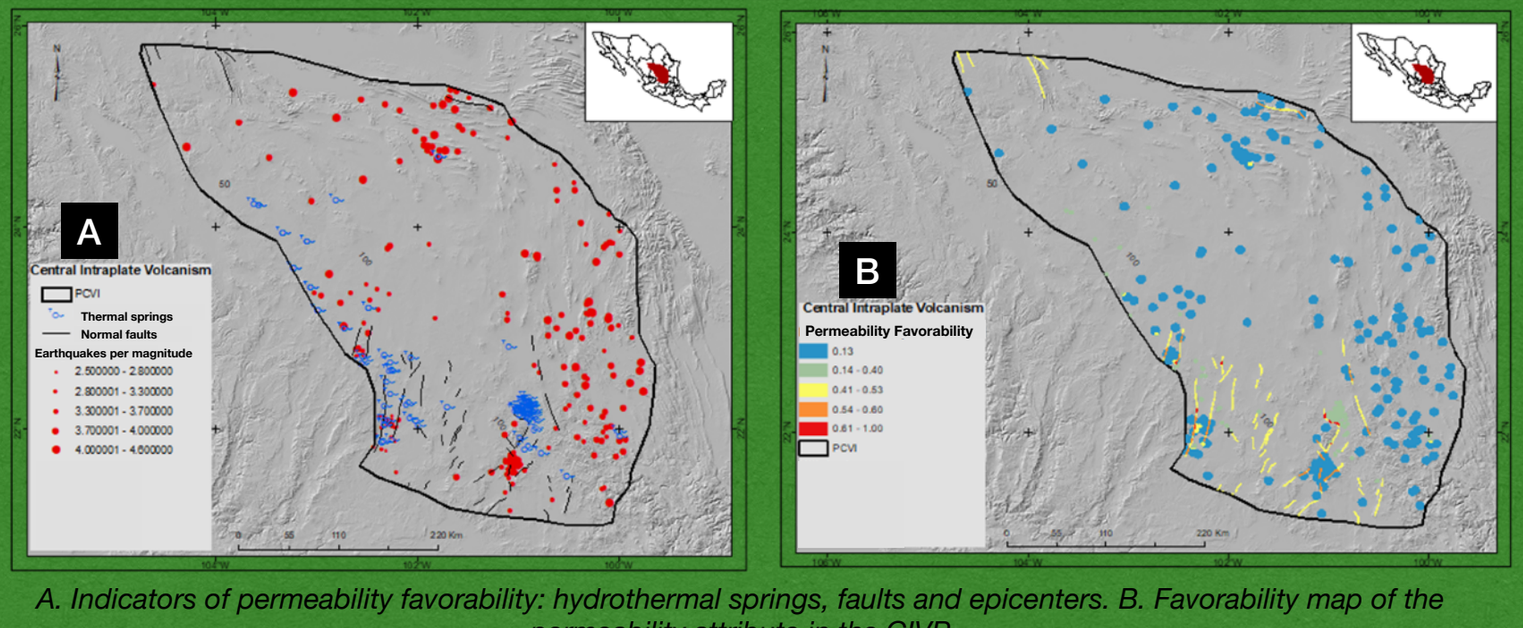
Favorability map of the heat source attribute in the CIVP

Hydrothermal fluid



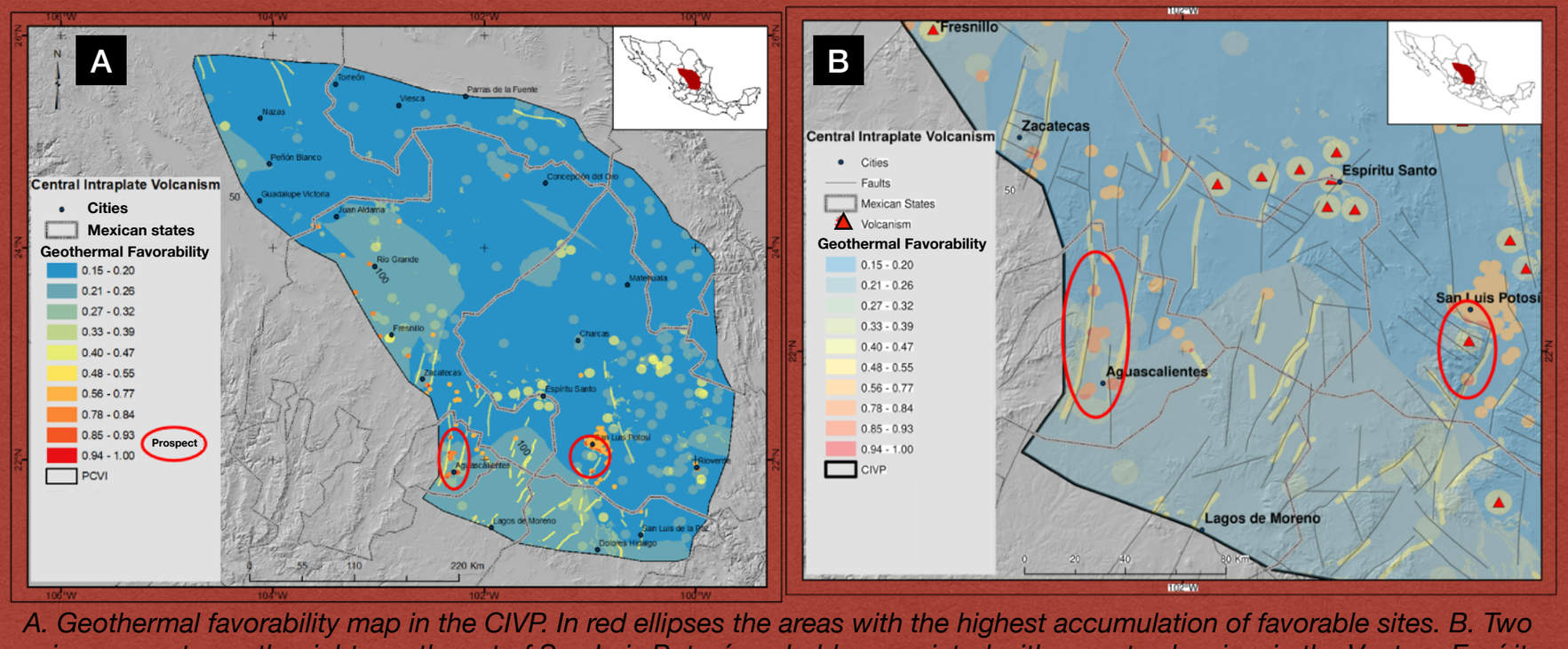
Favorability map of the hydrothermal fluid attribute in the CIVP

Permeability



A. Indicators of permeability favorability: hydrothermal springs, faults and epicenters. B. Favorability map of the permeability attribute in the CIVP

Results: Final Play Fairway favorability



A. Geothermal favorability map in the CIVP. In red ellipses the areas with the highest accumulation of favorable sites. B. Two main prospects: on the right, southwest of San Luis Potosí, probably associated with recent volcanism in the Ventura-Espíritu Santo field, and the Villa de Reyes graben; to the left, the center of Aguascalientes, associated with the Aguascalientes graben

Conclusions

- The prospects that gather more favorable sites in this first evaluation are areas dominated by elements of extensional tectonics and intraplate volcanism: San Luis Potosí and Aguascalientes states (Nieto-Samaniego et al., 2005).
- This represents a first hierarchy of the areas of geothermal interest in the province as a decision-making tool.
- These results should be considered preliminary: subsequent evaluations will include sites with hydrothermal alteration, favorable structural configurations, and the first stage of scoring.
- The implementation of tools based on the data driven approach could help reduce uncertainty in subsequent evaluations.

References

1. Aranda-Gómez, J. J., Henry, C. D., & F. Luhr, J.I., 2000. Evolución tectonomagmática post-paleocénica de la Sierra Madre Occidental y de la porción meridional de la provincia tectónica de Cuencas y Sierras, México. En Boletín de la Sociedad Geológica Mexicana. Vol. 53, Issue 1, pp. 59–71.
2. Faulds, J., Hinz, N., Coolbaugh, M., Ayling, B., Glen, J., Craig, J., McConville, E., Siler, D., Queen, J., Witter, J., & Hardwick, C., 2021. Discovering Blind Geothermal Systems in the Great Basin Region: An Integrated Geologic and Geophysical Approach for Establishing Geothermal Play Fairways: All Phases. Office of Scientific and Technical Information (OSTI). https://doi.org/10.2172/1724080
3. Henry, C. D., Aranda-Gómez, J. J. 2000. Plate interactions control middle–late Miocene, proto-Gulf and Basin and Range extension in the southern Basin and Range. Tectonophysics 318, 1–26
4. Lindsey, C. R., Ayling, B. F., Asato, G., Seggiaro, R., Carrizo, N., Larcher, N., Marquetti, C., Naón, V., Serra, A. C., Faulds, J. E., & Coolbaugh, M. F., 2021. Play fairway analysis for geothermal exploration in north-western Argentina. Geothermics, vol. 95, p. 102128. Elsevier BV. https://doi.org/10.1016/j.geothermics.2021.102128
5. Moeck, I., 2014. Catalog of geothermal play types based on geologic controls. Renewable and Sustainable Energy Reviews, 37, 867–882. https://doi.org/10.1016/j.rser.2014.05.032
6. Nieto-Samaniego, Angel Francisco, Alaniz-Alvarez, Susana Alicia, & Camprubí i Cano, Antoni., (2005). La Mesa Central de México: estratigrafía, estructura y evolución tectónica cenozoica. Boletín de la Sociedad Geológica Mexicana, 57(3), 285-318. https://doi.org/10.18268/bsgm2005v57n3a3
7. Prol-Ledesma, R.M., Morán-Zenteno, D.J., 2019. Heat flow and geothermal provinces in Mexico. Geothermics, 78, 183–200. https://doi.org/10.1016/j.geothermics.2018.12.009