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Nanostructure of the carious tooth enamel lesion

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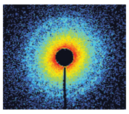
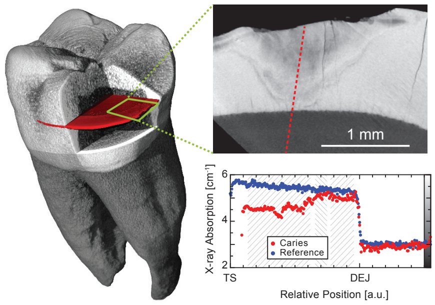
INTRODUCTION



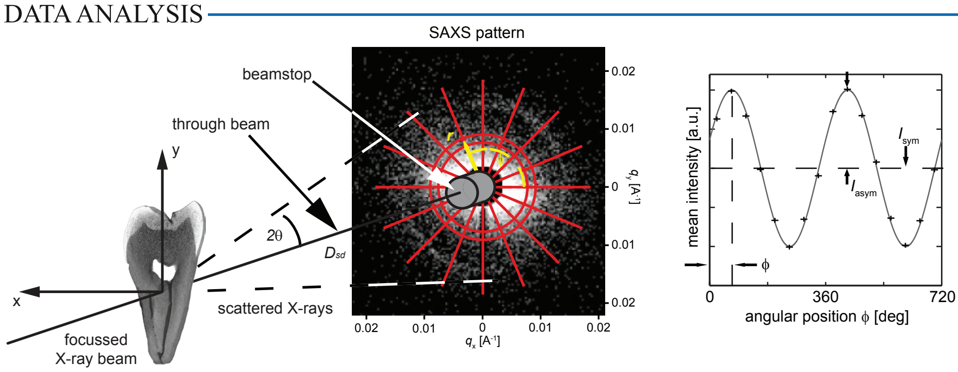
Carious lesions exhibit a complex structural organization – composed of zones of higher and lower mineralization - formed by successive periods of cyclic de- and re-mineralization. Thorough understanding of the lesion morphology is necessary for the development of suitable treatments, aiming at repairing rather than replacing the damaged tissue. Scanning small-angle X-ray scattering with pixel size of 20 × 20 μm² was used to characterize two lesions, allowing for the identification of distinct zones with varied absorption and scattering behavior, indicative of varied porosity and pore morphology.

CARIOUS SPECIMEN

A representative naturally occurring moderate smooth surface carious lesion, obtained from a third molar, extracted for clinical reasons, was studied. A 200 μm thin slice was cut in transverse direction from the specimen The synchrotron radiation-based micro tomography (SRμCT) measurements discerned three distinct zones in the lesion (surface zone missing).

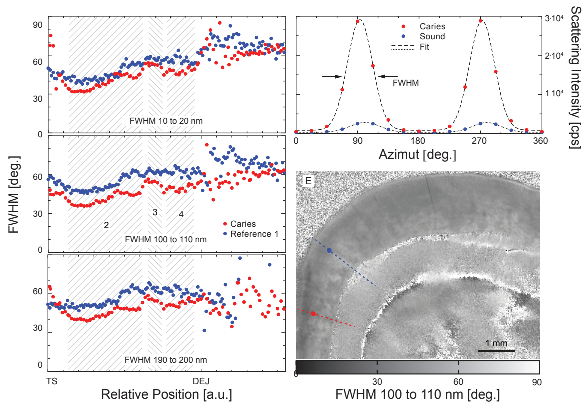


DATA ANALYSIS



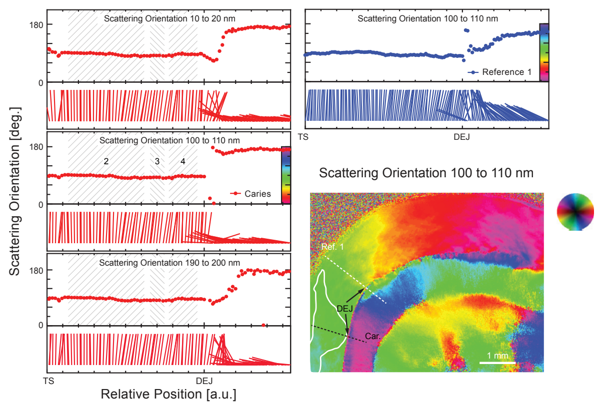
To process the high amount of information generated, automated analysis routines are needed. The first step in SAXS data analysis consists in a radial integration of the scattering patterns over sixteen radial segments in a specific q-range interval . The intensity in each circular segment is then plotted as function of its angular position ϕ. If the scattering pattern presents a moderate asymmetric intensity distribution, the plot is well approximated by a cosine curve. The mean scattered intensity, I_{sym} relates to the abundance of scattering centers in the selected q-range, while the amplitude of the cosine I_{asym} relates to their orientation. The phase ϕ yields the mean orientation of the scattering signal.

ANISOTROPY



The azimuthal plot around the direct beam of the total scattered intensity in a selected radial range, gives rise to two distinct peaks. The width of these peaks is closely related related to the anisotropic arrangement of the crystallites. Only a slight increase in SAXS anisotropy, can be found in the carious region, especially towards higher periodicities.

ORIENTATION



The color in the image shows the main orientation of the scattering signal for each point according to the color-wheel. The mean orientation of the scattering signal in healthy enamel is related to the arrangement of the crystallites running from the DEJ towards tooth surface. Carious enamel samples and their sound unaffected controls exhibited remarkably little difference.

CONCLUSION AND ACKNOWLEDGEMENT

The fact that both orientation and anisotropy of the SAXS signal from carious enamel closely resembled those from unaffected regions reinforces the notion that naturally occurring de- and re-mineralization produce an anisotropic structure that retains the original nanoscale organization. The retention of organization, despite de-mineralization, has important implications for the potential for interventions to not only re-mineralize de-mineralised enamel, but to do so in the original organizational form at the nanostructural level.

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