Strontium isotope ratios in Mexican hair and tap water- potentials and limitations for aiding the identification of Undocumented Border Crossers

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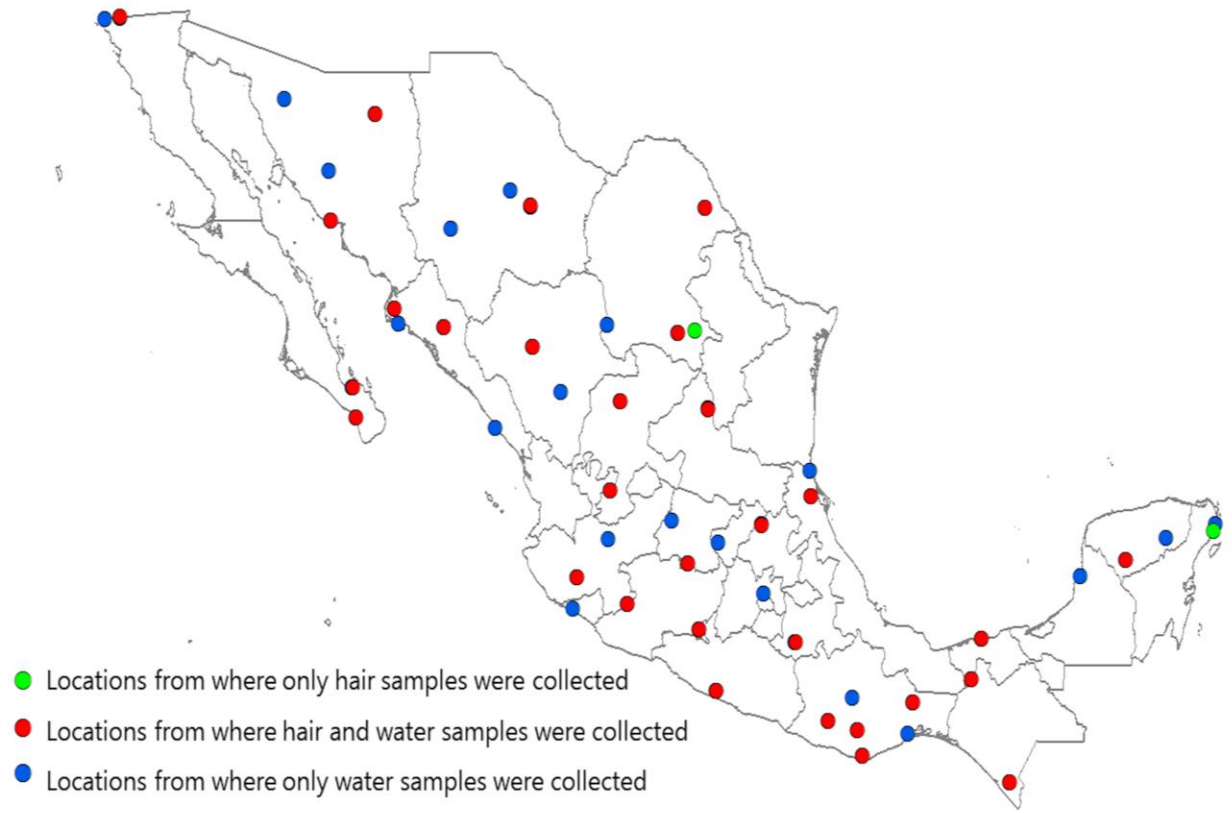
Highlights:

- $^{87}Sr/^{86}Sr$ of 101 human hair and 151 tap water samples are reported from across Mexico
- $^{87}Sr/^{86}Sr$ ratios range between 0.70424 and 0.71613 ($\Delta Sr_{max–min}$ = 0.01189) in Mexican human hair samples
- $^{87}Sr/^{86}Sr$ ratios range between 0.70404 and 0.71385 ($\Delta Sr_{max–min}$ = 0.00981) in Mexican tap water samples
- A strong correlation (R^2= 0.80) is observed between $^{87}Sr/^{86}Sr$ of human hair and tap water data and location averages have a stronger correlation (R^2= 0.87)
- These data provide the basis for provenance studies in forensic anthropology
- Preliminary isoscape region of origin predictions include correct known place of origin



Map of Mexico showing the sampling locations (green: n=2, red: n=30, blue: n=21).

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Background:

Deceased undocumented border crossers are some of the most difficult individuals to identify due to the inability to narrow down the region of origin and therefore to obtain family reference samples for DNA comparison.

The isotopic compositions of various body tissues have been demonstrated to be useful biomarkers for tracking locations and movements to aid in the identification of human remains.

This research closes the large spatial gap of available $^{87}Sr/^{86}Sr$ ratios from North America in tap water and presents the first $^{87}Sr/^{86}Sr$ human tissue-based ratios from Mexico.

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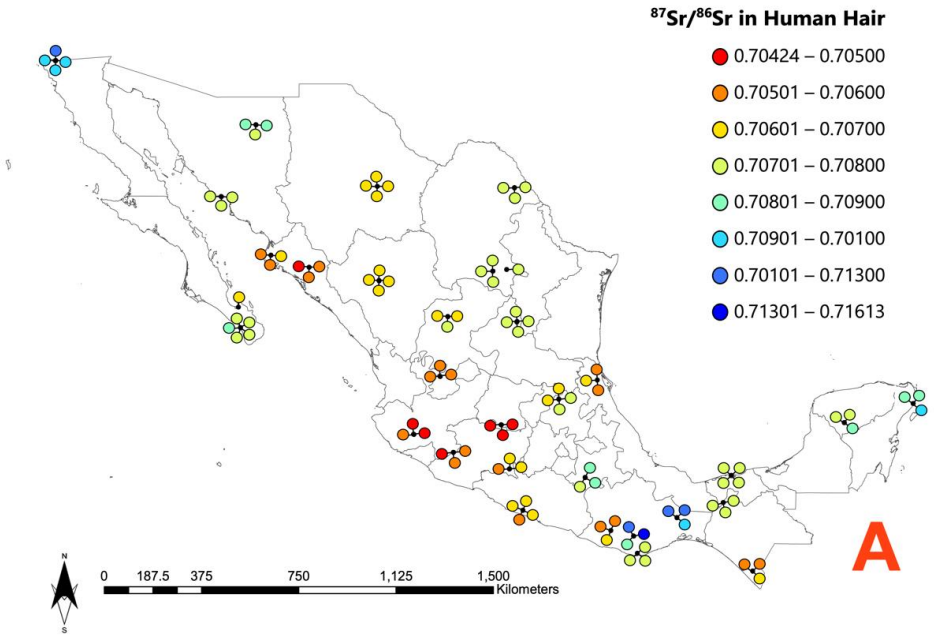

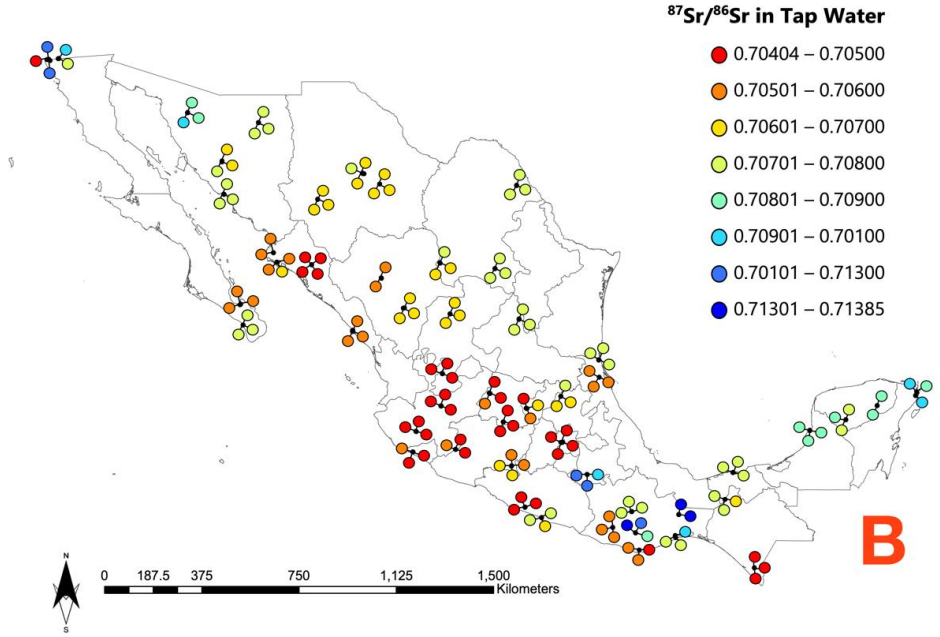

Results:

The 101 hair samples from 32 locations in Mexico range in $^{87}Sr/^{86}Sr$ ratios from 0.70424 to 0.71613 ($\Delta Sr_{max–min}$ =0.01189).

The 151 tap water samples from 51 locations range between 0.70404 to 0.71385 ($\Delta Sr_{max–min}$ = 0.00981).

Overall, small variations in the hair and tap water samples collected from individual locations were recorded ($\Delta Sr_{max–min}$ = 0.00041 and 0.00034 respectively).

For both hair and tap water samples, the lowest Sr isotope ratios appear along the west coast and Sierra Madre mountainous range, mainly in the states of Guanajuato, Jalisco and Michoacán.

The highest $^{87}Sr/^{86}Sr$ ratios were found in the states of Oaxaca and the north-west of Mexico, specifically Tijuana (Baja California).

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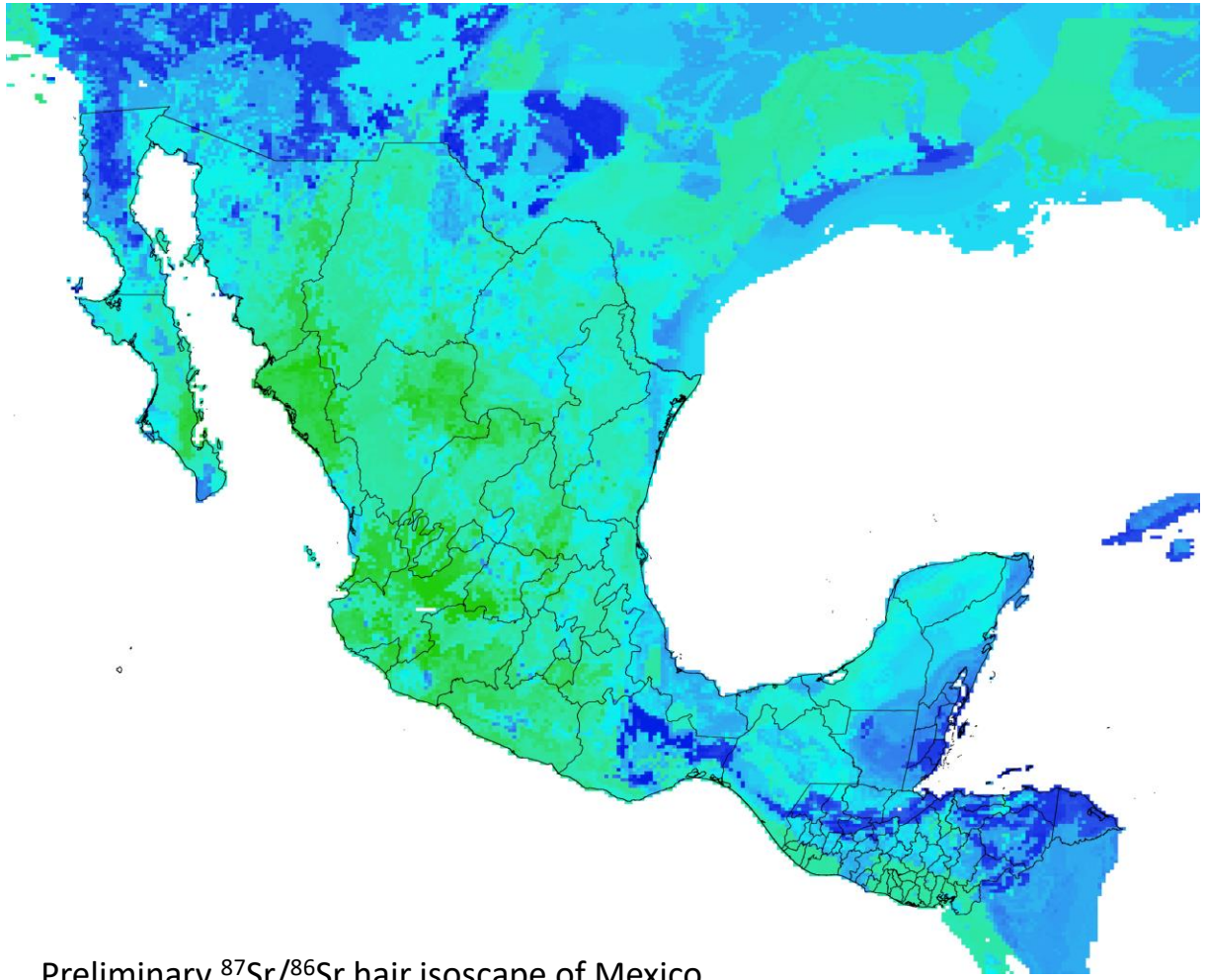
Preliminary hair isoscape:

This preliminary hair isoscape was developed using the Bataille *et al.* (2018) machine learning approach.

The isoscape was interpolated to the border regions of the United States as well as the Northern Triangle countries (Honduras, Guatemala, El Salvador) and Belize. This was done in order to investigate potential influences of exogenous signatures that may skew with $^{87}Sr/^{86}Sr$ ratios recovered from human tissues, especially human hair as well as to predict potential regions of origins as an increasing number of UBCs come from the Northern Triangle countries.

It is important to note here that the interpolation undeniably introduces a greater error because there are no reference data in these countries to base the interpolation on.



Preliminary $^{87}Sr/^{86}Sr$ hair isoscape of Mexico.

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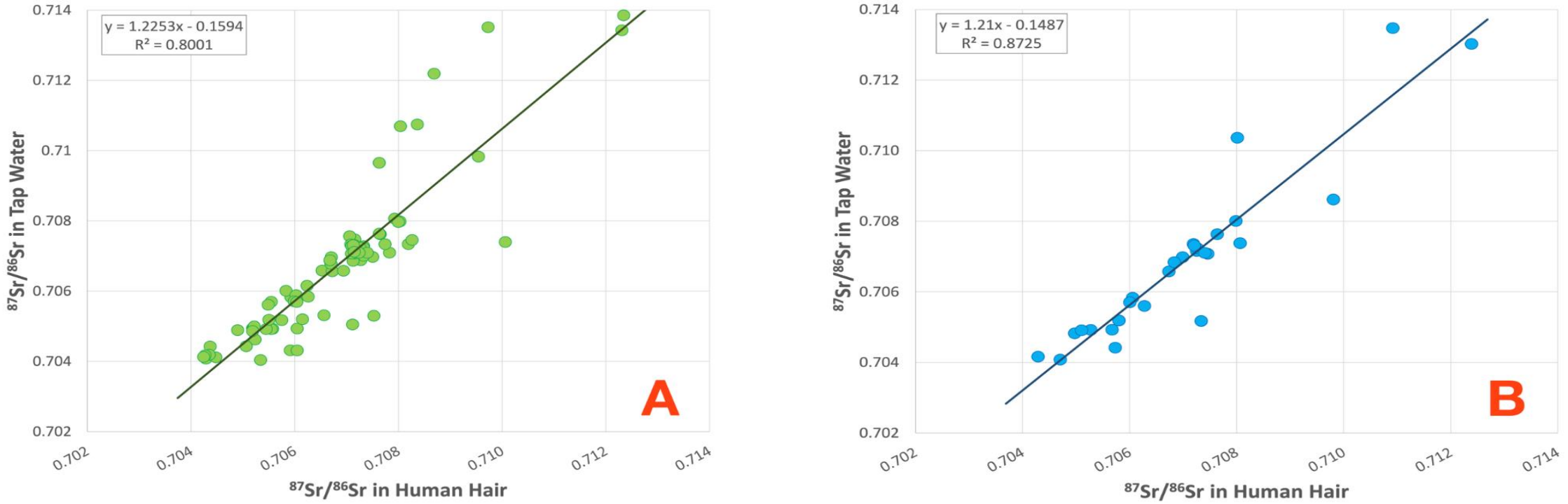
Hair-Water Correlation:

Despite the fact that Mexico is one of the largest bottled water consumers in the world, the $^{87}Sr/^{86}Sr$ ratios of human hair and tap water correlated strongly ($R^2 = 0.87$ for location averages and $R^2 = 0.80$ when using individual data points).



Relationship of $^{87}Sr/^{86}Sr$ ratios in human hair and tap water collected from the sample locations (n=30).
A: all data ($^{87}Sr/^{86}Sr$ Tap Water = 1.23 * $^{87}Sr/^{86}Sr$ Human Hair -0.16; $R^2 = 0.80$)
B: location averages ($^{87}Sr/^{86}Sr$ Tap Water = 1.21 * $^{87}Sr/^{86}Sr$ Human Hair -0.15; $R^2 = 0.87$)

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Region of origin prediction example for recently identified UBC:

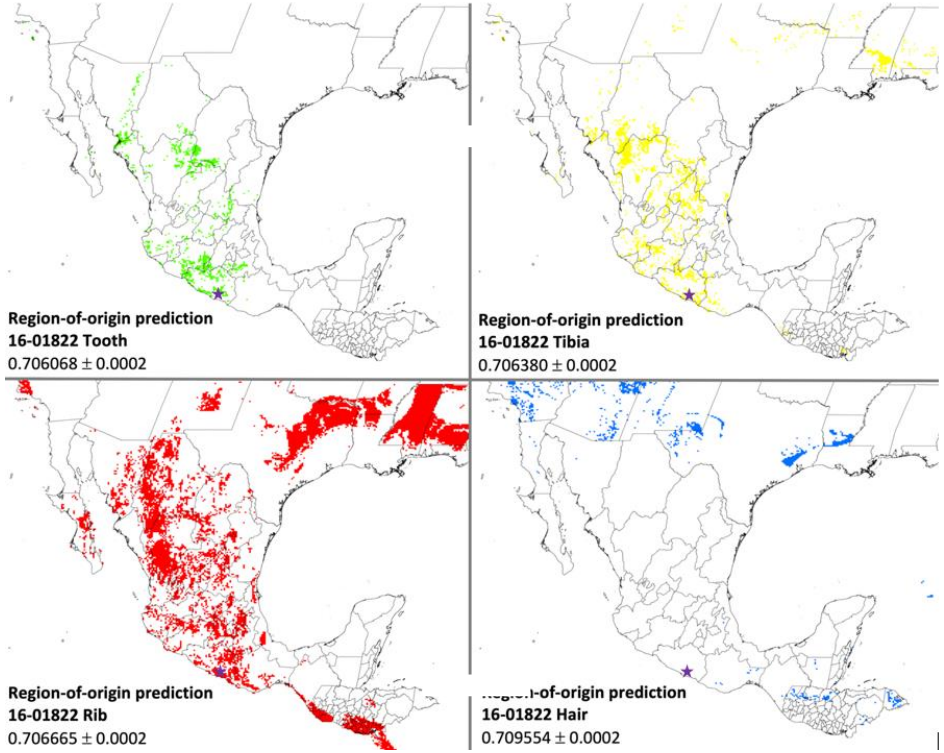
This is individual has been recently identified and the place of origin (star) is included in the predicted regions of origin.

The tooth ratio rules out an early childhood residence in the Northern Triangle countries and places him within Mexico. The $^{87}Sr/^{86}Sr$ bone ratios 7indicate that the individual moved in the period from the formation of the canine to his time of death.

The rib shows a much higher ratio than the tooth and the tibia, indicating that the individual must have moved for a significant period of time. The tibia $^{87}Sr/^{86}Sr$ ratio falls in between the tooth and the rib ratio, which is indicative of a mixed signature as the turnover rate is longer than in the rib.

The hair values are representative of the border region and most likely represent a mixed signature.

It is unknown to the author if and where this individual moved to during his lifetime. Furthermore, it is unknown if the known place of origin is the true birthplace or if the next of kin may have reported the last place of residence.



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Conclusion:

This research has shown that the $^{87}Sr/^{86}Sr$ ratios in human hair and tap water from Mexico have great potential to be used for provenancing studies, such as determining potential regions of origin of undocumented border crossers found along the Mexico- United States border.

In the future, it will be essential to determine potential regions of origin by underlying the prediction error maps and therefore getting a more confident answer to the research question at hand. A potential tool to rescale isoscapes using known-origin isotope data and assigning origin to the unknown samples is AssignR, a R package which takes into account the likelihood of a certain isotopic value/ratio to occur in any one particular location on the isoscape.

Furthermore, it is pertinent to expand the research to other known body tissue samples in order to establish potential relationships of human hair to body tissues more frequently consulted in forensic anthropology.

Please read more about the Strontium ratios presented here in the following article:

Comparison of strontium isotope ratios in Mexican human hair and tap water as provenance indicators

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