Dinosaur Egg Structure Investigated by MRI

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Introduction
In July 1993, the Hunterian Museum of the University of Glasgow was offered a sandstone block with a clutch of intact dinosaur eggs, from Hunan Province, China. Later, a number of single eggs were also acquired.

An inter-disciplinary project began to investigate the structure of these eggs. Investigations carried out included egg shell structure analysis, protein analysis, and a program of imaging including CT|, neutron radiography, and MRI.

In this poster, the results of imaging the eggs in two commercial high field MRI scanners based at Glasgow hospitals, are presented. The MR scanners are Seimens 1.0 T Impact and 1.5 T Magnetom.

Egg Structure
The clutch of eggs is surrounded by a matrix of sandstone. Each egg is approximately 17cm in length and 8cm along the other axes. The 1mm egg shell is composed mainly of calcium carbonate. The sandy matrix is rich in quartz, mica, feldspar, clays and iron-oxide cemented by micritic calcium carbonate.

The egg shell has been compacted by the weight of over-burden and as a result has an extensive network of cracks covering the exposed surface. The single eggs examined are similar to those in the clutch below.

Methods
Due to the size of the specimen, the clutch of eggs was imaged in the body coil of a Seimens 1.0 T Impact MR scanner. A standard body loader and a bag of saline were used to load the radio frequency (rf) coil. Small oil capsules were used as markers. A simple SE (540/15) sequence was used, with 13 averages, and acquisition time of 30 mins for 256*256 matrix images.

In subsequent studies single eggs were used, and imaging protocol used the head coil to improve the available signal to noise ratio (SNR). A number of imaging sequences were run including spin echo (SE), short echo (FLASH) and one sequence with diffusion sensitivity. The FLASH sequence has an extremely short echo time of 4ms. This is useful when imaging samples with short T2 values, such as viscous fluids or semi-fluid samples. The diffusion sequence should distinguish between free and bound water in the sample.

Results

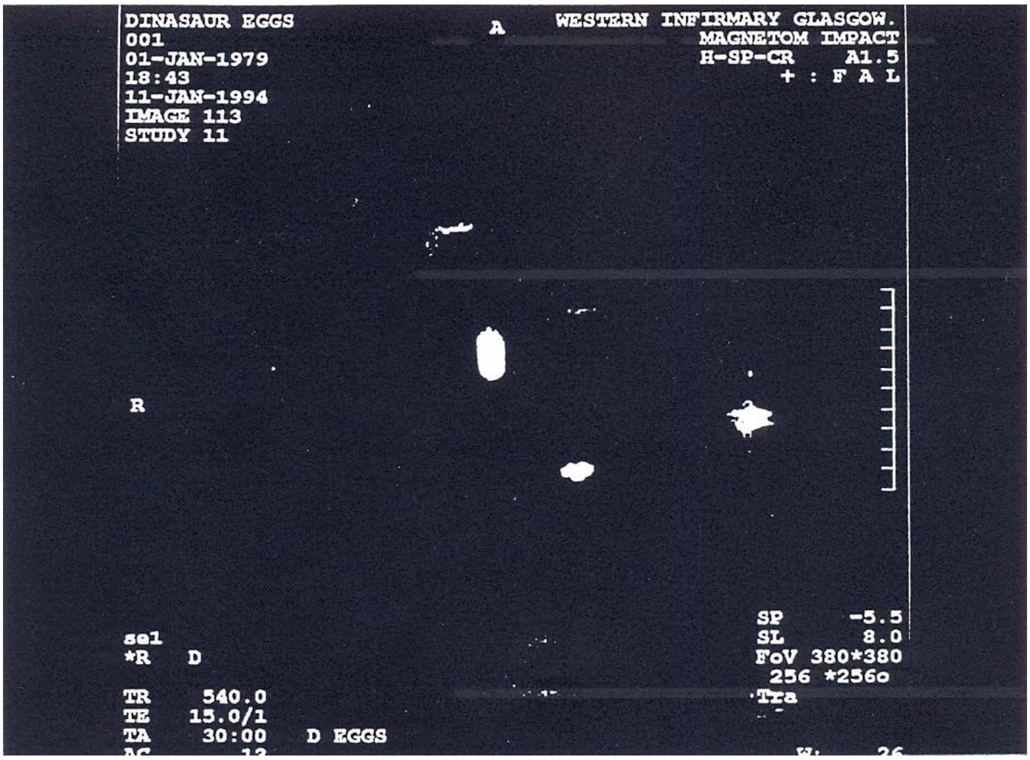

Fig 1. shows a 256*256 image of an 8mm slice through one of the eggs in the large clutch. Close to the oil markers, a curved line of signal from the egg shell is clearly delineated.
(Acknowledgement: Fig 1 was acquired by Muriel Cockburn, MR Unit Superintendent Radiographer.)

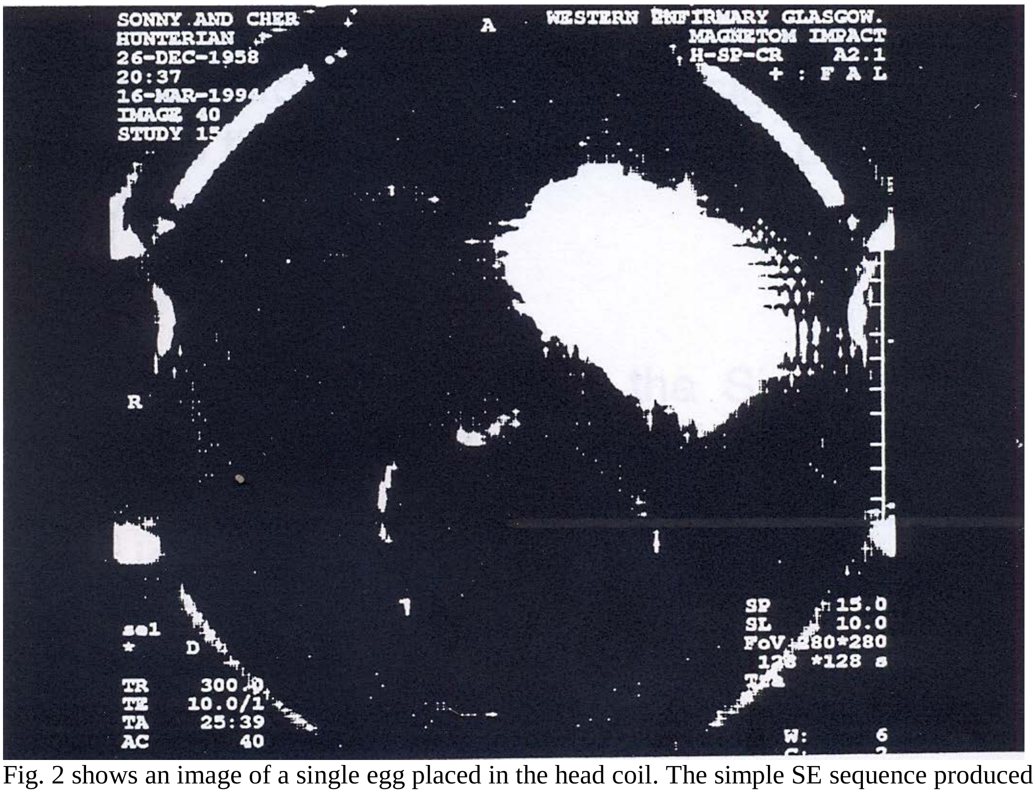

Fig. 2 shows an image of a single egg placed in the head coil. The simple SE sequence produced images with the best SNR compared to results obtained using FLASH sequence (allowing 100 averages to be performed in around 2 mins). A SE sequence with bipolar diffusion sensitising gradients also produced poor results, suggesting the signal present is not from tight bound water.

The signal seen in the images appears to be a layer of moisture which infiltrated the shell structure via a network of cracks in its surface. It is difficult to know how long the moisture has been there. The water appears not to be tightly bound, so it is possible that it entered the egg following discovery and exposure to the environment.

Quantification

Usinf an image sequence developed by Dr Barrie Condon [1], the signal from the egg shell was quantified. The sequence acquires a 20cm image slice to produce a projection of the entire egg. Signal from everything except the water is minimised by using a long echo time (TE=600ms) and a long repetition time (TR=5s). One 64*256 acquisition is obtained in around 5 mins. The signal from this projection is then calibrated with water phantoms of known volume.

A single egg was imaged in the Siemens 1.5 T Magnetom MR scanner at the Southern General Hospital in Glasgow. The results found that 3.5ml of water is contained around the egg shell.

Summary

Commercial MR imagers in clinical sites use liquid-state MR techniques, and produce high quality images of mobile NMR-friendly protons in, for example, water and lipids. It appears strange, then, to attempt to produce images of a sample of fossilised rock.

From out results, the dinosaur eggs appear to have a layer of trapped moisture around the egg shell, enabling is to differentiate the shell from the rest of the egg structure.

Although techniques such as amino-acid analysis and CT imaging remain the methods of choice for investigation of archaeological artefacts, this represents a novel and unexpected application for MRI.

References

1. B Condon *et al.* J. Comput. Assist. Tom. (1986); 10; 784-792.