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:** Imaging the unexpected dentitions of the most primitive jawed vertebrates	**Experiment number**: ES-673
Beamline: ID19	**Date of experiment**: from: 1. 11. 2017 to: 18. 2. 2018	**Date of report**: 5. 3. 2018
Shifts: 12	**Local contact(s)**: Vincent Fernandez, Paul Tafforeau	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report: The main aim of the experiment was to use propagation phase contrast synchrotron microtomography (PPC-SRμCT) to investigate the anatomy and histology of dentitions from primitive jawed vertebrates of Silurian and Devonian age from the Prague Basin (Czech Republic) and Yunnan (Southwest China). ES-673 was a follow-up beamtime application of project ES-505. 10 specimens from the collection of the National Museum in Prague were chosen for anatomical lower resolution scans and an additional 4 specimens for high resolution histological spot scans. 40 specimens from the Chinese material have been scanned in total, 4 of them as high resolution spot scans.

The experiment was performed according to plan in 12 shifts. One to several specimens of similar size were stacked vertically in plastic tubes and PPC-SRμCT scanned at once, which proved to be a very effective method and allowed successful imaging of all of the extremely important material from the National Museum in Prague and the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing as well as additional specimens borrowed from Russian, American, Australian, Swedish and British colleagues.

In the first session (1. - 6. November 2017) a total of 50 specimens were PPC-SRμCT scanned at lower resolution (voxel size 12,86 μm). Subsequently, histological resolution spot scans (voxel size 0,67-0,72 μm) were performed on 16 specimens mounted individually. The additional session on 17. February 2018 was focused on rescanning 8 problematic but very important specimens in lower resolution (voxel size 11,35 μm). We received the data from the first session at the beginning of 2018 and are still waiting for some of the data from the second session. At the moment we are in the process of creating projects in 3D rendering software (Mimics Research 19.0, VG Studio Max 3.1) and evaluating the obtained data. Most of the scans prove to be very informative. The contrast between bone and matrix is generally good, making modelling fairly easy.

The preliminary results already demonstrate a very good histological preservation of dentition of the Prague Basin acanthothoracids, for example in the tooth-bearing element of *Radotina* (Fig. 1) where individual cell spaces are visible. The subsequent rendering will show the vascular architecture of the teeth and basal bone, the sequence of addition of the teeth, the tissue composition of the teeth, and any buried resorption surfaces that may be present.

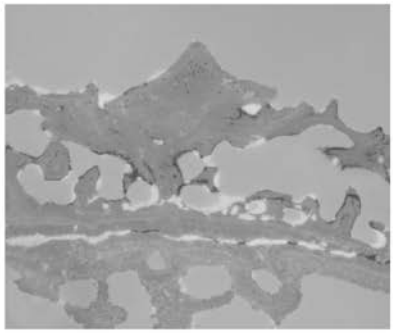

Fig. 1

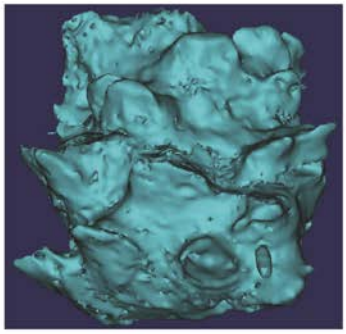

Fig. 2

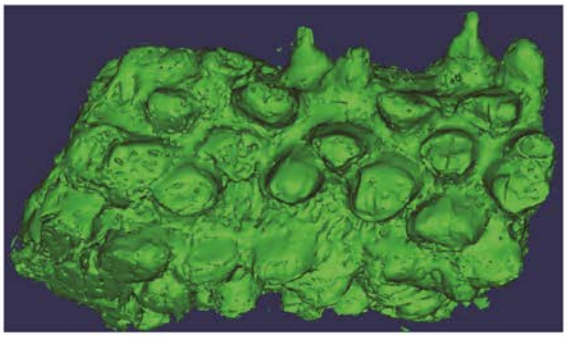

Fig. 3

Another important preliminary result is the discovery of a tooth-bearing element in a supposed new placoderm genus from the Lochkovian (Lower Devonian) of the Prague Basin. This element (Fig. 2) differs substantially from other known dentitions discovered during project ES-505, and thus validates the existence of a new taxon. This results in an even greater acanthothoracid placoderm diversity in the Lochkovian of the Prague Basin than previously expected. ES-673 also yielded a new tooth-bearing element of *Kosoraspis* (Fig. 3) with a morphology distinct from all the *Kosoraspis* dentitions discovered in project ES-505.

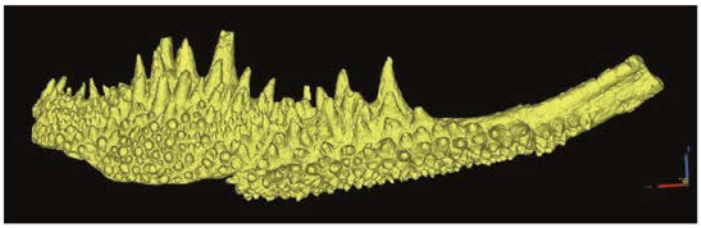

Fig. 4

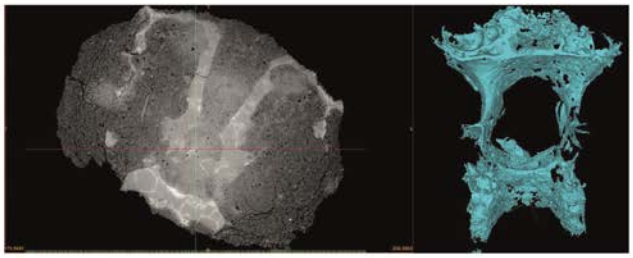

Fig. 5

The preliminary results of the Chinese material show that the preservation of histological details in some of the specimens from the Late Silurian of Yunnan is better than previously thought. The scans show the preservation varies between individual specimens. The teeth of osteichthyan lower jaws are generally well-preserved with details of structure such as dentine, pulp cavity, etc. Two mysterious dermal plates, possibly lower jaws that belong to an undescribed early jawed vertebrate, with numerous large acute teeth-like structure were scanned, the one scanned in high resolution is affected by recrystallization. The one in lower resolution (Fig. 4) shows very promising histological preservation and if investigated by higher resolution scanning, may very well help to further resolve the mystery of what these bones are and how they fit to the current framework of the evolution of the vertebrate skeleton.

The scanning result of *Entelognathus* holotype, a famous “transitional” fossil that combines a conventional placoderm body plan, and an osteichthyan jaw with marginal jawbones, also reveals previously unrecognized information regarding the inner dental arcade of jaw bones, and the opercular attachment to the cranium. The perichondral lining of the endoskeleton is also preserved well. The scanning results of the material from the Early Devonian Xitun Formation shows even better preservation of histological structure than the ones from the Late Silurian. Of particular interest is a tiny osteichyan skull previously diagnosed to be a *Youngolepis* juvenile scanned in 0.4 μm spatial resolution (Fig. 5).

The results of ES-673 will greatly enhance our understanding of the origin of the vertebrate dentition, and will almost certainly have a major impact on the current phylogenetic consensus about placoderms and their relationship to the jawed vertebrate crown group. All the results from this project will be of substantial interest to the vertebrate palaeontology community and will be presented at major international meetings such as SVP, SVPCA and ICVM over the coming years. In terms of publications, we expect to submit a paper on the acanthothoracid dentition to *Nature* or *Science* once we have the histological data rendered. Descriptions of other aspects of the anatomy will most likely be targeted to high-visibility journals such as *Proceedings of the Royal Society*. We anticipate that ES-673 will produce at least 6-8 major descriptive papers (dealing with *Radotina*, *Kosoraspis*, *Tlamaspis*, several different early gnathostomes from Yunnan, and a unique tiny Late Devonian tetrapod skull from Russia) in addition to the dentition paper.