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:** Three-dimensional investigation of muscle attachment architecture on dermal bones in primitive recent fishes	**Experiment number**: EC 519
Beamline: ID 19	**Date of experiment**: From: 24/10/2009 to: 26/10/2009	**Date of report**: 01/03/2012
Shifts: 6	**Local contact(s)**: Paul Tafforeau	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

Experiment:

The aim of the experiment was to do a series of scans at medium and high resolution, i.e. with a voxel size ranging between 7.46 and 0.678µm to compare the microanatomical organization between regions with and without muscle attachment. During this first scan session, we decided to focus on the areas free of muscle attachment. It is necessary to understand first the 3D microanatomical and histological organization in regions where there is no biomechanical constraints to properly analyse that kind of disturbance then.

Preliminary results:

Thanks to this scan session we were able to visualize and describe the dermal bone growth of early gnathostomes in three dimensions. It seems that dermal bone organization has been greatly conserved in the evolutionary history of jawed vertebrates (Fig. 1).

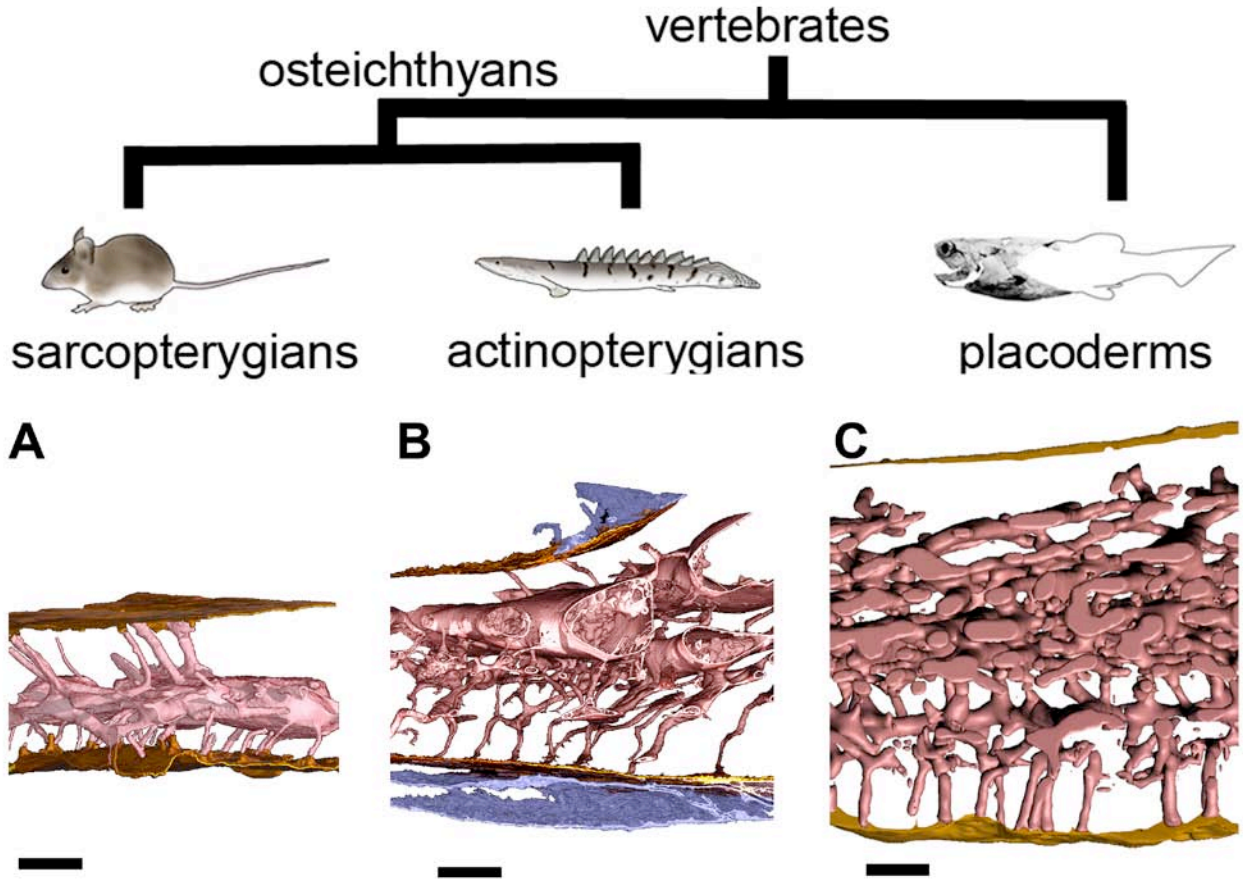

Figure 1: A-C, 3D models of dermal bone vascularization in the tetrapod (sarcopterygian) Rattus (A), the actinopterygian Polypterus (B), and the placoderm Compagopiscis (C). Transverse sections, external surfaces at bottom. In all groups the core of the bone consists of a surface-parallel network of large vascular spaces. External and internal to this, some small radial canals cross the periosteal bone up to the surface.

Its pattern could therefore be a great source of information for understanding the evolution of the different models of bone ossifications we know today. In order to confirm (or not) these preliminary hypotheses, we plan to image more dermal bones among other species

of placoderms at different ontogenetic stages. These scans should be done in July 2012 during the second session of the experiment EC-770.

Congress abstract:

Sanchez S., Dupret V., Ryll B., Trinajstic K., Wretman L., Zylberberg L., Tafforeau P. & P. E. Ahlberg. 2011. 3D Bone microstructures of the placoderm *Compagopiscis* (Gogo formation, Australia) revealed by Synchrotron virtual palaeohistology. *13th Conference on Australasian Vertebrate Evolution Palaeontology and Systematics, Perth (Australia).*

Usually only the teeth and bones (and other hard tissues) of animals are preserved as fossils and accessible for palaeontological studies. This mode of preservation has necessitated that palaeontologists use a comparative anatomical approach to reconstruct phylogenetic relationships or infer palaeobiological reconstructions. Until recently, supplementary microanatomical and histological information could only be obtained by sectioning fossil bones (*e.i.* in an irreversible destructive way). Today, we show that phase-contrast based synchrotron virtual palaeohistology not only allows the preservation of the fossils from any mechanical or chemical damage, but it also reveals the 3D architecture of fossil bone tissue up to the micron scale.

Within the framework of understanding the early evolution of bone tissues throughout gnathostomes, we present here results on the Australian placoderm *Compagopiscis croucheri* (Frasnian). The 3D organization of the vascular network and bone cells clearly shows three distinct layers: the external layer presents a lamellar structure with aligned cell lacunae parallel to the surface of the bone; the middle core is cancellous and presents a lamellar circumferential structure; the innermost layer progressively transits towards a horizontal lamellar structure. The discontinuity between the 3D architectures of the external layer and the cancellous core indicates the operation of two distinct processes of growth, which could not have been distinguished from observations of 2D thin sections. These preliminary observations suggest that previous models of dermal bone growth in gnathostomes require to be deeply modified.

Not only informative on bone growth, synchrotron approach also allows a better understanding of the nature of soft tissue attachments (*e.g.,* direct muscle attachment, tendon) and the orientation of their anchorage. Based on such 3D data in the branchial area of *Compagopiscis croucheri*, we have been able to determine the location of at least two muscles: one inserted on the ventral part of the gill skeleton (basibranchial complex, hypobranchials or hypohyals) and another one probably inserted on the posterior part of the ceratohyal or on the ceratobranchials.

Based on these preliminary results, synchrotron virtual palaeohistology promises to be a powerful tool for a better understanding of bone histology and palaeobiological reconstructions of soft tissues.