Natural History Collections

Lothar A. Beck · Ulrich Joger *Editors*

Paleontological Collections of Germany, Austria and Switzerland

The History of Life of Fossil Organisms at Museums and Universities

Springer

Natural History Collections

Series Editors

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This book series is devoted to the subject of collecting, organizing and preserving specimens. Natural history collections are the libraries of life and a valuable resource for experts in biodiversity, as well as in evolutionary and environmental sciences. New techniques offer endless possibilities for reanalysing specimens, and natural history collections are an impressive source of undiscovered species. As long as they are properly cared for, even centuries-old specimens can lead to new discoveries. This series highlights the importance of our natural history collections around the globe and summarizes the knowledge, research, opportunities and challenges associated with them. This includes new techniques for sampling and preservation, as well as new exhibition concepts.

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Archives of Earth's History: An Introduction

This book is devoted to the knowledge of up to 250 years of collecting, organizing, and preserving paleontological collections by generations of scientists. Collections are a huge resource for modern paleontological research and should be available for national and international scientists and institutions, as well as prospective public and private customers. Moreover, these collections are an important part of the scientific enterprise, supporting scientific research, public education, and the documentation of past biodiversity. Knowledge gained in order to understand our world is mainly based on data we owe to the collection, preservation, and ongoing study of natural specimens. Properly preserved collections of fossil marine or terrestrial plants and animals are libraries of Earth's history and vital to our ability to learn about our place in it today and in future.

The approach employed by the editors not only involves an introduction to the topic but also pays attention to general aspects such as new approaches of sorting, preserving, and research in paleontological collections as well as new exhibition concepts. In addition, the book provides information about important public museums where research takes place, outstanding state museums and collections in regional, local, or private museums, and also collections at universities. This is a highly informative and carefully presented book, providing scientific insight for readers who have an interest in fossil record, biodiversity, taxonomy, or evolution, as well as natural history collections at large.

German, Austrian, and Swiss scientists have been playing an exceptional role in the development of paleontology as a science since the beginning of the nineteenth century. Fossil sites and collections such as Holzmaden (*Posidonia* shale), Solnhofen/Eichstätt (*Archaeopteryx*), and the Geiseltal and Messel pits (Eocene mammals with preserved soft body tissues) have gained worldwide fame. Researchers such as Blumenbach, Goldfuss, Kaup, Fraas, Stromer, von Huene, Hermann von Meyer, and von Zittel deserve important positions in the hall of fame of paleontology. They described numerous taxa (the type specimens of which are deposited in the respective collections) and contributed important information to the development of the stratigraphic system. German terms like "Lagerstätte" have been incorporated in the terminology of our discipline.

Therefore, after Springer issued the book series "Natural History Collections" and the first volume "Zoological Collections," we were happy that we received consent to compile an overview on the paleontological collections of the German-speaking countries. It was, nevertheless, planned in English as its main audience will be the international paleontological community. A compendium of 57 manuscripts is—naturally—dependent on a diversity of contributors. We are thankful to all those colleagues who reacted positively to our request and provided manuscripts on the collections under their care. Some restrictions were necessary to keep the special limits of the book: We could not consider the hundreds of small fossil collections (mostly communal or private-owned) although we admit that they fulfill important roles at a regional scale. We are sorry and ask your pardon if you were not considered. A small minority of collection curators did not respond to our request or did not deliver a manuscript, even after the deadline had been repeatedly prolonged. Those collections may be included in a future second edition. Finally, we are sure that we attained a representative overview on the important paleontological collections of Germany, Austria, and Switzerland.

As stated in our book on the zoological collections (Beck LA (ed.), Zoological Collections of Germany) museums can be categorized by their legal status: large research institutions (in Germany usually within the Leibniz community), state-owned, university-owned, or private. In the case of paleontological collections, some of the state-owned collections are not housed in a museum, but in a geological service institution (Landesamt für Geologie or Federal Institute for Geosciences). Some statistics may be worth mentioning: The "big seven" of paleontology (more than two million specimens each) are the collections at Basel, Berlin, Stuttgart, Vienna, Munich, the combined Senckenberg collections, and Göttingen. Together with two other "millionaires"— the collections of the Federal Institute for Geosciences at Hannover/Berlin, and the collection of Tübingen University—these nine "big tankers" constitute an amazing number of about 25 million paleontological specimens. The smaller and medium sized collections listed here amount only to about four million. But many of these have historically valuable collections, in case of the Zürich University collection dating back to Scheuchzer's times (beginning of the eighteenth century) or even earlier (collections of Gotha or Schleusingen). Therefore, the collections' history is an important part of each description. Many collections are closely linked to local sites, expeditions to foreign countries, or private collectors who donated their personal collections to an institution. Compiling such diverse information in a single volume is possibly a major virtue of this book.

Each chapter of the book gives the principal data of the respective collection (number of species and/or specimens, main focus of the collection, history), today's conditions of infrastructure of the paleontological collection (staff, rooms, laboratories, exhibitions, perspectives), examples of today's research, national and international networks, publications, or other media, and educational work.

Last but not least we would like to thank the team at Springer, especially Verena Penninger who initiated the book series on "Natural History Collections" and Martina Himberger (Heidelberg), Ms. Suganya Selvaraj and Mr. Dhanapal Palanisamy (Chennai, India) who were very helpful in coordinating and producing this volume.

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Chapter 1
Research and Open Questions—A Modern Concept Behind Berlins *T. rex* Presentation of Tristan Otto

Uwe Moldrzyk and Linda Gallé

1.1 General Information

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Year of foundation, and age of parts of the collection: Funded as part of the Humboldt-University in Berlin in 1810, current museum building opened 1889. Parts of the collection dating back to the late fifteenth century: one of the oldest objects are pieces of a meteorite found in 1492.

Number of species and/or specimens, focal points: Around 30 million objects. Collections combine geology, zoology, paleontology and botany (mainly fossil plants).

1.2 Introduction

In 1902, Barnum Brown found the remains of an unknown predatory dinosaur in the Hell Creek formation in Montana. Three years later his colleague Henry Fairfield Osborn gave it its scientific name "king of the terrifying lizards"–*Tyrannosaurus rex*. Right from the beginning the remains of this extinct dinosaur caught the public's imagination like no other animal before. The most illustrious dinosaur of all time conquered cinemas in 1933 when it fought King Kong, and ever since Michael

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Crichton and Stephen Spielberg's "Jurassic Park" the muscle-packed carnivore with teeth the size of steak knives has become part of popular culture. *T. rex* became a superstar.

The excitement reached a preliminary climax when a nearly complete skeleton named Sue was auctioned at Sotheby's for $7.6 million (Hoganson 1998). Approximately 50 specimens have been discovered so far, all in North America, none of them complete. Whether they are called Wankel, Sue, Stan or Black Beauty–all of them are only partially preserved, but every find is special. Each specimen is a piece in a scientific jigsaw puzzle that contributes to an ever clearer picture. And all of them are sure fire big sellers for any museum to show them.

1.3 Paleontological Objects in Exhibitions

Fossils in general belong to the classics amongst objects presented in natural history exhibitions. With roots dating back to the sixteenth century, when the famous Swiss naturalist Conrad Gessner (1516–1565) put his collection on display (eNotes 2017), it has always been a premise of natural history museums to communicate science and raise awareness about nature. Since it is the dose that makes the poison the suitable tools to reach this goal are as simple in theory as they are difficult to use: emotion and information. Too much of each might lead a good idea to failure. Excessive information depth might overtax a general audience while an overload of entertainment might interfere with the trustworthiness of the institution.

One could argue that curiosity is one of the characteristics of the human species. Either way it is the driver that leads people to become scientists or to visit museums. But while a researcher can get enthusiastic about any specimen in a natural history collection, not all of them are suited to draw the attention of an audience–even though that is also dependent on scenography and storytelling (Fig. 1.1). However, it is undisputed that eye catchers make a curator's work much easier (Fig. 1.2).

Paleontological collections seem to be the source for ideal objects to induce curiosity and to explain life on earth. Fossils are a screenshot of life that no human eye has seen in reality. They inspire a visitor's fantasy. They are proof of scientific theories–such as *Archaeopteryx* (Fig. 1.3) is an evidence for evolutionary processes as the critics of Darwin's big theory demanded at the time of its publication (Darwin 1859; Kritsky 1992; Wellnhofer 1990). And they are connected to various stories, be it the geological history of an object buried for millions of years under stone, be it the Holmesque approach to extract data and information of the remains or be it the adventurous circumstances of their discovery. Above that, they are proof of extinct species and the battle of life in environments that have undergone multiple dramatic changes over time–thus they can help us understand and explain the environmental situation and challenges we are facing nowadays. And they make darn good eye catchers.

Fig. 1.1 Storage of fossils in the museum collection: Paleo-Botanists might become immediately enthusiastic, a general audience might need some help here. **Copyright**: Carola Radke, MfN

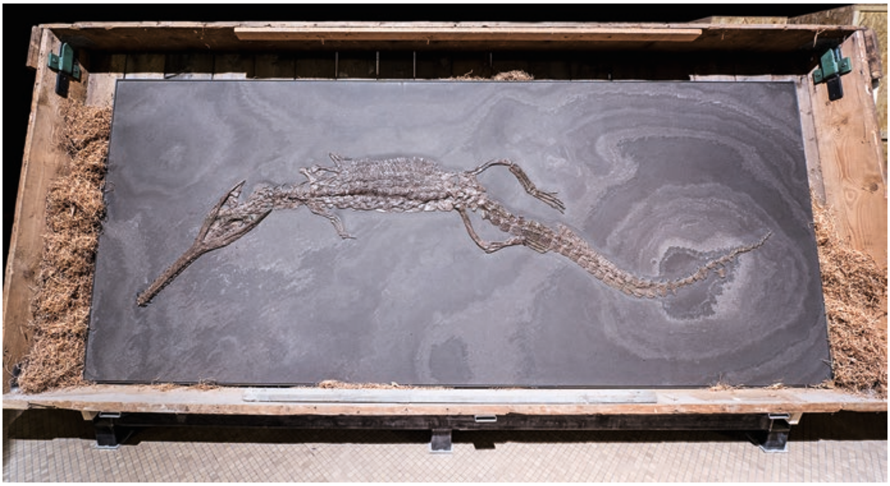

Fig. 1.2 Fossils of the Posidonia shales from the famous Holzmaden locations do make fantastic eye catchers for exhibitions. **Copyright**: Carola Radke, MfN

When the Museum für Naturkunde Berlin opened its renewed galleries in 2007 the wall of biodiversity was one of the eye catchers (Fig. 1.4), but the highlight ever since clearly has been its dino hall.

From the beginning the renewal project aimed on regaining international reputation (Moldrzyk 2015) as one of the important natural history museums in the world. With immediate success–the project got international press coverage over a period

Fig. 1.3 The famous Berlin specimen of *Archaeopteryx lithographica*. **Copyright**: Christoph Hellhake, München

Fig. 1.4 The wall of biodiversity works from the distance like a painting. The closer visitors get, the more the three dimensional character of the objects take over. **Copyright**: Carola Radke, MfN

Fig. 1.5 Sometimes mistaken as an installation: the wet collection actually is a research collection with the possibility for visitors to "have a look". **Copyright**: Carola Radke, MfN

of several months and only a couple of weeks after reopening funding was granted to restore the destroyed east wing and turn one of Berlin's last war ruins into the world's most modern wet collection (Fig. 1.5).

To recognize the museum's weaknesses over the past decades an analysis was run in the beginning of the renewal project. As a result, several premises were formed. First of all, the exhibitions (in an unguided visitor situation) should shift their function from educating the visitor to sparking interest. The general idea was to generate a space were visitors feel comfortable during their roughly 2-h stay and make them curious about nature. Concepts focused on scenography, the esthetics of objects and exhibition displays and a sensitivity not to overload with heavy contents–there should be no competition between objects and information on the visual level. Digital media should help understand objects and related stories but shouldn't compete with the exhibits. Objects should come from the own collection, original items should be preferred over casts, models or reconstructions, and contents should be focused on the research of its scientists or relate to the museum's history.

Regarding target groups the natural history museum in Berlin shifted its focus towards an adult audience. Not to be mistaken: school classes, children and families were still important to the museum, but they were already regular guests at that time. The group with the biggest growth potential was so called "single adults" that would rather be interested in art museums and galleries. Since Berlin is a tourist city, there was plenty of room to improve in that section as well. For the exhibition

Fig. 1.6 A crowded museum: the majority of the visitors in the dinosaur hall in this situation are adults. **Copyright**: Carola Radke, MfN

concepts that meant to reduce "school like" didactics and to avoid playful inter actives for kids, instead to put emphasis on scenography and to use texts written for a general public, not for children–who would hardly ever read themselves anyways, but that is another topic. The results were stunning, visitor numbers increased from around 200,000 to almost 500,000 per year ever since (Fig. 1.6). Visitor statistics prove the concept right: a disproportionately strong increase in single adults has been recorded.

1.4 Would You Like to Have a *T. rex*?

It might be the dream of museum directors that out of the blue someone offers a spectacular dinosaur for free but how about a real phone call from a real person offering a real *T. rex*. Who makes up these stories?

When in January 2015 the telephone rang at the Museum für Naturkunde, nobody knew that less than 12 months later, Berlin would have gained a spectacular crowd-puller: the first original *Tyrannosaurus rex* skeleton on display in Europe. Private collector Niels Nielsen was looking for a museum that would undertake scientific studies on his recently purchased *Tyrannosaurus rex* skeleton TRISTAN OTTO and make it accessible to the public (Ring 2015) (Fig. 1.7). The Berlin natural history museum was chosen not only because of its experience in displaying original

Fig. 1.7 Director General Johannes Vogel, Federal Minister of Education and Research Johanna Wanka and owner Niels Nielsen at the Tristan opening. **Copyright**: Carola Radke, MfN

dinosaur skeletons, but also because of its long tradition in paleontological research. Between 1909 and 1913, a dinosaur excavation took place at the Tendaguru hill in East Africa. Within 4 years, 230 tons of dinosaur fossils were recovered and taken to Berlin for further scientific research, which is still ongoing today. Due to the premises of the renewal project, the scientific results and the history of this important collection delivered the contents of the renewed dinosaur hall. This has the unusual effect that there are less dinosaurs today in the exhibition than there were before even though dinosaurs are crowd-pullers.

The offer was attached to the following conditions: to conduct research on the fossil and to make it accessible to the public by the end of the year. At the time of the phone call, the skeleton of the predatory dinosaur was still in a preparation workshop in Pennsylvania. Scientists from the museum in Berlin went to examine it there. The black bones were well preserved and had some special characteristics but the real sensation was the almost completely preserved skull. Their trip was the kickoff for studies that circle around the fields of anatomy, taphonomy, ecology, functional morphology and paleo-pathology (BMBF 2015). To put up the research program was the easy part.

Less than 11 months to develop and implement a complete exhibition from scratch, around an object that is not even ready to be presented is quite a challenge. But to keep to the own premises is even more so: the *T. rex* skeleton did not belong to the museum's collection, nor would the research program be able to provide results until the opening.

TRISTAN OTTO had been made available to the Museum für Naturkunde Berlin free of charge, for study as well as exhibition purposes. Although the skeleton remains in property of the private owners, it has been given an inventory number of the Berlin museum, a habit that is regular practice in art collections. MB.R.91216 makes the *Tyrannosaurus* find identifiable, and all generated data, including casts and scanning data, accessible for scientists.

Much more of a threat were two other issues related to the presentation of Tristan: How to use own research as the core to develop the exhibition contents, if there hasn't been any research conducted on the specimen so far? And–with adults as a new main target group–how can one seize the attraction of a dino-superstar, but not get overrun by publicity that jumps on the bandwagon of "Jurassic Park", Dino Adventures and other images which would ultimately throw one back in the corner of being a children's or family place only.

1.5 The Concept Behind the *T. rex* Show

Looking backwards the solution seems obvious and simple. As Tristan is the centerpiece of an active research program it should be nothing else in the exhibition. The same approach eases worries about potential risks regarding the image and reputation by being reduced to the Jurassic Park scenario through the media.

From the beginning, the project was brought into the public domain and accompanied by partnership. Both media coverage and the design of the exhibition itself demonstrated what can be achieved by an integrated research museum, bringing together current research in international networks, expertise in the handling of valuable exhibits, and expertise in the communication with the public at large. The arrival of the original skull in July 2015 was a first highlight, and at the press conference, the museum was teeming with journalists (Fig. 1.8). A few days later, a scientific dig began at the discovery site in Montana/USA to find further material for science study in the company of a camera team of the local TV station RBB (RBB 2015). They also reported live on the expedition. When the exhibition opened on 16 December 2015, Tristan grabbed the headlines of the daily newspapers, with a special supplement in the Berliner Zeitung. National Geographic and even the Financial Times reported not only about the exhibition, but also about research and collection.

The exhibition contents highlight the open questions that scientists will address in the coming years. Each of the five main research topics is presented in the exhibition by questions and a video installation in which each scientist explains in own words what is going to be investigated on the fossil and why this is relevant. As a result the exhibition contents evolve along the research program: any time new results are going to be published the exhibition will be able to give answers to some of the questions. In consequence information should be easy to change–a feat that digital media technologies offer with ease (Fig. 1.9).

The exhibition team developed new showcases that use a mix of projection and printed texts along with objects on display. The printed layers are easy to change,

Fig. 1.8 Media attention: the *T. rex* skull arrived in summer 2015. **Copyright**: Carola Radke, MfN

Fig. 1.9 The Tristan app provides additional information on the exhibits. Contents are easy to change if necessary. **Copyright**: Hwa Ja Götz, MfN

without the need of reproducing animations or rearranging the objects. Above all, the projectors enable the use of sensors in a way that only after the visitor's interaction the printed text becomes visible. The idea of "looking behind something", is also a metaphor for the second media installation where film clips are projected on transparent screens. Standing in front of it, visitors can either follow the films or look through them onto the skeleton of Tristan. This leads to an interesting effect that is supported by the position of the screens: visitors will always look at the part of Tristan's skeleton that is most important for the scientist's quest (Fig. 1.10).

However, the transparent screens serve a second purpose namely to regulate the visitor flow in the gallery. With Tristan being positioned in the center of the gallery and the expectation that most visitors would gather around the pedestal there was the need to create an additional incentive for people to back up from the central installation. In this situation, the transparency works its magic: while watching films usually is more or less an intimate situation, in the Tristan hall the audience does not feel locked out. They can still see the main attraction and everything going on in the exhibition hall (Fig. 1.11).

Next to Tristan its original skull is presented in a special showcase, while the cast of it completes the skeleton. Being the highlight of the fossil find the skull is mounted in a way that each of its single fragments can be taken and studied without the need of demounting it completely. Therefore the mount and the showcase have certain specifications to make it conveniently accessible for scientists and allow for studies to be conducted live in the exhibition during opening hours (Fig. 1.12).

The exhibition design is based on the fascination that transfers through probably every fossil find, be it scientist or visitor. Fossil finds are rarely complete, often scattered and twisted, buried and turned into stone from which they reappear in fragments after millions of years. Each has its own hidden story that has to be brought to light and adds to the bigger picture like a piece in a jigsaw puzzle.

The pedestal consists of a number of fragments that seem to be slightly detached– just as the fossil. The surface looks and feels like concrete (which would have been the material of choice be it not for the weight) creating a picture of the skeleton standing above the "stone" it was buried in for millions of years (Fig. 1.13). The illumination from above and underneath generate a playful mix of shadows from the skeleton all over the hall, meant as a metaphor for the remains that nowadays can be seen as the shadow of an animal that used to live in ancient times. These elements are also vivid parts of the overall communication design be it typo, graphics, key visual or the companion book (Fig. 1.14) of the exhibition.

So far the project is a tremendous success. Studies of the skull provided enough data for a thesis, scientific papers on paleo-pathology are about to be published and press- and media coverage (online and print) had a commercial equivalent of approximately 70 million €, Meltwater recorded 3750 online articles, there have been over 1000 printed reports, 481 radio and 152 television broadcasts and more than 1 million visitors have already seen the exhibition. Beyond that the concept of Tristan being the center piece of an ongoing research process transfers right in to the public: just prior to this publication a team of international scientists took samples from Tristan's teeth live in the exhibition with hundreds of visitors taking part (Museum für Naturkunde 2017).

The question of how to visualize the process of research in an authentic way is a hot topic in the field of science communication. There are plenty of projects worldwide dealing with the accessibility of research and collections as modern concepts. However, it is much harder to display real science in an exhibition than it is to give

Fig. 1.10 The magic of transparent screens: depending on the point of view projection and real objects can fuse. **Copyright**: Hwa Ja Götz, MfN

Fig. 1.11 Media installation and object presentation not only work together on a didactical level, they also optimize the distribution of visitors in the exhibition. **Copyright**: Carola Radke, MfN

Fig. 1.12 One of the world's most complete *Tyrannosaurus rex* skulls: 50 out of 54 bones are preserved. **Copyright**: Carola Radke, MfN

Fig. 1.13 The pedestal consists out of concrete-like fragments mixed with show cases and media installations. **Copyright**: Hwa Ja Götz, MfN

Fig. 1.14 Nice gimmick: a special edition of the companion book is covered in concrete. It has to be excavated like the fossil. **Copyright**: Carola Radke, MfN

an authentic view into collections. That is illustrated by numbers of live labs in natural history museums all over the world that can be observed unused or that are run by volunteers instead of scientists. As authenticity is the key word here the Tristan exhibition concept might work as an example for other projects. It at least works for Berlin (Fig. 1.15).

Fig. 1.15 How to measure success of exhibitions: visitor numbers can't be beaten. **Copyright**: Carola Radke, MfN

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Chapter 2
Scientific Methods of Geological and Paleontological Collections and Trends in Paleontological Investigation and Research

Cathrin Hühne

2.1 Introduction

In the last decades the methods of paleontological investigation have been significantly changed, from conventional mechanical and manual methods to technically advanced and computer based techniques. The new abundance of possibilities to investigate a paleontological object has, firstly, the advantage that the new methods can be used without destroying the very valuable and rare objects. A multitude of methods are easy and feasible with manageable costs. Disadvantages are the occasionally long waiting lists for investigation time on the special equipment or high initial costs. Other points to pay attention to are the large amount of required data storage space because of the high resolution scanning, the plethora of different file formats, and connected with these two points, a strategy for data protection and longtime data access.

2.2 Methods of Preparation and Preservation

One of the most important items for paleontological research and investigation is the nondestructive extraction of the fossils from their matrix. Conventional approaches for removing the matrix from the fossil specimen are to use mechanical, physical and chemical preparation methods. Mechanical tools include the use of needles, dentist drills, scalpels, and pneumatic air scibes. Physical methods include brushing, sand-blast units (resources are for example sand, metal

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powder, sodium hexametaphosphate (10%), backing powder or starch), ultrasound and laser beams. Common chemical processes exploit the chemical differences between the fossils and their host rock. According to the chemistry of the matrix and the chemistry of the fossil specimen, acids of different strength are used to dissolve the matrix and separate it from the fossils. For example, weak acetic acid can be used to remove limestone ($CaCO_3$) from phosphatic fossils (Jeppsson et al. 1999).

The general micro-paleontological preparation method is the enrichment of microfossils by dissolving or comminution of the host rocks and washing, sieving and picking out the samples. Furthermore, the fossil morphology can be recovered by filling the cavities of dissolved fossils with plaster, polyester resins, silicone or latex to make a cast. The production of thin sections and peelings, by etching the surface with acetone and transmitting the rock and fossil structures onto special synthetic films ("Triafol") are also common preparation techniques to identify structures of the investigated objects.

For several decades it was usual that rock plates, which enclose fossilized bones, were investigated by X-ray technology before the preparation takes place. For instance, in 2016 X-ray tomography was used by the State Museum of Natural History to investigate a plate of shale at the X-ray apparatus of a hospital in Braunschweig, Germany. On first sight, there were only small pieces of bones visible. However, by investigation with the imaging method of X-ray tomography some complete phalanges of *Dorygnathus*, an Early Jurassic pterosaur, could be identified (Figs. 2.1 and 2.2).

In spite of an extremely cautious approach throughout the preparation process, damage of particular features and delicate structures is possible. Furthermore, these techniques do not allow the study of internal anatomy. A solution to these problems is to take a tomographic approach, creating a 3D model of the fossil from series of 2D slices (Cunningham et al. 2014).

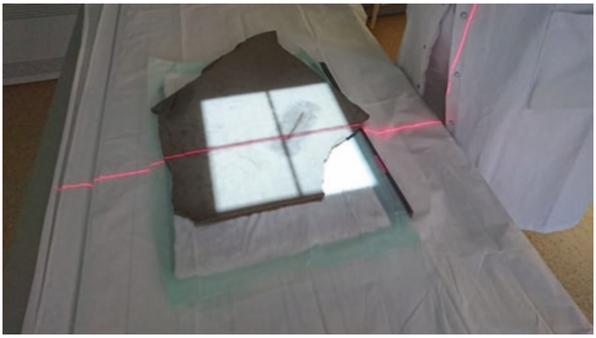

Fig. 2.1 Scanning process of a plate of shale with embedded phalanges of *Dorygnathus* by medical X-ray technology. Image: Sebastian Radecker, State Museum of Natural History in Braunschweig

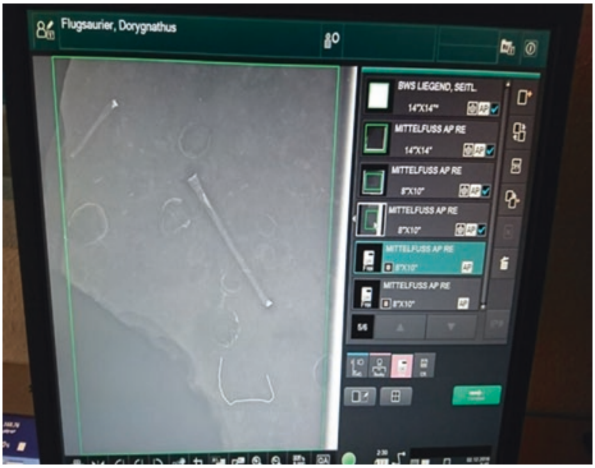

Fig. 2.2 2D visualization of the plate of shale and its fossil content on computer screen. Beside phalanges of *Dorygnathus,* several shells of bivalves can be seen. Image: Sebastian Radecker, State Museum of Natural History in Braunschweig

2.3 Spatial Visualization of Fossils

Computer tomography (CT), known as a very useful medical diagnostic procedure, has developed into a very powerful tool in modern paleontological research within the last three decades. In the 1970s, CT was introduced in material research while, in the 1990s, micro-CT (μCT) became an important nondestructive research technique (Cnudde et al. 2006). Computer tomography, or in full name "X-ray computed tomography", offers the nondestructive examination of valuable and irreplaceable fossils. With CT scans both the detailed analysis of internal structures and the visualization of surfaces in 3D are possible. Very small fossils of a size of less than a millimeter, like microfossils or teeth of small mammals, can be investigated as well as skulls or long bones from a centimeter to nearly a meter size, originating, for example, from dinosaurs or big mammals.

In contrast to the common X-ray, for computer tomography technology (*tomos* = slice, *graphos* = to write) a computer is connected to the X-ray apparatus. CT scanners take a great number of individual radiographs throughout the fossil at multiple angles. Each image is a single projection from only one angle. The CT software takes all these images and reconstructs the fossils, generating slices through the object and merges them into a 3D-graphic (Panciroli 2016).

CT scanning technology, which is used by paleontologists, is different from that of the medical profession. Micro-CT uses higher doses of X-rays than can be used on living organisms, allowing beams to penetrate denser materials like rock (Panciroli 2016). Furthermore, the medical CT scanners are restricted to relatively low-resolution imaging and thus are not able to visualize the fine anatomical details