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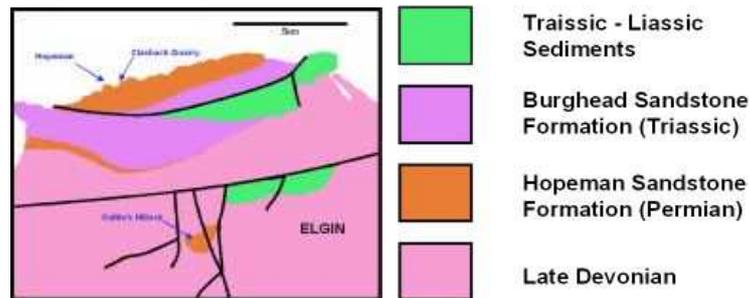
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## The Elgin Marvels – Neil D. L. Clark

Not to be confused with the Elgin Marbles, the Elgin Marvels actually come from the Elgin area of Scotland. They are well known fossil reptiles, and their footprints, of Permo-triassic age that were collected from old sandstone quarries mostly over a century ago. They are partly what inspired me to take up palaeontology, although I had never actually been to Elgin before, nor ever seen the fossils. It was through the lectures of Professor Euan Clarkson of Edinburgh University in the 1980s, that I first became aware of these animals, but it was not until much later that I came face to face with the Elgin Marvels.



Sketch map of the geology around Elgin

In the summer of 1996, whilst recovering from a broken leg as a result of dinosaur hunting on the Isle of Skye, I was asked to give a talk on my exploits at an Open University Summer School in Edinburgh. Most of the talk was concerned with the study of dinosaur footprints, their interpretation and identification. After the lecture, I joined the students in their usual nocturnal social discussion groups. It was at this time I was approached by one of the students who claimed to have seen some ancient footprints in the bedded sandstones near Elgin. The student, Carol Hopkins, invited me to Elgin to have a look at the footprints she had found. I could not pass the opportunity. As soon as I was able, I went to Elgin. Carol had undertaken some research into the history of fossil discoveries in, and around, Elgin and was able to confirm that what she had found were, in fact, previously unreported. I, for my part, was able to confirm that they were indeed footprints.



Set of very large footprints from Clashach Quarry first described in 1985 by Mike Benton and Alec Walker

Carol was inspired to look for more. She visited her local quarry at Hopeman and found a vast number of footprints being excavated from the Hopeman Sandstone Formation SSSI (Site of Special Scientific Importance) quarry at Clashach. Permission was obtained from SNH (Scottish Natural Heritage) because it was a SSSI, and the quarry owners, before the visit to Clashach Quarry, at Hopeman. The quarry had recently been reopened to supply stone for the facing of the new Museum of Scotland in Edinburgh. Sue Warbrick (then Area Officer for SNH in Elgin), taking an active interest in the quarry and the new discoveries that were being unearthed, often accompanied Carol on her forays. By 1997, Carol had investigated over 200 footprints and trackways with over 120 tail drags, and that was just the beginning! The tail drags were important as only 4% of previously known Permian trackways had tail drags. By 1999, Carol had investigated over 100 tail drags constituting over 40% of the trackways discovered.



Carol Hopkins recording some footprints in Clashach Quarry

The animals that were thought to have made the majority of the footprints were mammal-like reptiles. Many of the tail drags were straight suggesting that the animal did not move sinuously like a lizard does. The only place nearby where reptilian body fossils had been found in the past was at Cuttie's Hillock near Elgin. The Elgin reptiles included dicynodonts, a pareiasaur, and a possible procolophonid. The Cuttie's Hillock sandstones could be dated from these fossils as being of late Permian about 250 million years old. As the Hopeman Sandstone Formation lacked any identifiable, or dateable, fossils, it has been impossible to say exactly how old it was. We know that it is overlain unconformably by a Triassic sandstone, and that it consists of Aeolian dunes characteristic of both the Permian and Triassic, but tying it down more precisely was impossible.



*Gorderia traquairi* from Cuttie's Hillock in the collections of the British Geological Survey in Edinburgh

In September 1997, I invited Professor Hartmut Haubold, a World expert on Permo-triassic footprints, to visit Clashach. He was very excited about the footprints and was

able to suggest interpretations of some of the more confusing trackways. One in particular was very confusing. A three legged animal with a tail drag to one side and the footprints almost at right angles to the trackway direction, turned out to be an animal walking across the face of a steep dune. He stated that the footprints were of immense significance in helping to interpret a range of footprint types, better understand better the different states of preservation, and provide a useful reference resource for interpreting animal-environment interactions. All this was very interesting and useful, but I was greedy and wanted something that registered a little higher on the excitement chart.



Some of the various sizes of footprints found in Clashach Quarry

The month prior to this visit by Hartmut, Bill George, who worked in the quarry at Clashach, had found an intriguing rock with a hole in it. The rock was from the western end of the quarry where the rock was pink in colour. The rock that had been removed was too large for the lorry to transport and was split further in the quarry. When it was split, the hole was revealed. Carol and I had asked the quarrymen to look out for holes in rocks, not just the footprints, as these may represent the remains of fossil animals. No fossil bones had ever been found in the Hopeman Sandstone Formation except for a small unidentifiable fragment from Greenbrae Quarry in the 1960's, so this discovery was potentially an extremely important one. Carol had already measured the extent of the cavity using wire and determined that it went about 25cm into the rock. At that time, there was really only one way to deal with mouldic fossils, and cavities of all sorts, and that was to fill the space with rubber and smash it open with a hammer to remove the rubber. Luckily, I had decided that this was probably not the best way to investigate the cavity. I had previously done some computed tomography (CT) of a set of dinosaur eggs for the BBC's *Tomorrow's World*, and felt that this was a useful technique that could be applied to this situation as well. So, I removed the rock with the hole and took it back to Glasgow to be investigated further – with permission from Drew Bailey of the Moray Stone Cutters, and Susan Bennett of the Elgin Museum (who were ultimately receiving the rock into their collections).



The rock with a hole

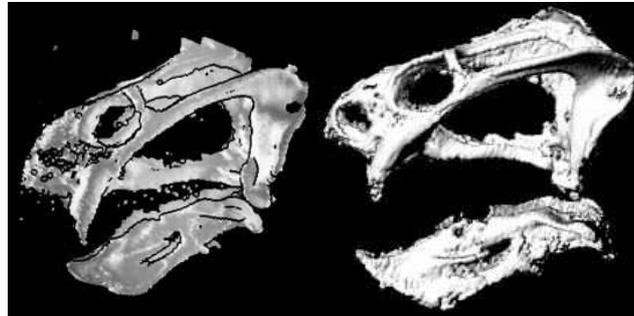
At the Western Infirmary in Glasgow, we performed some preliminary scans of the hole in the rock. It was not easy scanning through such a thickness of rock and the machine had to be tweaked close to its limits. Certainly beyond the safe limits for normal patient safety! I met Dr Calum Adams at this hospital, a consultant radiologist, who became intrigued by the scanning of this strange object. He moved to the Royal Infirmary in Glasgow and finally settled in the Royal Alexandra in Paisley where we continue to scan fossils during 'down-time', or for 'testing the equipment'. At each location he allowed me to bring the lump of rock from Clashach for scanning using both CT and Magnetic Resonance Imaging (MRI). As the CT produced its first scan, I was confused. What we saw was a Mickey Mouse-like image that was difficult to interpret. When all the scans were collected and collated into a 3-D composite, the nature of the hole in the rock became clear. It turned out to be the entire skull of the mammal-like reptile. How lucky was that!? The chances of the first recognisable fossil from the Hopeman Sandstone Formation being the entire skull of a mammal-like reptile, I suspect, was remote, but not only that, the size of the rock fragment in which it was enclosed was not much bigger than the skull itself!



One of the initial scans of the rock using CT

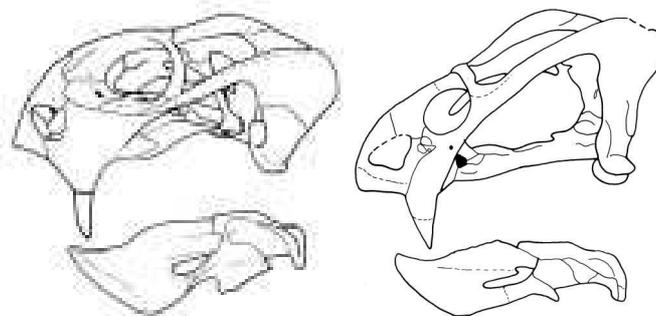
The MRI scanning was also useful as it showed exactly why the rubber technique may have caused the loss of crucial information. The lower jaw was not attached to the rest of the skull, so did not allow fluid to pass from the skull (which was open to the fractured surface of the rock). If rubber had been used, it would not have passed to the lower jaw which may have been damaged during the extraction process. As the MRI was providing slightly more detailed images of the skull, a CT directed drill hole was made at the point where the lower jaw was in closest proximity to the edge of the rock. After this, the rock was placed in a plastic box and filled with fluid to make the MRI scanning work. The whole process was so unusual that the BBC were interested

in doing another *Tomorrow's World* piece on this new technique for analysing fossils in a non-destructive manner. I'm just glad that no clips from the filming have been used in the many out-take programs that seem to be popular these days. Trying to explain the inner workings of an MRI in simple terms caused my tongue to become severely knotted on several occasions!



3-D images of the skull using CT (left) and MRI (right)

Anyway, the results of the research were that the skull was identifiable as being very similar to a known animal called *Dicynodon lacerticeps* from the Late Permian of South Africa. As it differed in some details, it could not be synonymised with this animal but can be shown to be the same as an animal closer to home. *Gordonia traquairi* is known from the Cuttie's Hillock sandstones to the west of Elgin along with a number of other species. Arthur Cruickshank, an expert in such animals showed that the beast of Clashach was, in fact, the same as *Gordonia traquairi* and that *Gordonia* is synonymous with *Dicynodon*. Sorting out taxonomic messes is not always easy, but the up shot of it is that the Clashach fossil skull is of *Dicynodon traquairi* ... for the time being at least! The fossil also helps us to date the rocks as Tartarian, Upper Permian.



Sketch of *Dicynodon lacerticeps* (left) and *Dicynodon traquairi* (right)

It is all very well relying on MRI and CT scans to identify fossils, but it is nothing like being able to handle something to complete the sensory experience. For a mere £1,000, I was able to convert the scans of the skull into a life-size solid 3-D stereolithographic prototype of the skull. This is now currently on display in the Hunterian Museum at the University of Glasgow. It is a whole new experience being able to handle a cavity in a rock in this way, and helps visualise it better.



Stereolithographic prototype of the hole in the rock

In March 1998, the quarrying was increased and put a number of critical footprints at risk of being destroyed. Sue organised a meeting to discuss the movement of the in situ footprints to a safe area outside the limits of the quarry. As a result, Drew Bailey of the Moray Stone Cutters kindly offered to move the slabs of sandstone containing footprints to a convenient spot forming an amphitheatre close to the coastal walk. SNH, the Hunterian Museum and the National Museums of Scotland in association with Carol produced some interpretation panels to be placed with the footprints. This fossil amphitheatre can still be visited on the coastal path just outside of Hopeman, near to Clashach Quarry.



Marker on the coastal path near Hopeman has a footprint carved into it. You may also be able to find real fossil footprints on the markers too.

All this seems like a nice story of how industry, palaeontologists, museums, heritage organisations, hospitals, students and amateurs can all work harmoniously together and produce important and exciting science. However, not all went well. One day while walking the beach with Carol and others, we noticed a square hole had been cut out of a slab of insitu sandstone. Someone had gone to a well known exposure of the Hopeman Sandstone Formation along the shore and taken a rock-saw to a few footprints. They had removed one of the better presented footprints and left others with just the cuts around them. Carol knew of these footprints and the local primary school used to take their pupils to examine them. It is unknown why the anonymous person removed the footprint, but they obviously had not thought about the potential impact on the local community, and not even asked permission from the landowners.

The National Museums of Scotland undertook to remove what was left of this vandalised trackway to serve as an example of inappropriate collecting by persons unknown. This year sees a set of guidelines for collecting fossils in Scotland published by SNH for public consultation following recommendations in the Nature Conservation (Scotland) act of 2004. The guidelines were drawn up by a large number of interested parties including landowners, landusers, commercial collectors, amateur collectors, professional palaeontologists and museum curators. The hope is that people collecting fossils in Scotland will follow the guidelines and collect responsibly. This would avoid situations where fossils are removed from exposures used frequently by schools, groups and individuals in the pursuit of greater geological knowledge and understanding. Have a read of the Scottish Fossil Code and see what you think <http://www.snh.org.uk/fossilcode/> . The consultation ends on the 7<sup>th</sup> September 2007. Its purpose is not to discourage fossil collecting but to encourage responsible collecting.



Footprints on the shore near Hopeman where one has been removed using a rock saw