Digging virtually into large fossils using synchrotron X-ray microtomography

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Palaeontologists have become regular users of X-ray computed tomography (CT) facilities to study fossils in a non-destructive way. Beyond the conservation aspect, X-ray CT offered the possibility to study samples in 3 dimensions, gaining extra information. The use of synchrotron radiation as a source was driven by specific characteristics. The brilliance, parallel geometry, and coherence of the beam participated in opening new opportunities compared to laboratory sources. At its debut, synchrotron light source experiments focussed mostly on small fossils, benefiting of the partial spatial coherence of the beam to use propagation phase contrast micro-CT. The increase in sensitivity from this technique allowed to show fossils that remained invisible with classical absorption based micro-CT [1-3]. Characterisation of large sample was challenging. While the synchrotron light is considerably more brilliant than laboratory sources, the energy available still limited sample to 15 cm in diameter, providing they were not abnormally dense (i.e., compared to common sedimentary rocks). The development of optics and other imaging protocols progressively allowed for horizontal field of view up to 25 cm, gradually introduced larger specimens. Combining the advantages of several beamlines (i.e. BM05, ID17 and ID19 at the ESRF), it was first possible to image specimens up to 25 cm in width and near 60 cm in length in their entirety, and then to focus on a region of interest at higher resolution [4,5]. The limit was hit with a large fossilised burrow cast enclosing skeletal material inside. The cast of the terminal chamber was excavated in two blocs of roughly 25x30x35 cm in size. For such a size, it was possible to either image each bloc individually on ID17 with a Germanium detector, but with a resolution so low that bones were almost invisible; or using the more coherent and more energetic beam of ID19 to reach 25 µm resolution and see the bones, limiting the analysed volume to a diameter of ~80 mm. While the equipment and synchrotron beam available before the EBS upgrade allowed the imaging of numerous iconic fossils (including several small sized dinosaurs and *Archaeopteryx*), the new ESRF-EBS and the new BM18 beamline should once more push this limits several steps further.

References

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