



	Experiment title: Using 3D tomographic scans to reveal exceptional mammal fossils from the Isle of Skye, Scotland.	Experiment number: ES-587
Beamline:	Date of experiment: from: 7 th April 2017 to: 11 th April 2017	Date of report: 6/2/20
Shifts:	Local contact(s): Vincent Fernandez	<i>Received at ESRF:</i>
Names and affiliations of applicants (* indicates experimentalists): Elsa Panciroli, National Museums Scotland, University of Edinburgh (at time of experiment, now University of Oxford) Stig Walsh, National Museums Scotland, University of Edinburgh Ian Corfe Stephen Brusatte, University of Edinburgh Florian Fousseis, University of Edinburgh		

Report:

Overview: The Jurassic rocks of Scotland have yielded an exceptional collection of early mammal fossils. Our knowledge of these animals is mostly based on rare, isolated fossil teeth. Bones from the rest of the skeleton are rare, and near complete skeletons rarer still. One such exceptionally complete fossil was found on the Isle of Skye in Scotland in 1973. Belonging to an early diverging member of the mammal lineage, this 165 million year old fossil could provide important information on the acquisition of mammal characteristics. Despite its importance, this fossil could not be successfully X-ray micro-CT (μ CT) scanned for digital reconstruction and study using lab-based μ CT, because the carbonate matrix has proved too dense for X-ray penetration without loss of contrast. Only a high-resolution synchrotron x-ray 3D tomographic scanning using phase contrast would permit the visualisation of the bones, and detailed study the anatomy of these critical fossils.

Experiment: The fossil mammal, nicknamed ‘Block A’ was scanned using propagation phase contrast X-ray micro-computed tomography. First, the whole limestone block was characterised at the ID17 beamline (Figure 1). The setup consisted of a 90 keV monochromatic beam (double bent Laue Si monochromator) and an indirect detector comprising a 350 μ m YAG scintillator, a two Hasselblad HC 100mm f2.2 Lenses set for a 1x magnification and a PCO.edge 5.5 generating images with an isotropic pixel size of 13 μ m, and then a subsection containing the palate and other cranial components was scanned to 6.15 μ m (Figure 1), and subsequently resampled to 12.3 μ m.

Results: It has been possible to reconstruct the partial skeleton of the fossil mammal from Scotland, using the scans acquired at ESRF (Figure 1). Data reconstruction and segmentation was carried out at National Museums Scotland by EP, using Mimics 19.0. Description of the partial skeleton is in the final stages. Initial

publications have already been made, including a detailed description of the petrosals (ear bones) (Figure 2) (Panciroli *et al.*, 2018), and the dentition (Panciroli *et al.*, 2019). Two further papers are in final stages of prep, detailing the morphology of the skull (Panciroli *et al. in prep.a*) and postcrania (Panciroli *et al. in prep.b*).

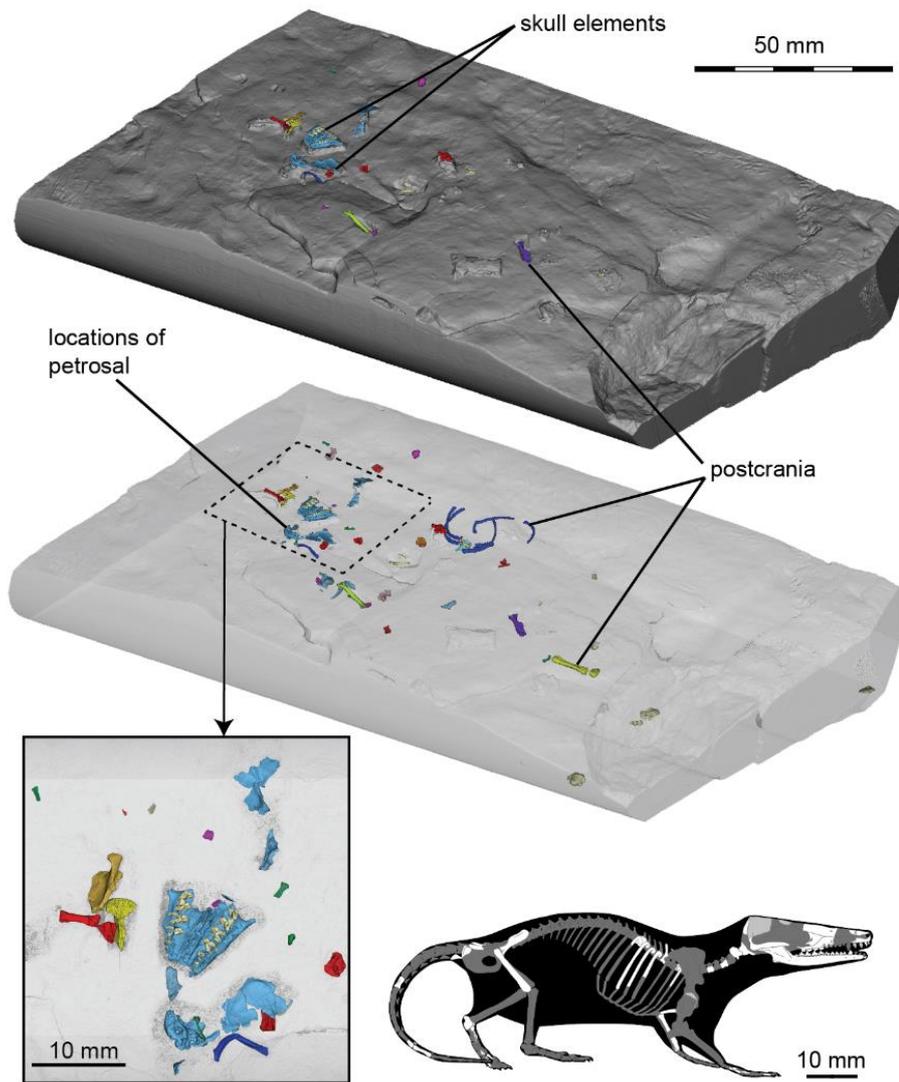


Figure 1: Digital reconstructions of 'Block A'. Top, 'Block A', and underneath it the same block with matrix semi-transparent to reveal fossil bones. Inset image of area containing skull, which was scanned at 6.15 µm resolution). Bottom right, initial full body reconstruction of fossil mammal from Scotland. Adapted from Panciroli *et al. in prep.a* and .b).

References:

- Panciroli E, Schultz JA, Luo Z-X. 2018. Morphology of the petrosal and stapes of *Borealestes* (Mammaliaformes, Docodonta) from the Middle Jurassic of Skye, Scotland. *Papers in Palaeontology* 5: 139–156.
- Panciroli E, Benson RBJ, Luo Z-X. 2019. The mandible and dentition of *Borealestes serendipitus* (Docodonta) from the Middle Jurassic of Skye, Scotland. *Journal of Vertebrate Paleontology* 39: p.e1621884.
- Panciroli E, Benson RBJ, Fernandez V, Butler RJ, Fraser NC, Luo Z-X, and Walsh S (*in prep*) New species of mammaliaform and the cranium of *Borealestes* (Mammaliformes: Docodonta) from the Middle Jurassic of the British Isles. (for submission to *Zoological Journal of the Linnean Society*)
- Panciroli E, Benson RBJ, Butler RJ, Fernandez V, Fraser NC, Humpage M, Luo Z-X, and Walsh S (*in prep*) The postcrania of two *Borealestes* species (Mammaliformes: Docodonta) and the emergence of ecomorphological diversity in early mammals.

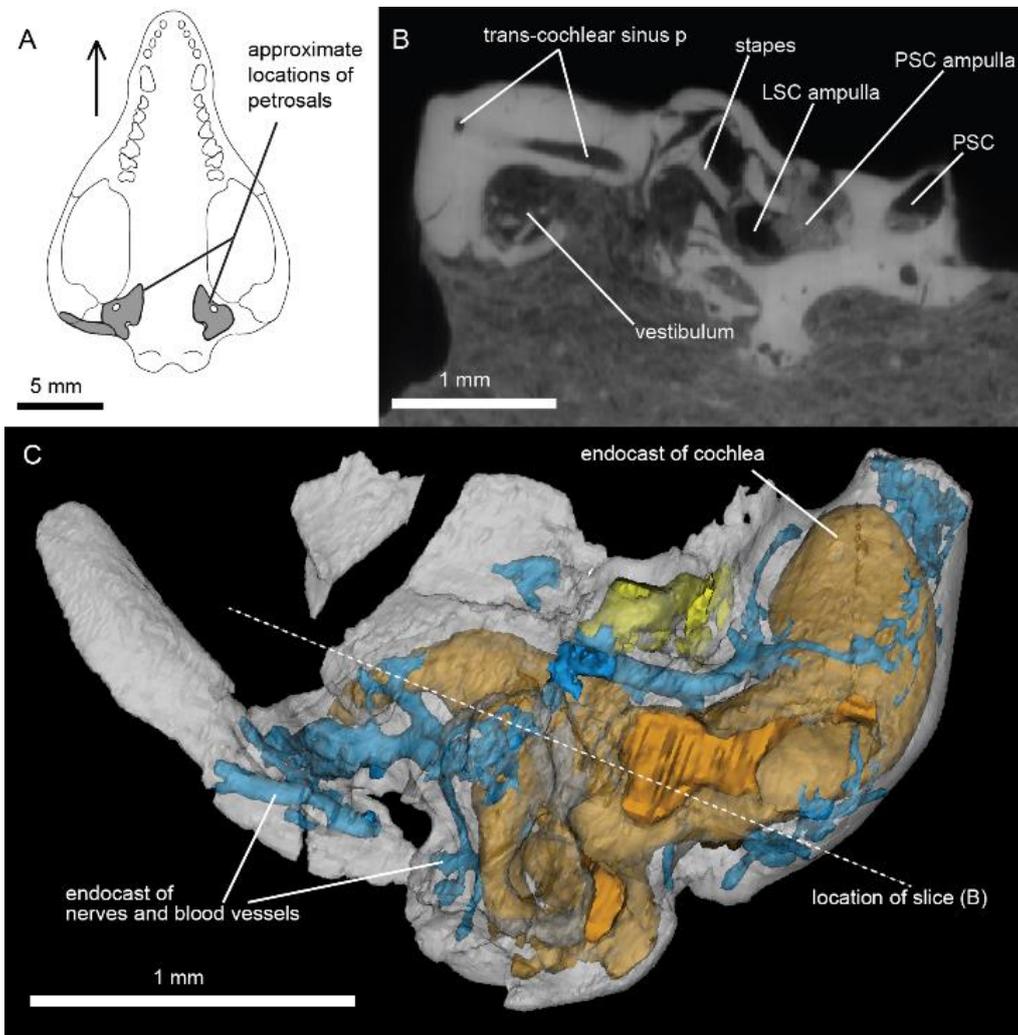


Figure 2: The right petrosal of fossil mammal. A, location of petrosals (ear bones); B, slice showing internal structures of the petrosal; C, digital reconstruction of petrosal, semi-transparent showing endocasts of vascular structures and cochlea. Adapted from Panciroli *et al.*, 2018)