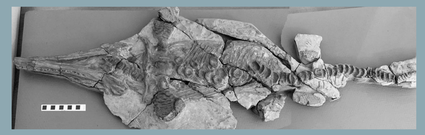

Taphonomy of England's Blue Lias Ichthyosaurs

A tribute to the lasting impact of paleontologist Mary Anning, 1799-1847

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Background

Mary Anning by B.J. Donne

The fossils of Blue Lias Formation (BLF) are world-renowned for exceptional preservation, but their preservation processes have often been overlooked. The formation is Lower Jurassic (200-195 Ma) and consists of dark grey marl, limestone, and shale layers, which preserve organisms from diverse paleocommunities.

The first ichthyosaur was found by Joseph and Mary Anning from the Blue Lias Formation off the coast of Lyme Regis, Dorset. Mary made her living selling BLF fossils and discovered numerous taxa. Despite being a 19th century woman from a working class, she inspired geologists and paleontologists with her self-taught knowledge of the Jurassic marine outcrops and their treasures.

We seek more clues pertaining to the death-burial interval of these well preserved ichthyosaurs, including those found by Mary Anning.

Questions

- What were the conditions that led to the death and preservation of relatively complete large vertebrate skeletons in the Blue Lias?
- How is what we know about anatomy and preservation affected by taphonomic, collection, and preparation biases?
- What is the "taphonomic legacy" of the pioneering work by Mary Anning and the scientists who described and studied the fossils she collected?

Duria Antiquior by Henry De La Beche depicted the BLF environment Mary Anning discovered was copied and sold to help her financially. (also background image)

Methods

Deep Time ichthyosaur USNM 4967
Photo Credit: Bill Keyser

1 out of 23 data sheets

Various other specimens, such as this German *Steneosaurus* (crocodilian) from the Posidonia Shale, were used in comparison with BLF Ichthyosaurs.

BLF specimens were examined at the following museums:

- Smithsonian Institution, National Museum of Natural History
- Sedgwick Museum of Earth Sciences
- Lyme Regis Museum
- Natural History Museum, London

Evidence of postmortem alterations in various lithologies in 23 marine reptiles were observed and recorded on data sheets:

- Presence of nodules
- Presence of soft tissue
- Skeletal element positions
- Presence of invertebrates
- Plastic deformation
- Matrix composition

The 14 ichthyosaur carcasses were divided into anatomical units, each assigned into stages (0-4) of articulation.(Cleary, 2015 and Beardmore, 2012). The articulation stages of the anatomical units were then averaged to represent the entire preserved carcass.

An example of a unit and the stages is shown using the Dorsal Vertebrae. (See next column.)

Stages of Articulation in the Dorsal Vertebrae (DV)

https://www.fossilera.com/fossils/11-3-plate-of-ichthyosaur-bones-somerset-england | https://www.fossilprimeval.com/fossilprimeval com-vertebrates-4 | Natural History Museum, London 33277 BLF Specimen | USNM 4967 BLF Specimen | PMU R435 (Lindgren et al., 2014)

Stage 0
- Isolated bones
- Completely disarticulated dorsal vertebrae

Stage 1
- More than 3 breaks in the dorsal vertebral column
- Extensive disarticulation in dorsal vertebrae
- Ribs disarticulated and jumbled

Stage 2
- 3 breaks in dorsal vertebral unit
- Extensive domino pattern in vertebrae can occur
- Ribs are associated with the dorsal vertebral column

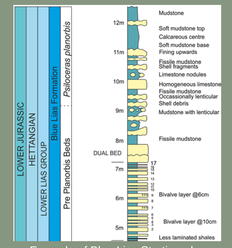
Stage 3
- 1-2 breaks in the dorsal vertebral column
- Slight domino pattern of vertebrae can occur
- Ribs associated but may or may not be articulated to DV

Stage 4
- No breaks in the dorsal vertebral column
- Minimal domino pattern
- Rib ends articulated to dorsal vertebrae
- Complete articulation of dorsal vertebrae

Stratigraphy

Early Jurassic England - Lyme Regis (arrow) (Martill, 2016), showing an array of land masses and marine basins.

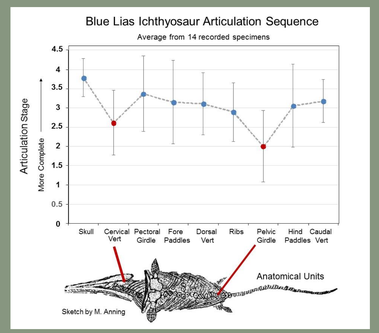
The Blue Lias Formation stratigraphy is cyclical; its lithologies alternate between shale, marl (limey mudstone), and limestone.



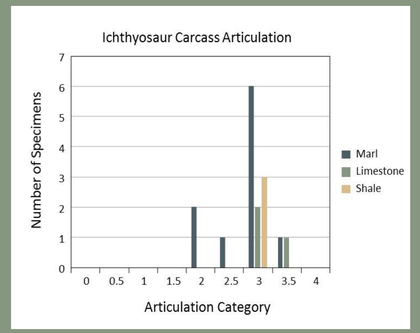
Example of Blue Lias Stratigraphy (Martill 2016).

The cyclicity of the shale, marl, and limestone has been attributed to astronomical cycles. These could have caused sea level, temperature and water column stratification to vary over periods of 10's to 100's of thousands of years. (Paul et al, 2008; McKean and Gillette, 2015)

Results



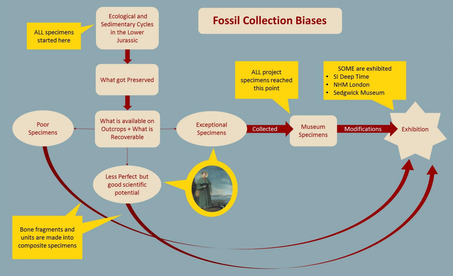
The cervical vertebral and pelvic girdle unit are consistently less articulated compared to other parts of the body. Overall articulation is relatively high. Bars show standard deviation.



Average articulation values for 14 Blue Lias preserved Ichthyosaur carcasses. Notice the variation in the marl articulation compared with the limestone and shale.

These results, for 14 individuals, indicate recurring taphonomic circumstances leading to unusually complete preservation of ichthyosaurs in the BLF.

Conclusions



The organisms that are preserved survive numerous taphonomic processes that can bias what we learn from the fossil specimens. These bias factors are not limited to natural causes; museum specimens and those held in collections (private and public) also have anthropogenic biases. We noted that particularly Victorian era exhibition specimens can have the following modifications:

- Altering the original layout of the skeleton
- Assembling unassociated bones into a composite display
- Removing materials through preparation
- Coating or painting over original matrix

Minimally disturbed, whole carcasses would not likely preserve in a highly oxygenated sea floor. Anoxic periods in the BLF were possibly synchronized with the overall regional temperature cycles. Warmer temperatures lead to dysoxia through minimal water column mixing while cooler temperatures lead to oxygenated sea floors through increased water column mixing. Influxes of fresh water may also have been a factor in water column stratification and anoxia.

Preservation Observations
- Compared to the Posidonia Shale, little plastic deformation in bone overlapping
- No encrusting of invertebrates on skeletons
- Soupy substrates possibly held whole bodies and soft parts together
- Stomach and/or intestinal contents were present in 4 out of 14 specimens

Blue Lias ichthyosaurs varied in preservation among the three main lithologies, but nonetheless, retained high skeletal articulation. We found that ichthyosaur cervical vertebrae and pelvic girdles were less articulated compared to the rest of the body units; this likely reflects lower strength in their anatomical connections.

Most observed BLF specimens came from the variable marl layers. The marl is exposed between the eroding shale layers and the resistant limestone, making it more accessible for fossil collectors, resulting in a bias towards marl-bearing specimens.

Summary: Variations in Preservation

Shale
- Few specimens, highly articulated

Marl
- Most variable in articulation
- Most specimens observed- perhaps due to the accessibility of these lithological layers

Limestone
- Soft bodied organisms occur here
- Petrified wood preserved
- Burrowing activity
- High articulation (especially in nodules)

Future Work

Our findings generate more questions pertaining to the BLF environment. A more in-depth study could provide insight on these questions:

- What would be the impact of a larger sample size? Many specimens are retained in private collections in Southern England. What would ichthyosaur fossils in these collections have to offer in terms of their taphonomy?
- How did the taphonomic processes responsible for exceptional preservation fit in with environmental cycles, particularly those occurring between shale and limestone boundaries?
- How does the preservation in the Blue Lias ichthyosaurs compare with other ichthyosaur bearing formations, such as the Posidonia Shale in Germany? How does it compare with other Blue Lias marine reptiles?

References & Acknowledgments

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