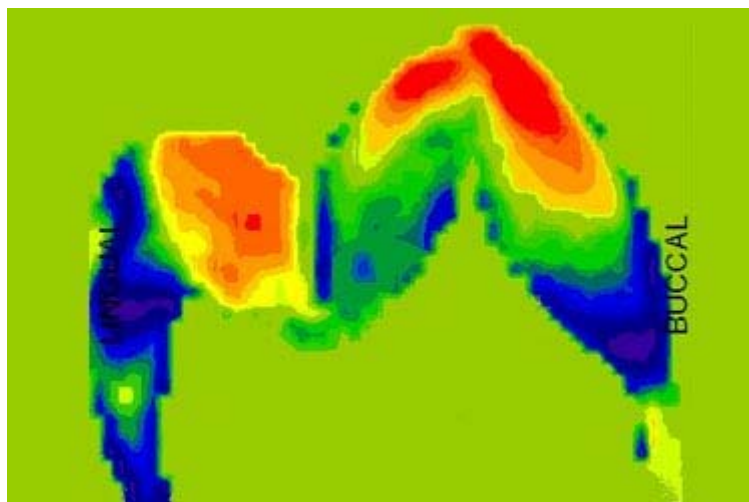


Poster Prize for IMR Student

Date: Sep 23, 2008



Congratulations to IMR PhD student Lisa Simmons who won a poster prize at the UK Synchrotron Users Meeting held at Daresbury Laboratory on September 11-12th.

Lisa has been working with final year Physics BSc student, Khadijeh Abboud to determine the texture in human dental enamel in 3-dimensions. In the poster Lisa presented the results of a two Synchrotron X-ray diffraction experiments on the XMaS beamline where the crystallographic parameters of the enamel hydroxyapatite phase across whole intact teeth sections had been determined, and 3-d maps of the texture deduced.

This work is part of an extremely active collaboration between the IMR at Salford and colleagues in Leeds Dental Institute.

University of Salford
Institute for Materials Research

Three-Dimensional Mapping of Texture in Dental Enamel

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Introduction

- Dental enamel – complex predominantly of hydroxyapatite (HAP) – is the most mineralised and hardest biological tissue.
- During enamel formation, HA crystallites are laid down as a lamellar with cross-sectional dimensions of 50nm x 250nm and length up to ~1µm. Clusters of lamellae, known as prisms, contain around 1000 crystallites and are approximately 5µm in diameter and may be up to several millimetres long.
- Characterising the orientation distribution of anisotropic HA crystallites aids in understanding of enamel growth & formation of dental enamel, and provides insight into how synthetic enamel-like materials may be developed.

The orientation of prisms in enamel has been studied in the past using electron microscopy. However, this does not give quantitative information on the degree of alignment in different parts of a tooth. Prisms run from the dentin (root) to the enamel (crown).

Synchrotron X-ray diffraction can be used to determine the basic crystallographic parameters of the enamel HA phase across whole intact tooth sections. By reconstructing the 2D data analysis, we can explore crystallographic texture direction and distribution maps in three dimensions.

Experimental details

- Measurements were taken on the XMaS beamline at the ESRF using an X-ray wavelength of 0.022 Å, equivalent to X-ray energy of 55 keV.

500µm
300µm
200µm
100µm
50µm
20µm
10µm
5µm
2µm
1µm
500nm
200nm
100nm
50nm
20nm
10nm
5nm
2nm
1nm

Rietveld Refinement

- 2D diffraction scans fitted into 1D patterns for Rietveld analysis with GSAS – HA phase refined and the coefficients extracted from fit.

2D Texture Direction Maps

- Texture direction was measured in the 002 reflection using 2D diffraction scans.
- The direction of preferred orientation in the 002 reflection for each of the same upper incisor suggests there is a change in texture orientation through the tooth.

3D Texture Distribution Maps

- An in-house automated mapping procedure was written and used to map 1000 diffraction patterns in 3D space.
- The texture coefficients for the same lower premolar were extracted from the fit.

Conclusions

- Synchrotron X-ray diffraction is a powerful technique in the study of crystallography and microstructure of dental enamel. It will allow us to completely characterise the crystallographic properties of dental enamel in 3D and therefore allow optimised design of dental restorative materials and procedures. The technique could be equally successful in the study of other biological hard tissues, bioambers, and biological hydrocomposites.