The Paleontograph

A newsletter for those interested in all aspects of Paleontology
Volume 4 Issue 2 April, 2015

From Your Editor

Welcome to our latest issue. I have some articles here which were lost for a time. When I retired, I changed computers and somehow these were lost. So I am bringing back for this issue. I apologize to Bob for the misplacement and to you, the reader, if any of it seems out of date. Although when you are talking about fossils that are millions of years old what's one more?

TC

The Paleontograph was created in 2012 to continue what was originally the newsletter of The New Jersey Paleontological Society. The Paleontograph publishes articles, book reviews, personal accounts, and anything else that relates to Paleontology and fossils. Feel free to submit both technical and non-technical work. We try to appeal to a wide range of people interested in fossils. Articles about localities, specific types of fossils, fossil preparation, shows or events, museum displays, field trips, websites are all welcome.

This newsletter is meant to be one by and for the readers. Issues will come out when there is enough content to fill an issue. I encourage all to submit contributions. It will be interesting, informative and fun to read. It can become whatever the readers and contributors want it to be, so it will be a work in progress.   TC, January 2012

Edited by Tom Caggiano and distributed at no charge

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Pterosaurs--A Review

Bob Sheridan January 19, 2014

Pterosaurs, flying reptiles from the Mesozoic, have always taken a back seat to dinosaurs in terms of popular books. I own three books on pterosaurs:

1. "The Illustrated Encyclopedia of Pterosaurs" by Peter Wellnhofer from 1991.
2. "The Pterosaurs: From Deep Time" by David Unwin from 2005.
3. "Pterosaurs" by Mark Witton from 2013.

These are all excellent books. The last is the subject of today's review. You should not confuse the Witton book "Pterosaurs" with a book from 2012 "Pterosaurs: Flying Contemporaries of the Dinosaurs," of which Witton is one of three coauthors.

By the way, the first popular book on pterosaurs "Dragons of the Air" (1901) by H.E. Seeley is available as a free e-book at http://www.gutenberg.org/ebooks/35316.

Witton is at the School of Earth and Environmental Sciences at the University of Portsmith. He is a freelance artist as well as a paleontologist and has a blog at http://markwitton-com.blogspot.com/ .

I will start with a little background on pterosaurs, which will make further discussions more understandable. (Here I am borrowing a lot of material from my 2005 review of the Unwin book.) Pterosaurs are the first vertebrates that learned powered flight. Compared to most vertebrates, pterosaurs tend to have extremely large heads and extremely small legs relative to their torsos. Many pterosaurs had a large ridge of bone above their dorsal vertebrae called the notarium, to which the scapula sometimes articulated. Bird wings are made of feathers attached to their (relatively short arms). Bat wings are made from skin stretched between the body and between five elongated fingers. Pterosaur wings were made from skin stretched from the body to an enormously elongated fourth finger, which is unique among vertebrates. There are enough fossils preserving the soft tissue of pterosaur wings, which is typically a few millimeters thick, that we can tell the wings contained, starting from the ventral side, a layer of blood vessels, a layer of muscle, and a layer of semi-rigid fibers. The wings and body of pterosaurs probably had some kind of fur or protofeathers, it is hard to tell which. All pterosaurs had a unique splint-like bone at the wrist called the pteroid, probably used to change the shape of the leading edge of the wing.

Despite having a very different wing structure, pterosaurs are convergent with birds on may features. They had bones with very thin walls (presumably for lightness). They had very rigidified ribcages, and there is evidence in the bones for air sacs. Presumably these features could have allowed for an efficient one-way respiration system as in birds. Their brains tended to be large and globular, like a bird's, and not elongated like a typical reptile's. All these point to a life as agile fliers requiring large amounts of energy. (Forget the antiquated idea of pterosaurs as gliders needing to jump off high cliffs to fly.)

Classically pterosaurs are divided into two types: rhamphorhynchoids (named for Rhamphorhynchus) and pterodactyloids (named for Pterodactylus). Rhamphorhynchoids lived from the Late Triassic until the Early Cretaceous. They generally were small and had large toothed heads on a short neck. They also had long tails with a rhomboid shaped vane at the end. Pterodactyloids lived from the Middle Jurassic until the Late Cretaceous. The had large heads on long necks, but no tails. Many of them were toothless.

The fact that pterosaur bones are hollow means that most fossils end up looking like "roadkill," and the fine anatomical details, such as the shape of the joints, is usually erased.

Aspects of pterosaurs that were mysteries for 100 years are not so much of a mystery since about a decade ago. There are enough well-preserved specimens (e.g. from China) that we know where the wing membrane attached to the body. We have enough pterosaur trackways that we have a good idea of how they handled themselves on land: as quadrupeds walking with their legs underneath, walking on wrist pads and the sole of the foot. There are now several known pterosaur eggs, and we know pterosaur babies probably could fly as soon as they hatched. What remains a mystery is which branch of archosaurs the pterosaurs arose from. Also we do not know a specific animal that could be the "protopterosaur" ancestor, that could perhaps climb trees and glide in the style of a flying squirrel, but not fly.

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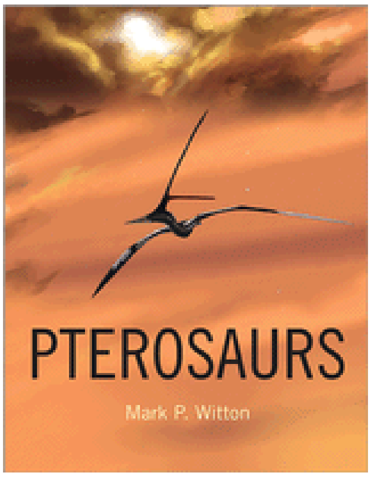
Pterosaurs Cont'd

This is more than enough background. One place to keep up on the latest news about pterosaurs is http://pterosaur-net.blogspot.com/.

Witton's "Pterosaurs" has 26 chapters, the first 8 deal with general findings on pterosaurs, their anatomy, how they flew, how they got along on the ground, how they reproduced, etc. This is very similar to what you find in Unwin's book. One interesting perspective from Witton is about the idea of "weight reduction." The classical idea is that pterosaurs acquired hollow bones and air sacs to make them lighter and more airworthy. Witton reverses this and says the idea is to take animals of a constant weight and make them larger (e.g. more surface area for flight). I'm not sure one can really distinguish the two in practice, but it is thought-provoking. Another idea presented by Witton is that the masses of pterosaurs are underestimated by most workers in the field, such that the mass per wing area is much smaller than that of living birds. If we allow for larger masses in pterosaurs, we can allow for more powerful muscles, which are needed for flight.



The real uniqueness of Witton's "Pterosaurs," compared to Unwin's book, is in the15 chapters on individual pterosaur subgroups. (There is a small irony here because the taxonomy is based on Unwin's system.) Each group is presented in detail: a discussion of each genus, unique features, the probable lifestyle, etc. Literature references are included. These chapters can be a little tough to get through in spots, since they are something like a professional review article, but that makes this book useful for professionals as well as interested amateurs like us. The first thing you learn is that pterosaur group names are pretty hard to remember (Anurognathidae, Wukongopteridae, Ctenochasmotoidae, etc.) But the important thing is that if you look within each group there is a tremendous diversity: longer vs. shorter heads, teeth vs. no teeth, crests vs. crests, larger vs. smaller legs and feet, long wings vs. short, claws on the hand vs. no claws, etc. Thus, pterosaurs were probably as diverse in anatomy and lifestyle as birds are now. Witton points out that the classical division into rhamphorhynchoids and pterodactyloids might not be useful in the sense that while pterodactyloids are probably a monophyletic group, the rhamphorhynchoids are probably a collection of primitive types, that might not be closely related to each other. Also, while we are pretty sure more groups of pterosaur are not likely to be identified, we know hardly anything about some groups like the Lonchodectidae because their remains are just so fragmentary.

Pterosaurs can have some really bizarre anatomy. For my money, the most bizarre snout belongs to Pterodaustro (from South America). Both its mandible and maxilla are upturned. The lower jaw has hundreds of extremely elongated teeth arranged in a comb-like formation. One can only imagine Pterodaustro using this apparatus to filter feed like a flamingo. The most bizarre crest is found in Nyctosaurus (from Kansas). The crest branches into two cylindrical spars, one pointing up and one pointing back. The crest is about three times as long as the skull and about 20% longer than the head, body, and legs combined. You look at this animal and your first thought is "No way that can be real." However, there are two specimens with the crest intact, so there is no doubt.

Speaking of crests, my impression from "Pterosaurs" is that the proportion of pterosaurs with crests is higher than anyone suspected before. While the crests of many pterosaurs are bony, or partly bony, some crests consist only of soft tissue. We see more of the latter now because we have more specimens with preserved soft tissue and/or we now know to look for soft tissue in fossils with ultraviolet light. The original Pterodactylus from Solnhofen, for instance, one of the first pterosaurs known, has a soft tissue crest along its entire snout. While a number of authors have suggested crests could have some aerodynamic or thermal function, it is most likely they were for sexual display since closely related species have different crests.

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Pterosaurs conclusion

Pterosaurs attained a size range that birds never came close to matching. Quetzalcoatlus (from Texas) is usually depicted as the largest known pterosaur in popular books, but Quetzalcoatlus belongs to a family of extremely large pterosaurs, the Azhdarchidae. The largest known is Hazegopteryx. It probably stood as tall as a giraffe, had wingspan of about 11 meters, and had the longest skull (3 meters) of any non-marine tetrapod. It is interesting that there are many large flightless birds, but as far as we know, there are no secondarily-flightless pterosaurs, even among the largest ones.

The writing style of "Pterosaurs" is pretty informal, despite the "review article" format, sometimes verging on "cuteness." I don't mean this in a bad way. I was amused by section headings such as "In the Absence of Proper Data, Speculate Wildly" and figure captions such as "*Tupandactulus imperator* doing his best Clint Eastwood impression on the scrubby hinterland of the Aptian Crato lagoon."

"Pterosaurs" has the expected photographs of fossil specimens and some very clear diagrams, plus world maps showing where key pterosaurs fossils are found. The pictures that depict living pterosaurs are of two types: the pterosaur in a standard "takeoff" pose, such that different genera can be compared, and the pterosaur in "real life" situations, flying, fighting, eating, etc. All of the restorations are watercolors done by the author. I enjoyed them and they get the point across, but they struck me as more "artistic" than "scientific", compared to comparable illustrations by, say, John Gurche.

This book is well worth reading and is available at a reasonable price.

Sources:

Unwin D.M.
"The Pterosaurs. From Deep Time"
Pi Press, New York, 2005, 347 pages. $40 (hardcover)

Valdmeijer, A.J.; Witton, M.; Nieuland, I.
"Pterosaurs: Flying Contemporaries of the Dinosaurs."
Sidestone Press, Leiden, 2012, 134 pages $60 (paperback)

Wellnhofer, P.
"The Illustrated Encyclopedia of Pterosaurs. An illustrated natural history of the flying reptiles of the Mesozoic Era."
Crescent Books, New York, 1991, 192 pages.

Witton, M.P.
"Pterosaurs"
Princeton University Press, Princeton, 2013, 291 pages. $35 (hardcover).

Early Pleistocene Footprints in England

Bob Sheridan February 15, 2014

I was surprised to come across an article about early human footprints (Ashton et al., 2014) discovered in Happisburgh, which is on the southeastern cost of England. First, human footprints in the fossil record are extremely rare. There are only a handful of sites (the Laetoli site being the most famous). Second, I normally don't think of England as the source of material for early humans except in a negative way, i.e. the site of the Piltdown hoax.

The Happisburgh footprint site is on a beach, at most 50 meters from the water line. In May 2013, erosion recently exposed some Early Pleistocene sediment that is somewhere between 0.78 and 1 million years old. This sediment apparently contains many footprints within an area of about 12 square meters. This would make this the oldest footprint site outside Africa. Unfortunately erosion continued to work and destroyed the footprints within a few weeks. Fortunately, a complete photographic and laser-scan record was made before that.

The sediment surface, contains irregular depressions and ripples, typical of a mud flat surrounding a river. The footprints there are poorly preserved, appearing only as elongated depressions. It is somewhat hard by eye to definitively pick out footprints from other depressions, since most are poorly preserved.

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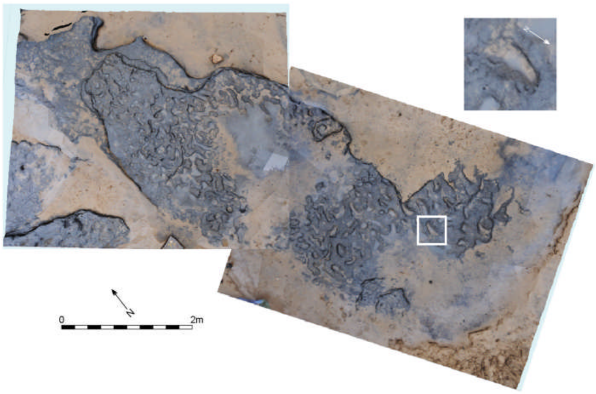
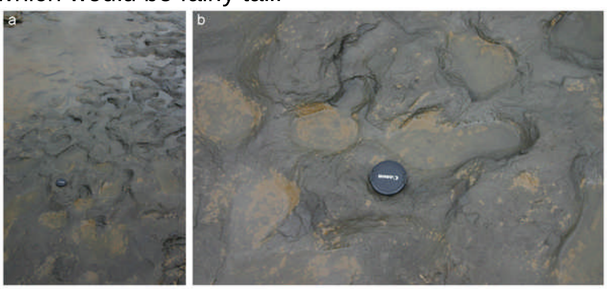
Footprints Cont'd

I would have been skeptical that any of these depressions are footprints except that one shows individual toe impressions. Out of 155 depressions, the authors assign 49 as probable footprints based on:
1. Being the right size for human footprints.
2. Having a length to width ratio consistent with the human foot.
    1. Showing left vs. right asymmetry.



The long axes of the putative footprints shows a strong preference for a north-south orientation. Since we can sometimes tell the front of the foot from the back in these footprints, it would seem most of the prints are indicating travel to the south. The footprints come in a range of sizes and may represent up to five individuals. Using typical ratios of foot size to height for humans from the Early Pleistocene, the authors estimate that the makers of the footprints varied from 1.4 to 1.7 meters in height, which would be fairly tall.



The authors suggest *Homo antecessor* as a possible maker of the footprints. *Homo antecessor* fossils are known from Europe in that time period, and stone tools discovered in England are assigned to *Homo antecessor*. Where *Homo antecessor* fits in the evolutionary scheme of things is not clear, but most would put it somewhere between an advanced *Homo erectus* and the common ancestor of Neanderthals and modern humans.

Sources:

Ashton, N.; Lewis, S.G.; De Groote, I.; Duffy, S.M.; Bates, M.; Bates, R.; Hoare, P.; Lewis, M.; Parfitt, S.A.; Peglar, S.; Williams, C.; Stringer, C. "Hominin footprints from early Pleistocene deposits at Happisburgh, UK" PLoS ONE 2014, 9, e88329.

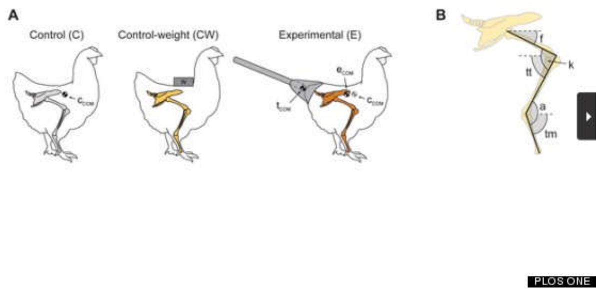
Chickens That Wear Dinosaur Tails

Bob Sheridan February 13, 2014

A theropod dinosaur, has the center of gravity more or less at its hips, with its long tail counterbalancing the weight of the body. The feet of a standing theropod are more or less under the hip joint. Averaged over a walk cycle, the femur would be pointing more or less downward, and the motion of walking would come from moving the femurs forward and backward. A modern bird, presumably the descendant of the dinosaur, has no tail, so the center of gravity is forward of the hips. To keep from toppling onto its nose, the bird has to bring its feet under its center of gravity, which means keeping the femur pointed forward most of the time. Walking is done by moving the shin forward and backward. The loss of a tail is the classic explanation of the forward displacement of the center of gravity in modern birds, but an additional explanation is that the arms got bigger (Allen et al., 2013).

The hypothesis that the change in walking style is due to the absence of a tail can be tested. Today's story concerns an experiment conducted by the University of Chile and Chicago University (Grossi et al., 2024) wherein a modern bird is given an artificial tail. Investigators raised 12 chickens from chicks to sexual maturity. One-third of them ("experimental") wore an artificial tail made of a wooden stick on a conical clay base. The weight of the stick was always about 15% of the weight of the chicken at a time. This tail was attached to fabric coat that the chicken could wear. The tail was replaced as the chickens grew. The tail is expected to move the center of gravity of an adult chicken back about an inch. One-third of the chickens ("weight-control") wore a similar coat, but with a weight (again 15% of the weight of the chicken) above where its normal center of gravity would be. Finally one-third ("control") wore coats but no weights. The chickens were raised in an environment where they could exercise freely.

Videotapes were made of the chickens walking along a track and the walking motion analyzed. The biggest differences between the subjects is in how the femur is moved. The experimental subjects moved the femur about three times as much as the control and weight-control subjects. Also, the femur was held more vertically on the average, and the femur in the experimental subjects grew a little longer than in the controls, although the thickness of the femur (as revealed by x-rays) was not different. These changes are fairly subtle; they are hard to see in the videos of the chickens walking, but the differences are very significant statistically, so there is something to the link between having a tail and walking style.



Sources:

Allen, V.; Bates, K.T.; Zhiheng, L.; Huchinson, J.R. "Linking the evolution of body shape and locomotor biomechanics in bird-line archosaurs." Nature 2013, 497, 104-107.

Grossi, B.; Iriarte-Díaz3, J.; Larach, O.; Canals, M.; Vasquez, R.A. "Walking like dinosaurs: chickens with artificial tails provide clues about non-avian theropod locomotion" PLoS ONE, 2014, 9, e88458.

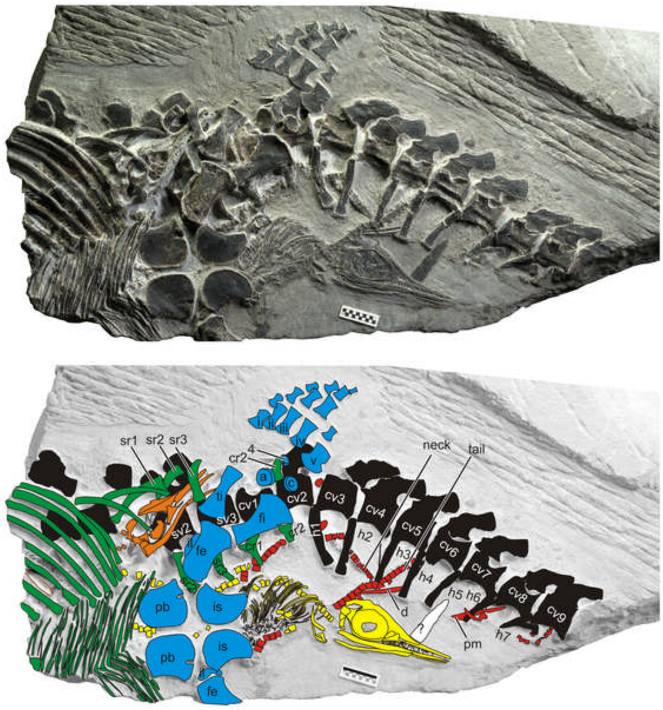
How Primitive and Advanced Ichthyosaurs Gave Birth

Bob Sheridan February 25, 2014

Most modern reptiles lay eggs. A minority are viviparous (give live birth). In the case of land dwelling reptiles, the typical explanation is that in the places where there are viviparous reptiles the climate is too cold for eggs to develop and retaining them in the body keeps them warm. This is true of many lizards. For marine reptiles, the explanation is that as the animals' bodies become more adapted for swimming (more streamlining, limbs that are not designed to bear weight, etc.), they are unsuited to moving on land, so laying eggs there is impossible. The modern sea snakes are the most cited example. In contrast, the sea turtle is a well-adapted marine reptile that does lay eggs on land. Being flattened from top-to-bottom and keeping your limbs like a turtle is obviously better for land travel than being flattened side-to-side and having no limbs like a sea snake.

It is now known that at least some Mesozoic marine reptiles gave live birth because there are fossils with embryos within the mother. (In such cases we need to go through a number of checks to be sure the "babies" are not really "lunch": the babies are not in the stomach region, the babies are of the same species as the mother, the bones of the babies are articulated, the bones of the baby show no sign of digestion, etc.) We have known about this aspect of ichthyosaurs for decades, but only recently have we established it for mosasaurs. The first live-birth specimen, is of the species Stenopterygius, which is a large (3 meter) advanced Jurassic ichthyosaur from Germany. That specimen had two or more babies inside and one mostly outside the mother's body. (It is not necessarily true that the mother was killed just as it was giving birth. It is possible that the mother died and gases of decay expelled the baby later.)

One key feature in Stenopterygius is that the babies are oriented so they would be delivered tail first. This is a feature often observed in marine mammals like cetaceans that cannot travel on land. The argument is that this keeps the babies from trying to breath before they are completely free to rise to the surface. Again, there are exceptions. Manatee babies can be delivered head-first or tail-first. Of course, marine mammals like seals that can get around on land, give birth on land in the usual head-first manner.



The maternal specimen with three embryos.
Color coding indicates: black, maternal vertebral column, including neural and haemal spines; blue, maternal pelvis and hind flipper; green, maternal ribs and gastralia. Embryos 1 and 2 are in orange and yellow, respectively, whereas neonate 1 is in red. Scale bar is 1 cm. Abbreviations: i-v, metatarsals; 4, fourth distal tarsal; a, astragalus; c, calcaneum; cr, caudal rib; cv, caudal vertebra; d, dentary; fe, femur; fi, fibula; h, haemal spine; il, ilium; is, ischium; pb, pubis; pm, premaxilla; sr, sacral rib; sv, sacral vertebra; and ti, tibia.

A new specimen of ichthyosaur described by Motani et al. (2014) adds some new information. The specimen, collected from Anhui Province, China, is of a basal Early Triassic ichthyosaur called Chaohusaurus. It consists of the pelvic girdle, some ribs and part of the tail. The total estimated length of the animal would be about 1 meter. Three babies are present, one inside the body, one outside the body, and one exiting the pelvic girdle. The babies would be about one-sixth the length of the mother. The interesting finding here is that all three embryos are oriented so that they would be born head-first. Unless this specimen is very unusual in that all embryos are "breech-births," this would imply that at least some primitive ichthyosaurs gave birth head-first.

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Ichthyosaur birth Cont'd

Even primitive ichthyosaurs do not look like they could crawl on land, so we can probably eliminate a "seal model" where head-first birth represents an intermediate stage where a marine mammal gave birth on land. The authors suggest a scenario where ichthyosaurs started as fully terrestrial animals giving birth on land (head-first), and kept that when they became obligate swimmers, then eventually switched to tail-first birth. However, one cannot eliminate the possibility that ichthyosaurs layed eggs while terrestrial and switched to (head-first) live birth after becoming obligate swimmers.

Sources:

Motani, R; Jiang, D.-Y.; Tintori, A; Rieppel, O.; Chen, G.-B.
"Terrestrial Origin of Viviparity in Mesozoic Marine Reptiles Indicated by Early Triassic Embryonic Fossils"
PLoS ONE 2014, 9, e88640

Melanin Detected in Fossil Marine Reptiles

Bob Sheridan January 11, 2014

In exceptional cases, and organic film that represents the soft tissue of a fossil animal will be preserved along with the bones. Amazingly, given our high-tech methods of analytical chemistry and microscopy, the film can be analyzed for its original chemical composition and anatomical features. In the past few years we have seen the analysis of preserved bird feathers for the presence of melanosomes and for the pigment melanin.

Today's story deals with the analysis of preserved organic film in three specimens of marine reptile: a 55 Myr-old leatherback turtle, an 86 Myr-old mosasaur, and a 190 Myr-old ichthyosaur. Lindgren et al. (2014) describe the use of two techniques on these fossils: scanning electron microscopy (SEM), and ToF-SIMS (Time of Flight Secondary Ion Spectroscopy). The latter is new to me, and probably is to you also. In ToF-SIMS, a very narrow ion beam is focused on a specimen. The ions knock off secondary ions from the specimen, and these ions are separated by mass. The number of ions for any given mass forms a spectrum that can be compared to the spectrum of known substances, in this case various kinds of modern melanin. Since the initial beam is so narrow, one can sweep the surface of a specimen and get a map of its chemical composition. For both techniques, it is necessary to separate a small sample from the fossil and place it in a vacuum chamber .

For all specimens of organic film, SEM shows small ovoid bodies which are consistent with the size of melanosomes, micron-sized particles that store the melanin in modern animals (and, as we know now, fossil feathers). ToF-SIMS shows that the spectrum of the film is consistent with modern eumelanin (black or brown), but less with other types of melanin like pheomelanin (red). The location of the eumelanin corresponds to the location of the presumed melanosomes, and the elongated shape of the melanosomes is consistent with modern melanosomes that contain eumelanin as opposed to the more spherical melanosomes that contain pheomelanin. So we can construct a very self-consistent story: these fossil marine organisms did contain a large concentration of melanin at least somewhere on their skin.

The rest of Lindgren et al. contains a discussion of the use of melanin in marine animals. For leatherback turtles, the major function is thermoregulation; a darker animal can absorb more sunlight, as is observed in modern marine turtles. Another use of dark pigmentation is countershading; if you are dark at the top and white at the bottom, you are harder to see from above or below in shallow water. In deeper water, it is useful to be totally dark so you are harder to see against the gloom.

The authors particularly remark that turtles, mosasaurs, and ichthyosaurs having melanin is an example of convergence among extinct marine reptiles. To me that fact is fairly uninteresting, in the sense that there is no doubt that almost all extinct animals were pigmented in some way, and that pigment would turn out to be melanin, the most common pigment in extant animals. It is almost like saying having red blood is an example of convergence. The really interesting fact is that our technology is good enough to analyze pigmentation in fossil animals.

Sources:

Lindgren, J.; Sjovall, P.; Carney, R.M.; Uvdal, P.; Gren, J.A.; Dyke, G.; Schultz, B.P.; Shawkey, M.D.; Barnes, K.R.; Polecyn, M.J.
"Skin pigmentation provides evidence of convergent melanism in extinct marine reptiles."
Nature 2014, 506, 484-488.