EUROPEAN SYNCHROTRON RADIATION FACILITY

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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** An examination of root dentine translucency and its correlation to chronological age at death in a known-age archaeological assemblage	**Experiment number**: EC-1019
Beamline: ID17	**Date of experiment**: from: Nov. 28, 2012 to: Dec. 1, 2012	**Date of report**: March 8, 2013 *Received at ESRF:*
Shifts: 9	**Local contact(s)**: Dr. Paul Tafforeau	

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Report:

The preliminary results obtained at the ESRF bring optimism to adult age-at-death estimation in archaeological remains, a science that has been notoriously difficult to ascertain. We use root dentine translucency (RDT), which is the gradual infilling of tooth root dentine tubules, as a measure of age at death.

Adult tooth roots appear translucent because the occluding mineral has a refractive index similar to the inter-tubular dentinal matrix, allowing light to pass unscattered. Mineral occlusion first appears at the root apex. With age it then advances coronally towards the cementum-enamel junction and medially from the cementum-dentine junction towards the root canal – beginning first on the mesial and distal sides and spreading towards the buccal and lingual sides with increasing progression along the root length. It is a three-dimensional phenomenon.

In archaeological material, diagenetic changes both on the tooth surface and within the tooth have made RDT difficult to measure using conventional techniques, especially when specimens must remain undestroyed. The approach taken at the ESRF has three main advantages: (i) non-destructive; (ii) takes into consideration the three-dimensionality of mineral occlusion; (iii) measures changes in density, which are more direct and objective than conventional measures of translucency.

The method taken in November 2012 involved scanning archaeological teeth of known age-at-death in bunches of 35 to 67 teeth at 45.96 microns, 100KeV on ID17. In total 319 teeth were scanned at conditions idealized for a dry sample. Scans at 16-bits were used for analysis. Each tooth was virtually extracted from the bunch in VGStudioMax 2.2 to create a new volume. According to the following method, standardized thresholding steps were applied to each tooth to isolate the core dentine and to create a histogram of density within this volume. First a preset filter was applied to isolate the whole tooth. A second preset filter was applied to isolate the core dentine. This core dentine region of interest was sequentially opened +1, closed -1, and eroded -4 in VGStudioMax 2.2 to further isolate the core dentine from both the cementum and the peripheral dentine, which has been shown to demonstrate a translucency that is uncorrelated to known age. The core dentine was then put through a median filter 5 and a final preset was applied to the histogram of the resulting volume. Density measures in the root dentine from these final volumes were correlated to known ages.

Preliminary results show that the 77 non-carious canines from 52 individuals had a Pearson correlation, r=0.73 (Fig 1), suggesting that canine root density is a statistically strong and significant predictor of age-at-death in these archaeological remains. Densities of teeth belonging to the same individual were averaged. Results from analyses of other non-carious teeth are summarized in Table 1. When tooth types were combined into larger groups, correlations on the whole tended to be statistically weak. The noted combination that produced a strong and significant correlation comprised canines and upper incisors; however at the current stage of analysis, a biological explanation cannot be made for this result. Figure 2 illustrates the progression of density changes with age in the group of upper incisors.

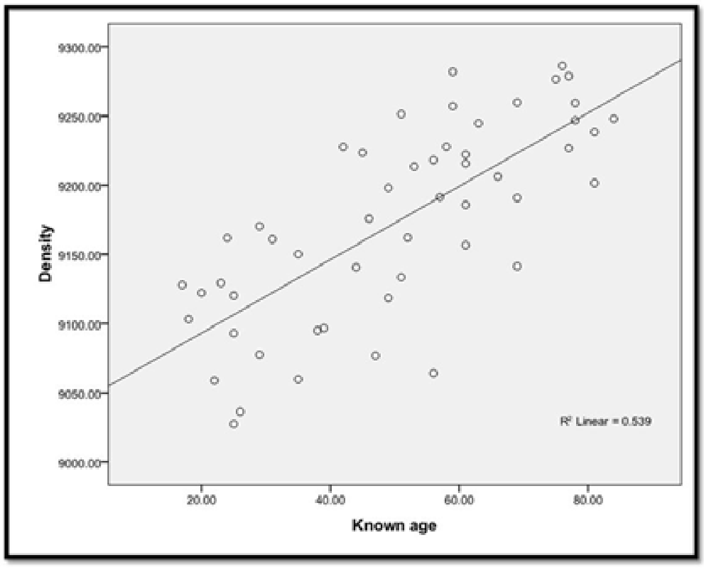

Figure 1. The relationship between known age at death (years) and root density in a collection of St. Luke's canines.

Table 1. Pearson correlation coefficients between root density and known age-at-death categorized according to tooth type and group.

Tooth Type	Number of teeth (number of individuals)	Pearson Correlation
Upper first incisors	6 (6)	0.74
Upper second incisors	3 (3)	0.71

Tooth Type	Number of teeth (number of individuals)	Pearson Correlation
Upper incisors	9 (7)	0.88
Canines	77 (52)	0.73
Canines + Upper incisors	86 (58)	0.74
Lower first incisors	9 (8)	0.72
Lower second incisors	10 (9)	0.80

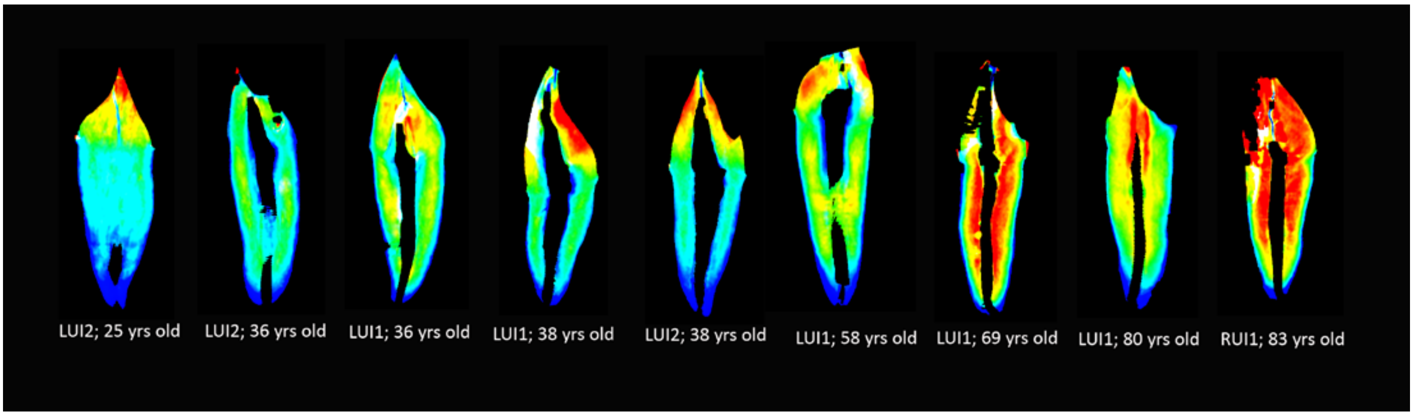

Figure 2. Qualitative visualization of density changes with age in the upper incisors. Least dense is dark blue, followed by cyan, green, yellow, and most dense is red. LUI1: left upper first incisor; LUI2: left upper second incisor; RUI1: right upper first incisor.

Further analysis of the premolar and molar groups will help elucidate the current method for analysing density changes in root dentine. It is possible that because of differences in root shape, preset density thresholds will need to be tooth type specific; this is something that will be further explored in the coming months. Further work also includes measuring density in different parts of the root as well as analysis of carious teeth and their fit into the regression lines.

It is also possible that some teeth are less susceptible to diagenetic change than others and thus will be better indicators of age at death. Photographs of all of the intact teeth positioned against a light box have been previously made to visually record RDT. From these images, anomalous patterns of mineralization have been identified. Another aspect of analysis in the coming months is to analyze patterns of density within the tooth to differentiate mineralization due to diagenetic change and mineralization due to peritubular dentine occlusion.

To the best of our knowledge the current results indicate the strongest and most objective relationship observed between RDT and known age at death for an archaeological tooth group. More works needs to be performed on the current data set. However, it is with great hope that by combining these results with a more in-depth analysis of mineral occlusion at the tubule-level, we will strengthen the study for a significant contribution to adult age-at-death estimation in archaeological material.