EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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:** 3d histological structures of early gnathostome scales revealed by synchrotron radiation x-ray microtomography, and its application to the deep phylogeny of jawed vertebrates	**Experiment number**: EC 1033
Beamline:	**Date of experiment**: from: 21/02/2013 to: 23/02/2013	**Date of report**: 31/08/2013
Shifts:	**Local contact(s)**: Bonnin Anne, Paul Tafforeau	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Qingming Qu*, Department of Organismal Biology, Uppsala University, Norbyvägen 18A, 752 36 Uppsala, Sweden;

Sophie Sanchez*, Department of Organismal Biology, Uppsala University, Norbyvägen 18A, 752 36 Uppsala, Sweden;

Henning Bolm*, Department of Organismal Biology, Uppsala University, Norbyvägen 18A, 752 36 Uppsala, Sweden;

Per E. Ahlberg*, Department of Organismal Biology, Uppsala University, Norbyvägen 18A, 752 36 Uppsala, Sweden;

Report:

Experiment:

This scan session was aimed to image the trunk scales from selected early jawed vertebrates in order to have a comparative dataset. Several large placoderm (*Romundina*) scales were imaged at 1.4µm with half-acquisition mode, in order to get full view of the speciemens. The we used 0.678µm resolution to image other types of scales, including some representitive acanthodians and early osteichthyans. The crown part of placoderm scales were also imaged at 0.678µm.

The scan session allows us to start building up the dataset to study the growth patterns of polyodontode scales of early jawed vertebrates. It further proves that the PPC-SRµCT is the best tool to study the 3D histology of vertebrate microfossils at high resolution. The growth model of the *Andreolepis* (early bony fish) scale has been reconstructed and the related paper has recently been published. The *Psarolepis* scale model and an acanthodian scales model have been partially finished and the two papers are in preparation.

Publication abstract:

Qu Q, Sanchez S, Blom H, Tafforeau P, Ahlberg PE (2013) Scales and Tooth Whorls of Ancient Fishes Challenge Distinction between External and Oral 'Teeth'. PLoS ONE 8(8): e71890. doi:10.1371/journal.pone.0071890

The debate about the origin of the vertebrate dentition has been given fresh fuel by new fossil discoveries and developmental studies of extant animals. Odontodes (teeth or tooth-like structures) can be found in two distinct regions, the 'internal' oropharyngeal cavity and the 'external' skin. A recent hypothesis argues that regularly patterned odontodes is a specific oropharyngeal feature, whereas odontodes in the external skeleton lack this organization. However, this argument relies on the skeletal system of modern chondrichthyans (sharks and their relatives), which differ from other gnathostome (jawed vertebrate) groups in not having dermal bones associated with the odontodes. Their external skeleton is also composed of monoodontode 'placoid scales', whereas the scales of most early fossil gnathostomes are polyodontode, i.e. constructed from several odontodes on a shared bony base. Propagation phase contrast X-ray Synchrotron microtomography (PPC-SRmCT) is used to study the polyodontode scales of the early bony fish *Andreolepis hedei*. The odontodes constructing a single scale are reconstructed in 3D, and a linear and regular growth mechanism similar to that in a gnathostome dentition is confirmed, together with a second, gap-filling growth mechanism (Fig.1). These results contradict the hypothesis that oropharyngeal and external odontode skeletons are fundamentally separate and suggest that the importance of dermal bone interactions to odontode patterning has been underestimated.

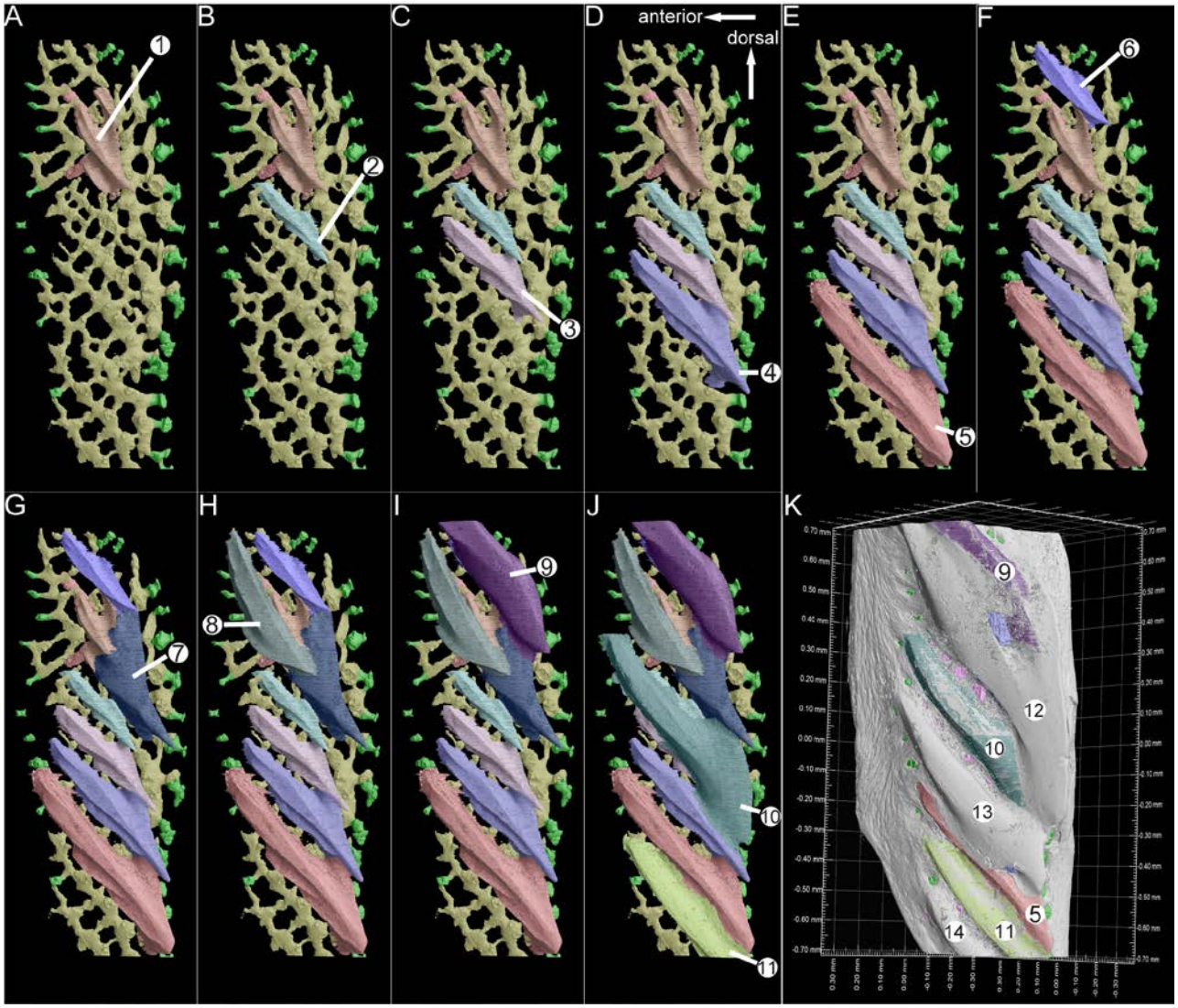

Figure 1. The reconstructed growth pattern of odontodes in the scanned scale of *Andreolepis*, crown view. A-J. The referred sequential addition of odontodes ① – ⑪ in the crown of the scale. The first generation odontodes (odontodes ① – ⑤, see text) form a growth series, but the other younger odontodes (⑥ – ⑭) do not necessarily fall neatly into the same sequence even though they generally continue to get larger; the yellow horizontal vascular canal system is used as landmark to show the positions of the odontodes K. Crown view of the scale with buried odontodes, showing the actual surface composition of the scale. Note that the most dorsal denticles compose the enamel layers from both odontode ⑨ and ⑫, odontode ⑨ is partially overlapped by ⑫; odontode ⑩ is only overlapped by ⑫ and ⑬ posteriorly and exposed to the surface otherwise.