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Ptychographic X-ray nanotomography: a new insight into the most primitive vertebrate skeleton

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Conodonts are an extinct group animal that have been suggested as the first vertebrates to possess a mineralized skeleton manifest as an oropharyngeal feeding apparatus. As such, the conodont skeleton is of great significance because of the insights it provides concerning about the biology and function of the most primitive vertebrate skeleton. However, the origin of this skeleton, the histological and developmental differences between the different groups of conodonts (proto-, para- and euconodonts), even their relationship with the rest of the vertebrates, remain controversial. It has been argued that the most primitive vertebrate skeleton occurs in the extinct euconodonts. However, the origin of the euconodont skeleton, and its relationship to the proto- and paraconodonts, remain under debate. Morphological, histological and stratigraphical data indicate that euconodonts evolved from paraconodonts, while the relationship with protoconodonts is unclear. A nanoscale characterization of the skeletal tissues in these groups will settle debate and finally resolve this 150 years old scientific controversy. The preliminary results using ptychographic nanotomography on the cSAXS beamline confirm the potential of this technique to characterize fully the nanostructure of the conodont tissues. To reach our goals we scanned different regions of interest within 5 specimens of the earliest representatives of conodonts: Phakelodus (a protoconodont), Furnishina (a paraconodont), Procondontus and Teriodontus (euconodont), as well as chaetognaths spines of Sagitta sp. (a proposed relative of the protoconodonts). The nanometrical resolution, with a voxel size of 0.0438 microns, showed subtle detail in the Calcium Phosphate material from which the elements are comprised, facilitating the recognition of significant small vacuities, growth lines, and tissue layers of differing density. These preliminary result from ptychographic nanotomography permit a detailed characterisation of the physical structure of proto-, para- and euconodont elements which will help us to test the hypothesis of relationships between paraconodonts and euconodonts, and the homology or analogy of conodont and vertebrate skeletal tissues, providing a direct insight into the evolutionary origin of the vertebrate skeleton.

Primary author: Dr MARTÍNEZ PÉREZ, Carlos (University of Bristol, School of Earth Sciences)

Co-authors: Dr GUIZAR-SICAIROS, Manuel (Paul Scherrer Institut); Prof. DONOGHUE, Philip (University of Bristol)

Presenters: Dr MARTÍNEZ PÉREZ, Carlos (University of Bristol, School of Earth Sciences); Dr GUIZAR-SICAIROS, Manuel (Paul Scherrer Institut)

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