Organic Remains in Fossil Embryo of a Dinosaur

*This report features the work of Robert R. Reisz and his co-workers published in Nature **496**, 210 (2013).*

Light from synchrotron has been long used in paleontology. Many fossils are analyzed with X-ray microscope to view the interior of precious specimens without cracking them. Three-dimensional tomography can be reconstructed to visualize the details inside these fossils.[1] Synchrotron light is useful also to analyze the composition of fossils. In 2013, Robert R. Reisz led scientists in a group from Canada, Taiwan and China to discover the earliest fossil embryos from China.[2] Using synchrotron radiation and Fourier-transform infrared (SR-FTIR) spectra, they confirmed the oldest evidence of preservation of organic remains *in situ* in a fossil. Their research is highlighted on the cover of *Nature* journal, and is also selected as one of "365 days: Images of the year" in *Nature* of 2013.

The fossil was found in a monotaxic bone bed near Dawa, Lufeng County, Yunnan Province, China. Such a monotaxic bone bed allows scientists to study the development and growth of a single species. The bone bed is dated from the Early Jurassic (Sinemurian) period, about 190-197 million years ago, temporally equivalent to the oldest known dinosaurian embryos preserved in South Africa.

The bones are disarticulated; all of them are less than 25 mm. On comparison with other fossil embryos, these specimens from the Lufeng bone bed are confirmed to be embryos, not hatchlings. For example, there is no preserved neural arch; both centra and femora bones are poorly ossified; the thin slices of femora are similar to embryonic bone of other geologically younger dinosaurs.

These bones conform to the anatomical pattern of a basal sauropodomorph dinosaur and are tentatively identified as the sauropodomorph *Lufengosaurus* of Lufeng Formation (Fig. 1). Sauropodomorpha is a long-necked herbivorous dinosaur. The earliest kind was small and slender, about 1.5 m long, but they became the largest dinosaurs at the end of the Triassic period. The largest kind, sauropod, could extend to 30-40 m and 60,000-100,000 kg. The size of Lufengosaurus is moderate, length about 6 m.

On comparing 24 femora bonds of various lengths, the embryonic growth of these dinosaurs can be studied histologically. The conclusion drawn is that these sauropodomorph embryos probably grew

Fig. 1: Skeleton (left) and illustration (right) of Lufengosaurus (Source: Wikipedia, http://www.wikipedia.org). The inset is the illustration of embryo with length of a few centimeters (Source: University of Toronto, http://www.utm.utoronto.ca/main-news-research-news-general/worlds-oldest-dinosaur-embryo-bonebed-yields-organic-remains).

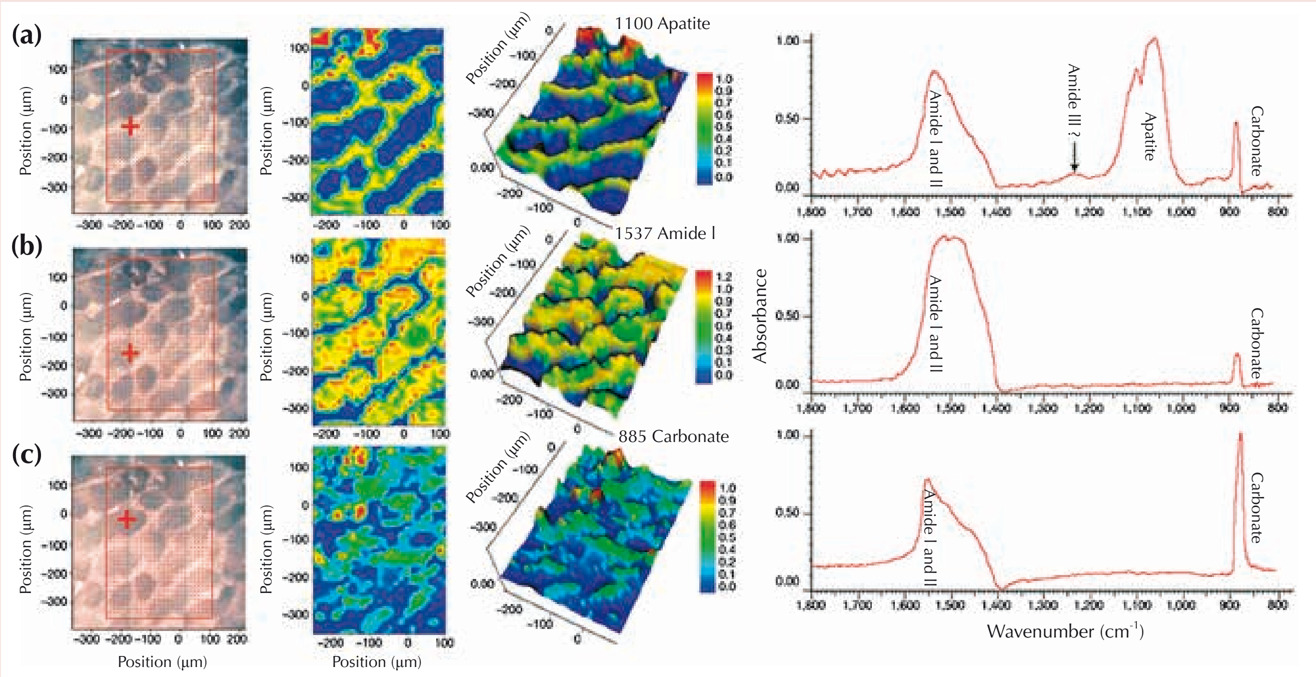

Fig. 2: FTIR spectra of a slice of fossil embryo. Signal extracted from different positions are marked in red cross (a, b and c) and the corresponding spectra are on the right. (Reproduced from Ref. 2)

more rapidly than extant birds and other dinosaurs. This effect might explain why sauropodomorph dinosaurs could achieve a larger adult size than that of their contemporary counterparts. The asymmetrical thickness of the walls of the long bones resembles that of mice and chickens, which has this epigenetic phenomenon because of the muscle contraction and body movement before birth or hatching. Such features might be needed for a newborn dinosaur to adapt to its environment.

SR-FTIR (at beamline **BL14A1**) makes possible a study of the composition of embryonic bones *in situ* without extraction. FTIR spectra provide an excellent tool to identify chemicals through the motion of chemical bonds; it is commonly used in organic chemistry and biochemistry to determine the composition of organic compounds. For example, proteins have specific amide features (the strongest being amide I between 1600-1700 cm^{-1}, another amide II between 1510 and 1580 cm^{-1} and a complicated and less usable amide III). The small size of the beam of a SR-FTIR instrument can scan through a large area in small steps to obtain high-resolution information with a wide field. In this case, SR-FTIR is used to scan through thin slices of fossil embryos. 12 optical images, each 150 x 180 μm, were pieced together in step size 15 μm. The result yields three-dimensional FTIR distributions that allow scientists to inspect the FTIR absorption at a specific part of a bone. Although it is not astonishing to find signals of amides I and II in vascular spaces of a fossil embryo, probably from direct products of protein decay or contamination from the environment, large amide I, II signals and a small possible amide III signal from a primary bone made an exciting discovery because this area has a strong signal from apatite crystal, unreachable by microbial contamination and post-mortem artefacts. It must hence be from the decay of original tissues in the bones. This discovery makes them the oldest organic remains in a fossil. The use of synchrotron light adds another layer of excitement to this fascinating story of fossil embryo.

References

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2. R. Reisz, T. D. Huang, E. M. Roberts, S. Peng, C. Sullivan, K. Stein, A. R. H. LeBlanc, D. Shieh, R. Chang, C. Chiang, C. Yang, and S. Zhong, Nature **496**, 210 (2013).