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*

Deadlines for submission of Experimental Reports

Experimental reports must be submitted within the period of 3 months after the end of the experiment.

Experiment Report supporting a new proposal ("relevant report")

If you are submitting a proposal for a new project, or to continue a project for which you have previously been allocated beam time, you must submit a report on each of your previous measurement(s):

- even on those carried out close to the proposal submission deadline (it can be a *"preliminary report"),*
- even for experiments whose scientific area is different form the scientific area of the new proposal,
- carried out on CRG beamlines.

You must then register the report(s) as "relevant report(s)" in the new application form for beam time.

Deadlines for submitting a report supporting a new proposal

- 1st March Proposal Round - **5th March**
- 10th September Proposal Round - **13th September**

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.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the experiment number 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:** Endoskeletal bone in a shark-like early vertebrate	**Experiment number**: **LS-2541**
Beamline: ID19	**Date of experiment**: from: 24 Sept. 2016 to: 26 Sept. 2016	**Date of report**: 26/02/2020
Shifts: 3	**Local contact(s)**: Paul Tafforeau	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

***Mr Richard Dearden, Imperial College London**

Dr Martin Brazeau, Imperial College London

Report:

The aim of this experiment was to investigate and characterise the nature and morphology of an unusual tissue, possibly endochondral bone, in an exceptionally well-preserved fossil of *Diplacanthus*, a Middle Devonian "acanthodian" member of the cartilaginous fishes (sharks, rays, and chimaeras). A secondary aim was to characterise the gross morphology of the head, jaws, and gill arches for comparative anatomical purposes. In the experiment we acquired two datasets: a higher resolution dataset of 0.55 μm targeting the structure of the tissues in a specific part of the head and a lower resolution dataset of 2.26 μm voxel size visualising the entire specimen's skeleton. Both of these datasets were successfully processed in VG studio Max and Mimics v16 (Materialise) respectively.

The high resolution dataset revealed that the tissue in which the skeleton of this animal is preserved is in fact not bone, but calcified cartilage. The dataset clearly shows that the tissue comprises an avascular matrix punctured by lacunae for chondrocytes. In places rings and lines of Liesegang, indicating incremental growth, can be observed. The lacunae appear to be organised into chondrons, as in living jawed vertebrates. This data provides the most detailed glimpse we have into the three-dimensional organisation of early jawed vertebrate cartilage, and provides a valuable comparative datapoint for those studying this and the evolution of other jawed vertebrate endoskeletal tissues, such as bone.

The low resolution dataset provided extensive three-dimensional information on the morphology of the jaws, gill arches, and braincase of *Diplacanthus*. Broadly speaking the morphology of the braincase, branchial arches, and jaws in *Diplacanthus* are similar to that of *Acanthodes*, the only other "acanthodian" in which these anatomies are fairly completely known. In itself however this provides valuable information on the likely phylogenetic relationships in early chondrichthyans, bolstering ideas of a separation between "*Acanthodes*-like" acanthodians, including *Diplacanthus*, as the sister-group to

all other more shark-like chondrichthyans. *Diplacanthus* is only the third 3D “acanthodian” endoskeleton known to science and we expect it provide important data for early vertebrate comparative anatomists.

The results of this experiment are currently in preparation for submission as two separate articles: one on the structure and comparative anatomy of the cartilaginous tissue of *Diplacanthus,* and another on the gross morphology and comparative anatomy of its braincase, jaws, and gill arches. Meanwhile, full details, descriptions, and images of both of these datasets are available to view in the PhD thesis of Richard Dearden, which can be found at the following link. Chapters 4, 5, and 6 contain data from this experiment.

https://drive.google.com/file/d/14FynhCihUDo7LjE4XE6ZjlWmcphc9wso/view