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Speleothem Laminae Counting and Growth Rate

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Speleothem Laminae Counting and Growth Rate

Abstract

The goal of this project is to determine if there is a correlation between annual laminae in speleothems and Uranium dating. To do this, we counted laminae using high-resolution images and calculated a line of the best fit for the resulting data. We found that our data could supplement Uranium dating, but unless more data is obtained, laminae counting gives relatively imprecise age and growth rate estimates.

Keywords

Speleothems, Laminae, Uranium Dating

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PROBLEM STATEMENT

Calculate an accurate age and growth rate of a given speleothem using laminae counting.

MOTIVATION

Uranium dating is often used to determine the age of speleothems. It is a difficult process because the growth of speleothems is affected by various factors. For example, rainfall changes affect the amount of dissolution of limestone, which decreases the amount of deposition within the cave.

Lamina counting has been considered as a possible alternate method to determine the age of speleothems. This approach works in places where wet and dry seasons alternate and affect the laminae coloration (Baker, Smith and Jex). It is conceivable that this dating technique could be used along with Uranium dating to elucidate specific climate events that occurred in the past. We have applied this technique to a speleothem from a known Mayan ritual site to assess a possibility that a specific climate event could have contributed to the collapse of the Mayan empire.

MATHEMATICAL DESCRIPTION AND SOLUTION APPROACH

The speleothem used in the project was cut and polished by van Beynen. The laminae on this speleothem were counted as follows. First, a cross section of speleothem was laid on a black table to increase the contrast. Then, its photos were taken using a high-resolution camera, measuring the same distance between the speleothem c-axis and the camera. High resolution prints of these photos (see Figure 1, right) were used to count the laminae. The counting was



Figure 1: Workplace where the measurements have been taken (left);
Close up photograph of the cross section (right).

aided by a desk lamp, a magnifying glass, and a Sharpie marker (see Figure 1, left). For comparison, laminae were marked in the center and the bottom of the images. Once the initial markings were made, the photos were given to Katherine Deberry for additional verification.

The averages of all the counts are presented in Table 1. We have calculated the least-squares line of the best fit for these counts as $y = mx + b$ where

$$m = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}} \text{ and } b = \bar{y} - m\bar{x}.$$

Here, n stands for the total number of data points while \bar{x} and \bar{y} are the means of the distances and the laminae counts respectively. We have used Microsoft Excel to confirm our findings (see Charts 1-5) and compared the results with van Beynen's radioisotope data (van Beynen).

Unfortunately, our results did not correlate with this data well.

DISCUSSION

We were able to accurately count the laminae on a speleothem from a known Mayan ritual site. All of the data points turned out to lie on a straight line, which we have calculated using the least squares method (and confirm our findings by Microsoft Excel). This suggests that the number of laminae for this speleothem grow linearly with time. Although we were unable to predict speleothem growth based solely on laminae counts, we suspect that these counts could be used to supplement Uranium dating.

CONCLUSION AND RECOMMENDATIONS

We have studied laminae formation over the entire length of the speleothem and calculated the line of the best fit for each set of measurements that we performed. These lines could be used to predict the number of laminae over time for a specific speleothem or group of speleothems. However we've found it difficult to estimate the age of speleothem based on laminae count without knowing the precise climatic conditions in which it grew. In future, we could use locally grown speleothems to learn how to better account for changes in the climate. Further research and data collection from the same region within this cave are needed to have a greater pool of data for analysis. Specifically, if more usable Uranium dating from a similar speleothem in the same region of the cave with the same connectivity were sampled, a general comparative growth rate could be feasible.

NOMENCLATURE

Symbol	Description
m	Slope of a line of the best fit
b	y-intercept of a line of the best fit
n	number of data points
\bar{x}	Mean of the distances
\bar{y}	Mean of the laminae counts

REFERENCES

Baker, A, et al. "Annually Laminated Speleothems: A Review." International Journal of Speleology 37.3 (2008): 193-203.

Larson, Ron, Robert Hostetler and Bruce H Edwards. Calculus: Early Transcendental Functions. 4th. Boston: Houghton Mifflin Company, 2007.

van Beynen, P. Report on Speleothem Work for Xcoch Archaeology. Tampa: University of South Florida, 2010.

APPENDIX - TABLES

Distance	Count 1	Count 2	Count 3	Count 4	Average
2	39	41	54	54	47.00
4	80	82	102	102	91.50
6	143	145	144	144	144.00
8	198	200	215	215	207.00
10	255	258	282	282	269.25
12	303	306	343	344	368.75
14	356	359	406	407	382.00
16	402	405	464	465	434.00
18	438	443	508	509	474.50
20	482	493	570	571	529.00
22	529	538	638	639	586.00
24	564	573	688	689	628.50
26	596	610	757	758	680.25
28	643	657	818	819	734.25
30	683	700	859	860	775.50
32	743	760	912	913	832.00
34	796	813	964	965	884.50
36	838	855	1003	1004	925.00
38	881	898	1041	1042	965.50
40	936	953	1090	1091	1017.50
42	998	1015	1148	1149	1077.50
48	1093	1110	1305	1306	1203.50

Table 1: Laminae counts at a given distance from the center. Counts 1 through 4 correspond the number of laminae counted at the center (two measurements) and outside (two measurements) respectively.

APPENDIX - CHARTS

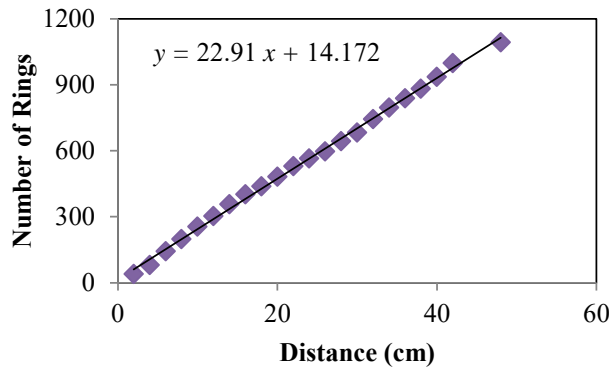


Chart 1: Laminae counts at a specific distance from the center (1st count at the center).

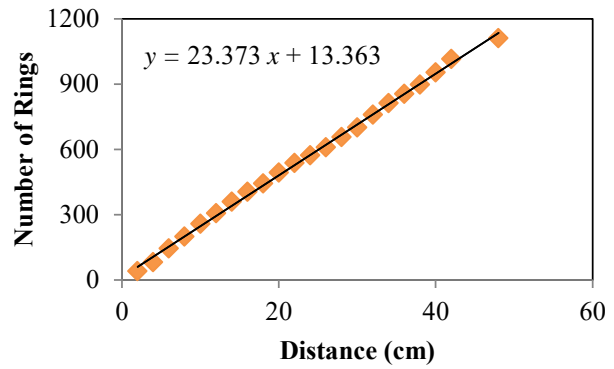


Chart 2: Laminae counts at a specific distance from the center (2nd count at the center).

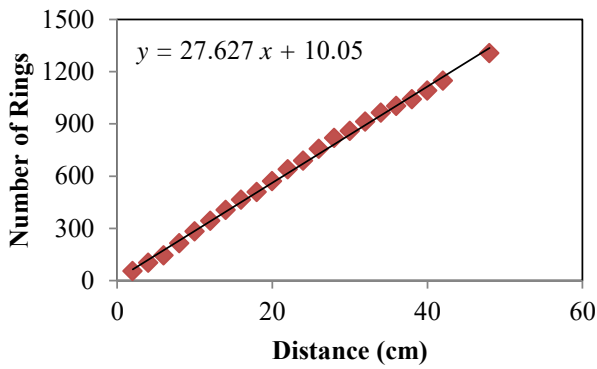


Chart 3: Laminae counts at a specific distance from the center (1st outside count).

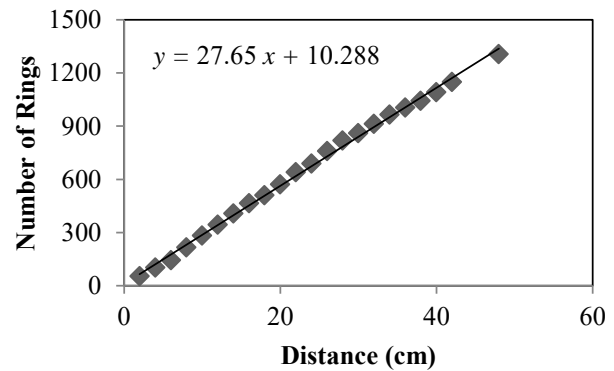


Chart 4: Laminae counts at a specific distance from the center (2nd outside count).

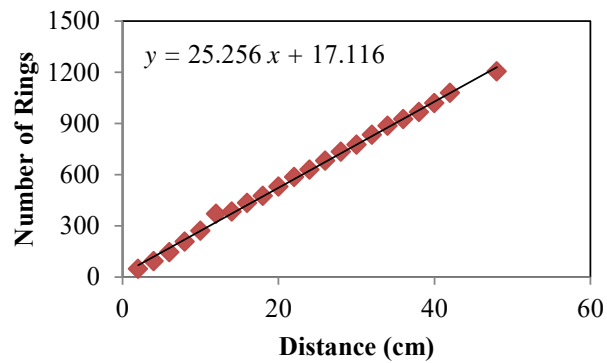


Chart 5: Laminae counts at a specific distance from the center (average of all counts).