

# Assessing Elemental Indicators of Growth within Equine Teeth Using XRF Technology

Alex Galloway

UNC Department of Anthropology

## INTRODUCTION / METHODS

The ratio of strontium to calcium in animal tissues (Sr/Ca) is closely associated with diet, especially trophic levels. The higher up the trophic pyramid an animal is, generally, the higher their Sr/Ca. Within herbivores before and during weaning, calcium uptake mimics that of a carnivore due to the high levels of calcium and low levels of strontium in nursing milk. Sr/Ca ratios can also track other changes in dietary sources through time.

This study explores if non-destructive X-ray fluorescence (XRF) is a viable method to measure Sr/Ca ratios in archaeological and bioarcheological specimens. Ratios of elemental concentration of barium, strontium (Sr/Ba), and calcium (Sr/Ca) were obtained from topical scans of 10 modern Equine teeth housed at UNC to see if there are general trend lines that correlate to growth patterns, specifically by exploring how growth affects the elemental makeup of developing tooth enamel in horses (*Equus caballus*). Data were collected every 0.5cm along the length of the tooth using a handheld XRF unit (TRACER 5i, Bruker Corporation) for 90 second assays using an internal calibration (Mudrock). Data are presented in photon counts per second.

## RESULTS

A growth pattern was detected via the elemental composition of the teeth, signified by variation in the Sr/ Ca ratio over time as seen in Fig. 1. Around two years and eight months the ratio was at its highest point with a drastic drop seen thereafter. The cause of the ratio drop is twofold; a drop in the amount of strontium found in the teeth (Fig. 2) and an increase in the amount of calcium found in the teeth (Fig. 3). From that point on the Sr/ Ca ratios and calcium levels remain the same, while the strontium continues to fluctuate between high and low peaks, gradually declining over time.

## REFERENCES

Hoppe, K. A., Stover, S. M., Pascoe, J. R., & Amundson, R. (2004). Tooth enamel biomineralization in extant horses: Implications for isotopic microsampling. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 206(3-4), 355-365. <https://doi.org/10.1016/j.palaeo.2004.01.012>

Louise T. Humphrey (2014) Isotopic and trace element evidence of dietary transitions in early life, *Annals of Human Biology*, 41:4, 348-357, DOI: 10.3109/03014460.2014.923939

Soana, S., Gnudi, G., & Bertoni, G. (1999). The teeth of the horse: evolution and anatomo- morphological and radiographic study of their development in the foetus. *Anatomia, histologia, embryologia*, 28(5-6), 273-280. <https://doi.org/10.1046/j.1439-0264.1999.00204.x>

Taylor, W., Hart, I., Jones, E., Brenner-Coltrain, J., Thompson Jobe, J., Britt, B., . . . Roberts, P. (2021). Interdisciplinary Analysis of the Lehi Horse: Implications for Early Historic Horse Cultures of the North American West. *American Antiquity*, 86(3), 465-485. doi:10.1017/aaq.2020.109

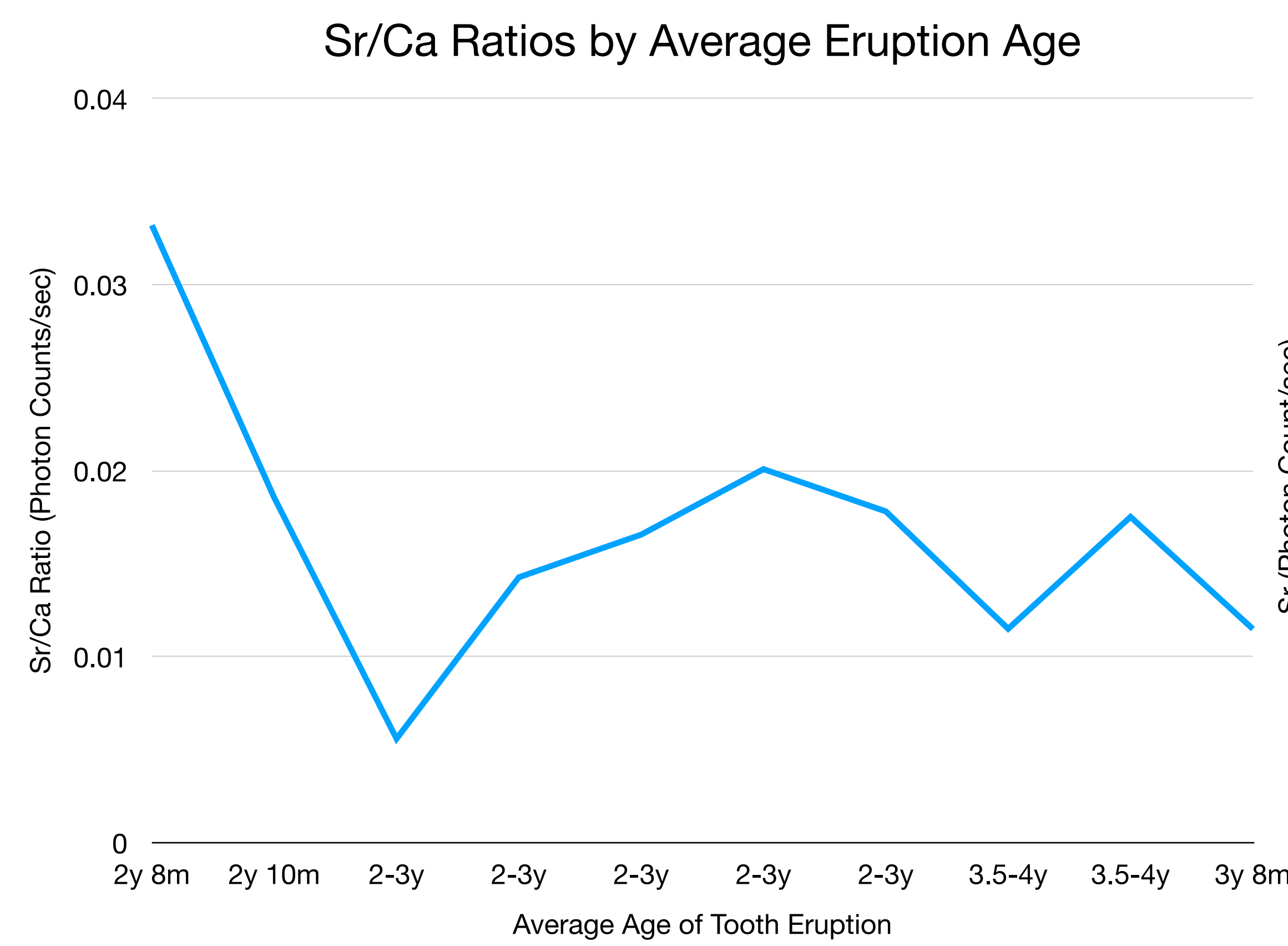


Figure 1: Sr/Ca ratio measurements of all centimeter marks on each tooth where averaged by tooth. Each tooth was then placed in eruption sequence pattern

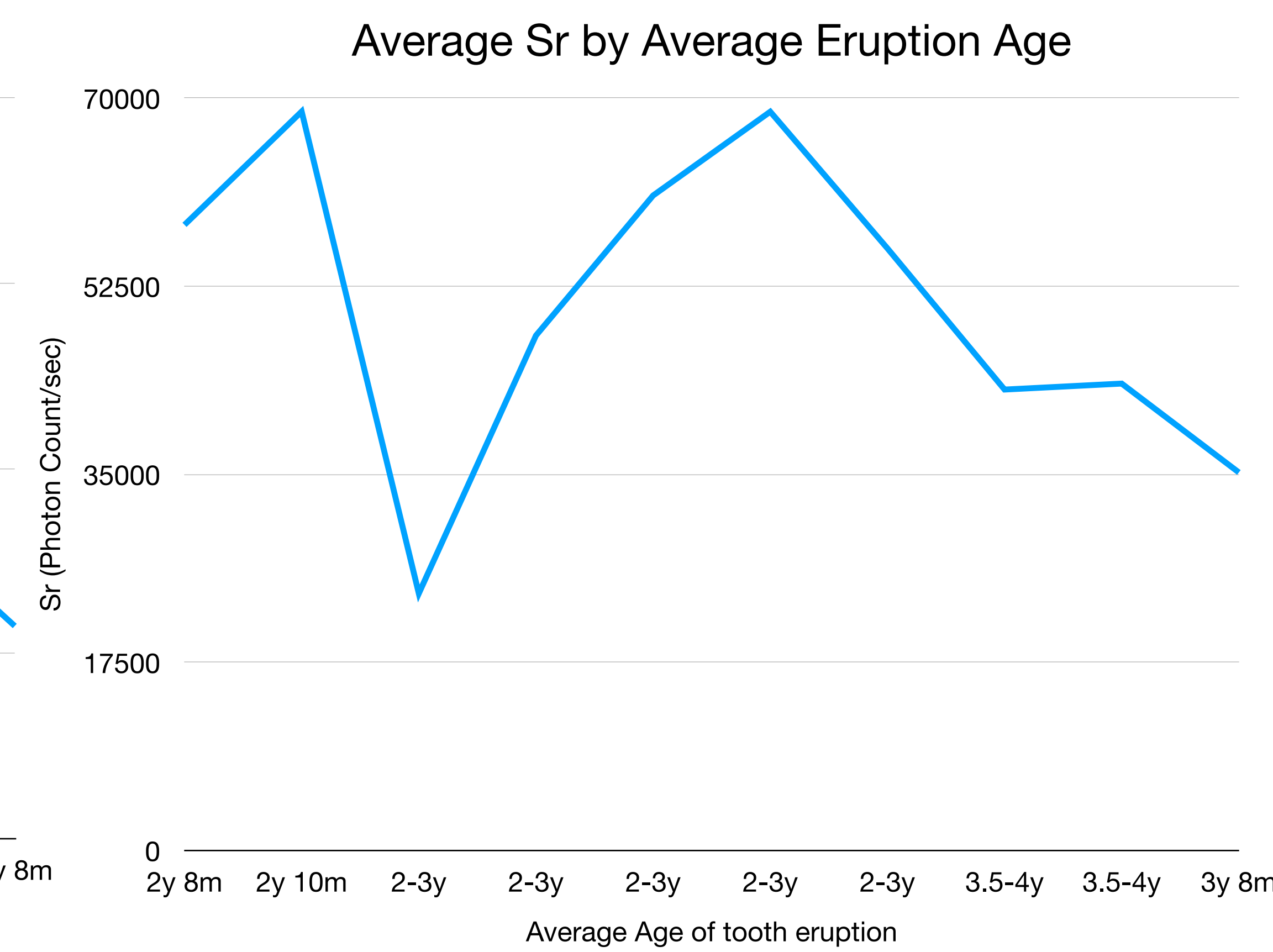


Figure 2: Sr measurements of all centimeter marks on each tooth where averaged by tooth. Each tooth was then placed in eruption sequence pattern

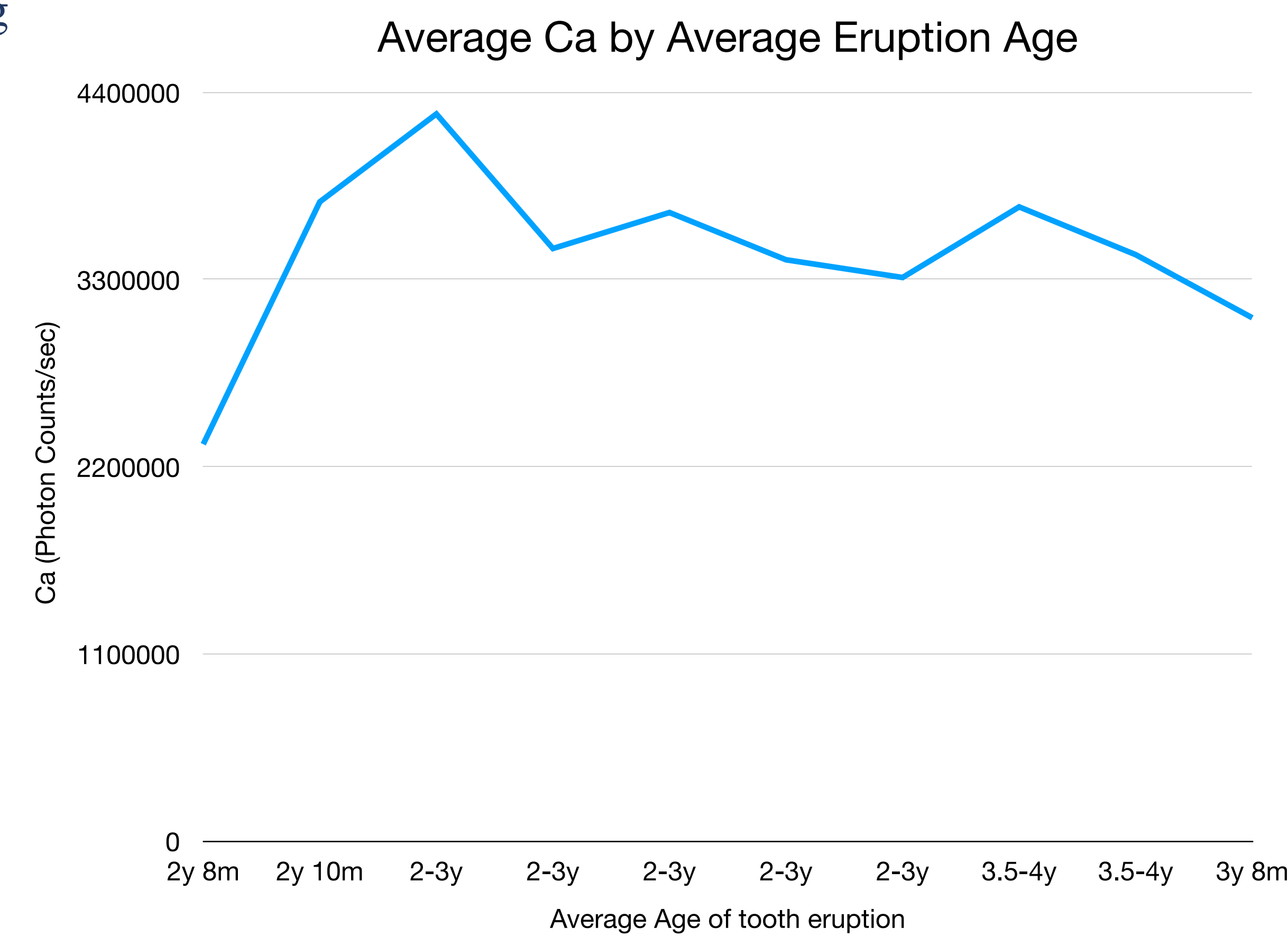


Figure 3: Ca measurements of all centimeter marks on each tooth where averaged by tooth. Each tooth was then placed in eruption sequence pattern



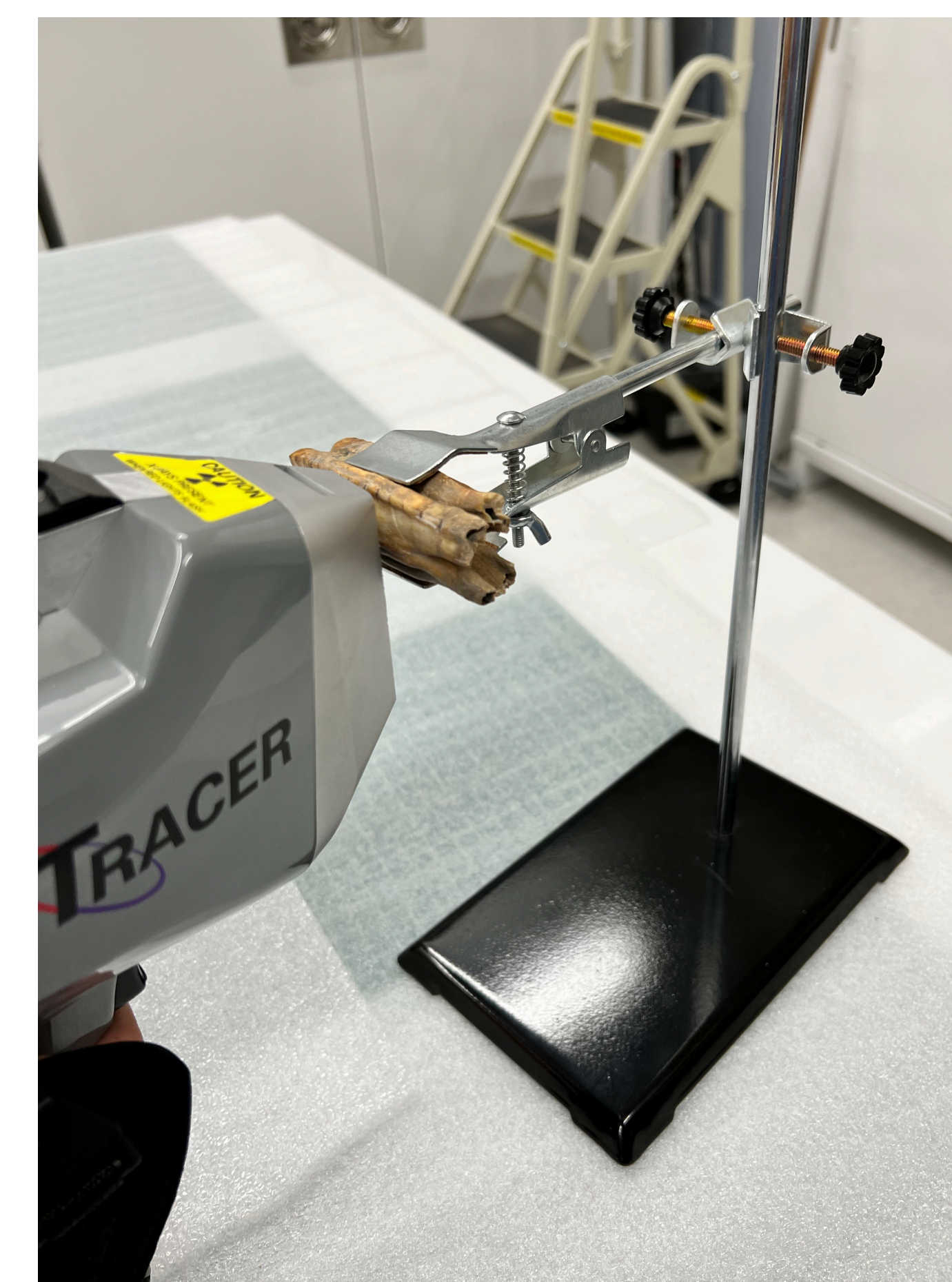
All 10 horse teeth with potential identifications



A tooth with markings at every 0.5 cm



Upper left second molar x10 magnification



Tooth held by clamp for XRF scanning

## CONCLUSIONS

Shifts in Sr/Ca ratios are expected at weaning in all mammals. However, the drastic drop in calcium in the samples occurred well after weaning even for a wild horse. Because of the age development of even the earliest tooth in these samples, this cannot be a weaning signal, although it mimics the pattern. Therefore the cause of this is most likely caused by a change in diet from a food source high in calcium and low in strontium, to a food source low in calcium and high in strontium. Without knowing elemental make up of feed given to adult and developing horses it cannot at this time be clear what the exact change in diet occurring in the youngest of the samples was without further research. However, as a signal indicating dietary shifts is seen, the XRF is a viable method of analysis.

## SIGNIFICANCE AND NEXT STEPS

Within both archaeology and zooarchaeology the domestication of horses is an important yet clouded topic in human deep history. While signs of riding can be seen on horse vertebrae, this research will explore if there is a delineation between domestication and riding of horses. Using this method, with refinement, the hope is to catch elemental signs of early domestication indicated by rapid and widespread changes in elemental composition of skeletal remains; potentially separate from signs of use beyond a food source and beast of burden to further clarify the use of horses in early human history.

To further refine this method and test it's accuracy and applicability; samples of all teeth of known domesticated and wild horses will need to be collected and compared to show the most complete dietary shifts possible. In addition, food sources given to both foal and adult horses will need to be assessed to see what the elemental compositions of each are to further understand the potential affects it would have on a horses elemental composition over their lifespan based on different dietary preferences whether natural or artificially selected for.

## ACKNOWLEDGMENTS

I would like to thank Dr. Taylor of UC Boulder for his assistance with identifying the horse teeth and providing his insights. I would also like to thank Dr. Hamilton for all she has done, this project would not have been possible if not for her tremendous help. Including, but certainly not limited to, extremely helpful guidance and mentorship.