# Calculus Analysis of Viking-era Icelandic Remains

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## Abstract

The ideological shift from Paganism to Christianity among Icelandic Viking populations (~1000 A.D.) marks a period of changes in mortuary, social, and economic practices. The cemetery of Keldudalur, in the Skagafjörður region of north Iceland (Fig. 1), represents one such population. Individuals from Keldudalur consistently have large calculus deposits on their dentition. Recent anthropological studies have shown that dietary and material cultural information can be retrieved from calculus. The application of calculus analysis to the study of the Keldudalur burials has the potential to reveal the relatively invisible role that plants may have had in the seemingly meat-centered diets of the early Icelandic settlers. Two protocols currently exist for the analysis of calculus. This project tested both protocols to determine which one was more appropriate for the study of archaeological remains. Protocol 1 (P1) treats calculus with 5% HCl to remove potential surface contaminants, but results in partial destruction of the sample. Protocol 2 (P2) does not address the issue of contamination and extracts microfossils through grinding and suspension of the calculus sample in distilled water. This study suggests a modified protocol to minimize destruction and address possible contamination. *In situ* examination of calculus samples using reflected light microscopy (RLM) allows us to confront possible contamination by noting whether microfossils are embedded in the matrix of the calculus without destroying samples; combining *in situ* microscopy with P2 allows for nondestructive microfossil examination. Microfossils identified in this project include starch grains, plant phytoliths, and blue and red dyed fibers.


**Fig. 1: Map of the Skagafjörður, Iceland**

## Introduction

Around A.D. 1000, Iceland's government declared Christianity the country's official religion, resulting in a widespread conversion from Paganism to Christianity. Christianity called for different methods of worship and burial, and families began to construct small churches with private burials on their land (Zoëga 2007). Keldudalur (A.D. 1050-1150) is the site of a Viking-age farmstead where a Christian cemetery was uncovered in 2002 (Fig. 1). 52 graves had been uncovered (Zoëga 2007) and a number of analyses of health and diet have been undertaken with the remains, one of which involves the examination of dental calculus to infer the diet of Viking-age Icelanders (Fig. 2). Calculus, according to Hillson (1996:255), is mineralized plaque that is attached to the tooth. Analyses of dental calculus (Henry 2011) have revealed microfossils such as starch grains and plant phytoliths. These plant-based microfossils add to knowledge of past diets, especially those sites with good faunal preservation but limited floral remains.

One common protocol, Protocol 1 (Fig. 3), for examining microfossils involves digesting calculus samples in weak HCL to remove possible post-mortem contaminants. The amount of time spent in HCl varies, ranging from five minutes (Kucera et al. 2011) to 5 days (Hardy et al. 2009). Another established protocol, Protocol 2 (Fig. 3), (Henry 2008), does not treat the calculus with any chemicals but does not address the question of post-mortem contamination. This project assesses the pros and cons of P1 versus P2, and tests a new protocol, Protocol 3 (Fig. 3), which entails an initial *in situ* analysis of calculus samples with reflected light microscopy (RLM) to distinguish between surface contaminants and microfossils that are embedded in the calculus matrix. I hypothesize that this method in combination with P2 has the greatest potential to minimize damage to calculus while addressing the presence of post-mortem contamination.

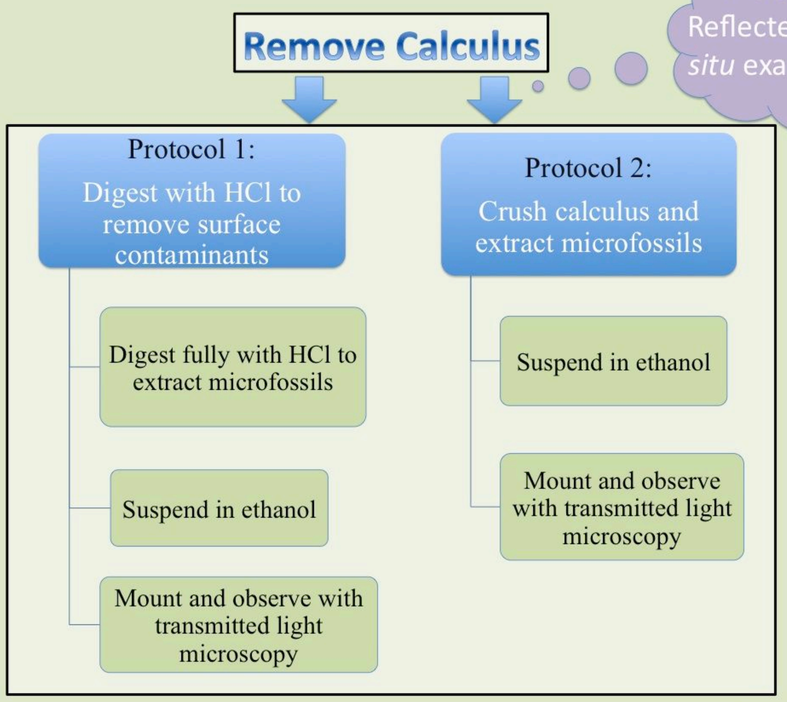


**Fig. 3: Steps associated with Protocol 1 (P1), Protocol 2 (P2), and Protocol 3 (P3).**

**Table 1: Results from Microscopy**

| Individual | *In situ* | P1 | P2 |
|---|---|---|---|
| A-11 | •Numerous starch grains<br>•Black fibers<br>•Possible phytoliths | •Few starch grains<br>•Possible phytolith<br>•Possible black fiber | •Possible phytoliths<br>•Starch grains |
| A-2 | •Starch grains<br>•Possible phytoliths<br>•Black fibers<br>•Synthetic fiber | | |
| A-4 | •Starch grains<br>•Black fibers<br>•Blue fiber<br>•Possible phytoliths | | •Starch grains<br>•Fiber |
| A-29 | •Starch grains<br>•Blue fiber<br>•Red fiber<br>•Black fiber | | |
| A-5 | •Possible phytoliths<br>•Black fiber<br>•Colorless fibers | | |
| A-10 | •Black fiber | | |
| A-15 | •Starch grains<br>•Blue fiber<br>•Colorless fibers | | |

## Methods & Results

To minimize introduction of modern contaminants, P3 was performed in a closed room while wearing only synthetic clothing. Samples from the synthetic clothing were examined with RLM (Fig. 4). These fibers appeared smooth, lacking scales or twists indicative of fibers from organic materials. Fig. 5 shows a synthetic contaminant on the calculus of individual A-2 under cross-polarized light. Tweezers were soaked in hydrogen peroxide then sprayed with alcohol, and powder-free latex gloves were worn to avoid introducing cornstarch to the calculus. The sample was placed on a piece of tin foil under RLM. A grid pattern was used to examine both sides of the sample under 50x, 225x, and 475x magnification using normal and cross-polarized light. Pictures were taken of potential residues. *In situ* RLM of multiple samples from seven individuals revealed starch grains in five individuals, possible phytoliths in four individuals, and fibers of varying colors in all individuals (Table 1). The RLM demonstrates that many of the microfossils observed on the outer surface of the calculus are not modern contaminants. Figs. 6, 7, and 8 illustrate how it is possible to see the fibers entering the calculus matrix. The details of two of the fibers (Figs. 6 & 7) are obscured due to a thin layer of carbonate overlaying the fibers.

Protocol 1 (Fig. 3) was tested on individual A-11 (Fig. 2). There were many more organic remains observed *in situ* than were apparent after digestion with HCl (Table 1). Given the destructive nature of P1, no more samples were examined using that protocol. Protocol 2 (Fig. 3) was tested on individuals A-2 and A-4. Unlike the results of P1, there was not a dramatic reduction in the number of microfossils remaining after implementation of P2 (Table 1). Fibers consistent in appearance with those observed in P3 (Fig. 6) were observed after P1 (Fig. 9). Starch grains observed *in situ* from individuals A-2 and A-4 match those observed after microfossil extraction (Figs. 10 & 11).

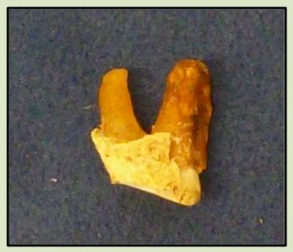

**Fig. 2: Calculus deposit on right maxillary second molar of individual A-11.**

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## References

Hardy, K., Blakeney, T., Copeland, L., Kirkham, J., Wrangham, R., & Collins, M. (2009). Starch granules, dental calculus and new perspectives on ancient diet. *Journal of Archaeological Science*, *36*(2), 248-255.

Henry, A. G., Brooks, A. S., & Piperno, D. R. (2011). Microfossils in calculus demonstrate consumption of plants and cooked foods in Neanderthal diets (Shanidar III, Iraq; Spy I and II, Belgium). *Proceedings of the National Academy of Sciences*, *108*(2), 486-491.

Henry, A. G., & Piperno, D. R. (2008). Using plant microfossils from dental calculus to recover human diet: a case study from Tell al-Raqā'i, Syria. *Journal of Archaeological Science*, *35*(7), 1943-1950.

Hillson, Simon. *Dental Anthropology*. Cambridge: Cambridge University Press, 1996.

Kucera, M., Pany-Kucera, D., Boyadjian, C. H., Reinhard, K., & Eggers, S. (2011). Efficient but destructive: a test of the dental wash technique using secondary electron microscopy. *Journal of Archaeological Science*, *38*(1), 129-135.

Smith, Hannah. "Preliminary Analysis of Dental Calculus from Viking Age Iceland: Implications for Reconstructing Diet and Lifeways." Poster presented at KCSSS 2012. 2012 Oct; Gambier, OH.

Wesolowski, V., Ferraz Mendonça de Souza, S. M., Reinhard, K. J., & Ceccantini, G. (2010). Evaluating microfossil content of dental calculus from Brazilian sambaquis. *Journal of Archaeological Science*, *37*(6), 1326-1338.

Zoëga, G and Traustadóttir, R. 2007. "Keldudalur: A Sacred Place in Pagan and Christian Times in Iceland." In Ulf Fransson, Marie Svedin, Sophie Bergerbrant og Fedir Androshchuk (eds.). Cultural interaction between east and west. Archaeology, artefacts and human contacts in Northern Europe (pp. 225-230). University of Stockholm.

## Discussion & Conclusions

Protocol 1 was demonstrated to be destructive of irreplaceable archaeological materials. While it is important to consider the issue of contamination, there are less damaging ways to do so. Protocol 2 does not address contamination by itself, but does not destroy the calculus sample. This study argues for use of a new protocol (P3), which combines *in situ* analysis of samples prior to extraction using P2. *In situ* analysis is shown to be a powerful step in the analysis of dental calculus because it allows for identification of remains both as surface contaminants and as microfossils embedded in the calculus. Further analysis could include scanning electron microscopy of starch grains and fibers for possible taxonomic attribution.

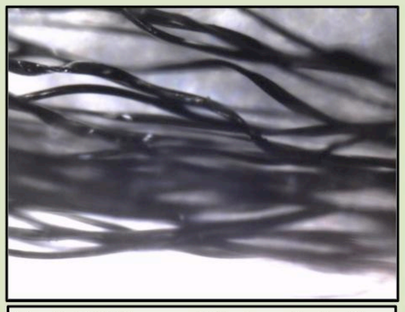

**Fig. 4: RLM image of black synthetic fiber**

**Fig. 5: RLM image of black synthetic fiber found on individual A-2.**

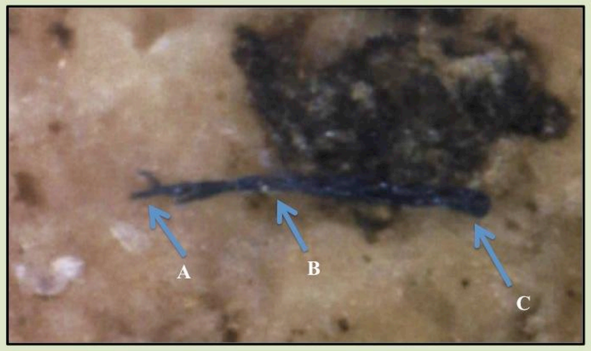


**Fig. 6: RLM image of blue twisted fiber found on individual A-4.**
**A. Twisted end of the fiber.**
**B. Thin film of calculus over the fiber.**
**C. Fiber entering the matrix**

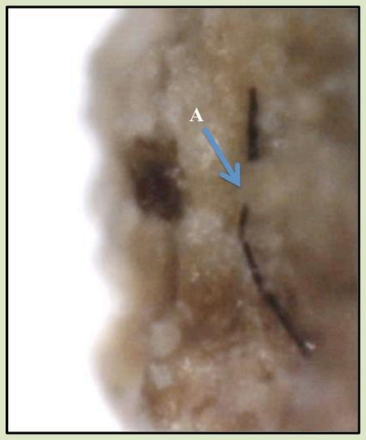


**Fig. 7: Embedded black fiber, A-4.**
**A. Fiber entering and exiting the matrix.**

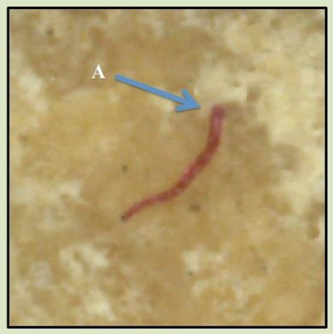


**Fig. 8: RLM image of embedded red fiber.**
**A. Fiber entering the matrix.**

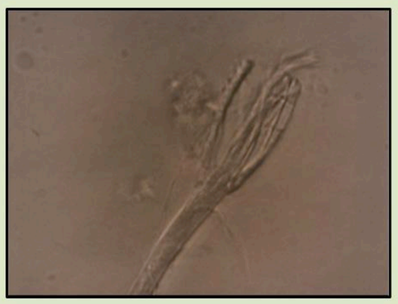

**Fig. 9: TLM image of twisted fiber found on individual A-4 after P2.**

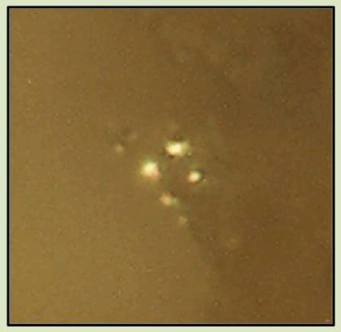

**Fig. 10: RLM image of starch grain before P2.**

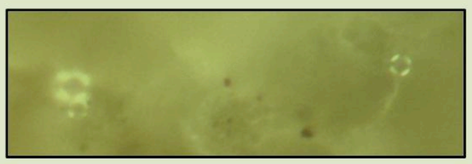

**Fig. 11: TLM image of starch grains after P2.**