Preparation of the remains of the oldest Tetrapoda in hard stones

by

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The Preparation Laboratory of the Division of Lower Vertebrates of the Paleontological Institute of the Academy of Sciences of U.S.S.R. has lately reached significant success in the exact morphological preparation of Paleozoic land vertebrates. For the raising of the art of preparation to the height where it is now, Russian science is in debt to the leader of the North Dvina Museum (at present the Division of Lower Vertebrates), the late Academician P. P. Sushkin, under whose close watch the authors of this article worked. We dedicate this work to his memory.

The remains of Paleozoic Tetrapoda are nearly always met in hard layers, and the older the bones are the more fragmentary are their remains and the harder the stone. The distribution of vion-flint compounds in layers of Carboniferous and Permo-Carboniferous makes them harder for preparation than the Permian layers, where the bones are contained mostly in the dense sands and marls. The hard layers and fragile bones of Paleozoic animals need special methods and practice for successful preparation. The present article is for individuals who know the basis of preparation work and therefore it does not contain a description of the basic method of work. The authors will consider their work successful if it will to some extent convince paleontologists working on the oldest quadrupeds to dismiss their usual fear of the stones that surrounds the objects of

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their work. Except for certain comparatively rare cases, every object may and must be prepared so that all of its details will be clearly seen. The basis of today's paleontological knowledge demands knowledge of anatomical preparation, the ability to free from the soil all of the morphological details that a given object has; and with that to be so careful as not to injure the thinnest lamellae of the bones. The future and meaning of an interesting paleontological remnant that is unprepared is equivalent to its being buried again. For many years to come, it will hide its morphological characteristics, on the basis of which many really important discoveries in paleontology could be made. The aims of the old authors, with few exceptions, are all such. Today, to our sorrow, in the greatest scientific institutes of Europe and America exceptionally interesting remains of Paleozoic Reptilia and Amphibia are preserved that were written about by many authors who did not even do the basic preparations of their objects.

From all of these remains one of the most interesting is the labyrinthodont *Melosaurus* from the Permian Capperish sands of pre-Urals in the U.S.S.R., which was described by H. v. Meyer and which, because no attempts for its preparation were even made, is up to now nearly unknown to paleontologists. Its skull is in the dense Capperish marl and very little deformed. From exactly the same marls we prepared in detail a skull of the labyrinthodont *Platyops*. Preparation is easy, the bones is such layers are well preserved, and undoubtedly a good preparation of *Melosaurus* will give all the details of the structure of its palatal and parietal surfaces and also of the basicranial and otic regions.

Some of the amphibians from the lower Permian of Texas and Illinois in the collections of Amer. Mus. of Natural History and the Walker Museum in Chicago and others also are unprepared. Such are the whole skulls of *Zatracnis* and *Cricotus*, described by Case and Broom. In these skulls, buried in the soil, are palatal and parietal surfaces (possibly hiding important representatives of Lower Permian Embolomeri). Also many skulls of amphibians and partly of reptiles, even well described, are left unprepared and unknown in many parts. For example *Bothriceps australis*, which has the ventral surface of the skull unprepared; *Brachyops*, *Gondwanosaurus*, *Dissorophus*, *Broiliallus*, *Platyhystrix*, *Micropholis*, *Cochleosaurus, Sclerocephalus, Onchlodon, Stephanospondyus*, and so on. Such a list may be very long. Some genera of amphibians are very fully worked over, for example: *Eryops*, *Archegosaurus*, *Cacops*, and others, but they are known from additional fragments, the breakage of which permitted the separate preparation of basicranial and otic regions, while their whole skulls are not prepared in detail. Even such a remarkable paleontologist, famous for his high technique in preparation, as Prof. D. M. S. Watson in his work, "The structure, evolution and origin of the Amphibia," writes for example about *Batrachosuchus* – "The praevomers are largely concealed by matrix" (p. 45).

But, judging by the preservation of the object, it would be not hard and would not take much time to remove this stone; and then the picture of the structure of the palate of *Batrachosuchus* would be complete. All this shows that the scare of preparation still exists in scientists and, what is worse, it results in leaving the most important morphological and systematic parts unprepared – the palatal and parietal surfaces of the skull. Paleontology armed with comparative anatomy makes a tremendous success. Today the question is brought up about looking over all of the forms not fully prepared. Because of that, every paleontologist who is performing the hard work of studying the oldest Tetrapoda should be able to know the methods of preparation perfectly, so that his work would not pass by and become one of the many pseudo-scientific descriptions that stand on the way of simple and clear reasoning in the field.

The quality of work that has been done improperly lowers the value of a scientific collection. For example the big collections from the Karoo, South Africa, which partly were obtained during older digging, are prepared very unsatisfactory from the technical point of view. The same is noticeable with the collections of Prof. V. P. Amalitsky from the North Dvina, which were prepared using the old method. Beginning in 1921 in Russia, there was a struggle to introduce the new method, and after 10 years the quality of preparation become quite satisfactory. Also the originals from the older work, which exist in the same condition at the present time are under detailed over-preparation.

The authors of this article had an opportunity to prepare many different bones of Permian Amphibia and Permo-Triassic Amphibia and reptiles, in particular the skulls, from different locations and different layers. Practice of a few years showed the possibility of preparation of any example from any layer. The only exception to this rule is an exceptionally spongy bone, which falls apart at the slightest stroke and which is located in the flint stone in such combination as we have not met; in the flint stone a bone usually is quite hard. In such cases it is possible, by dividing the soil on the corresponding parts, to beat out to the smallest detail all of the bone and making a series of thin casts to get quite a good picture by connecting them. We practiced this method on many fragments of badly destroyed bone. Preparation with the help of acids, which destroy the matrix, was left out by us after a series of experiments with different acids. As the bone which has been petrified in a given soil will consist of the same materials as this soil, it is clear that every acid that will destroy a given soil will also destroy the bone. Also the process of the destruction of soil is very slow. It is much faster to break off matrix with a chisel.

A usually practiced "handsome" preparation, contained by smoothing the soil around the exposed surface of the bone, is not good at all, as many of the borders, edges, and the general appearances of bones are destroyed and distorted. The taking apart of the bone and the soil must be done by striking or a sharp pushing instrument. Then the surface of the bone will be clear; sutures and connections are seen clearly then, too.

If the object of preparation happens to break in parts before or during the process of preparation, – it should not stop a scientist. Breaking is nothing if all of the pieces, even the smallest, are saved and if their interrelationships are not lost. An able and careful placing and gluing of the pieces of the bone will not, to some extent, destroy their original shape. The use of very strong gluing substances assures the necessary firmness of the object for further preparation. The best substances for such gluing are: D liquid glass – No_2Si_3, mixed with ocher and 20–30% talc until it reaches the consistency of cream, and then carefully ground up. This glue holds remarkably well and will always used by us for gluing the soils and bones before and during the process of preparation; it requires quite a long period for drying and is not waterproof; 2) ambroid (American cellulose glue) is good for work with thinner objects, for example: an already prepared piece of the bone, which is not quite prepared; it dries very quickly and holds very well but with time leaves a film, particularly on smooth surfaces; 3) for the smooth surfaces we recommend common glue, which after drying is covered with shellac so as to prevent the danger of its dissolving in water. It holds very well. One of the best substances for the preservation of spongy and cracked bones is an alcohol solution of shellac. Saturated with shellac, the spongiest or most fragile bones will stand the process of preparation very well. If an object has many cracks, they are then filled with a thick solution of shellac or liquid ambroid, and the object then is dried, and after that becomes fully monolithic; even the very dense bones should be covered with shellac as soon as they are reopened during preparation, so as to prevent their cracking. The wholly completed object also must be saturated with liquid shellac, otherwise its destruction will be slow but sure.

The reconstruction and filling in of lost parts is done with gypsum mixed with gum arabic. If an object is thin, and bones are fragile or located in a ??[†] matrix, then it is filled in with gypsum and then the rest of the soil is beaten off. After that the gypsum is softened in water and object is taken out. Depending upon the needed strength, gypsum for support is mixed with gum arabic or carpenter's glue for the matrix, support is made from cement.

The preparation always takes place on canvas pillows filled with sand. The fragile remains are best prepared in a big, flat box filled to the top with sand. Such a box permits the steady and safe position of an object of any shape, and is especially recommended in the last stages of detailed preparations of skulls, when many of the parts are supported only by their natural supports, free of soil.

The inventory of the preparation laboratory is comparatively simple and cheap. Any sort of automatic instruments are not good for preliminary preparation, as they can never give the necessary gradation of the sudden change from the strong, sharp stack to

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[†] *mpeuyuseobampsonopogy*.

light knocks. Of the many pneumatic, centrifugal, and electric perforating chisels tried by us, the only quite good one was the striking dental perforating drill (manu. by Zimmermann, Munich). It is made after a type of electric dental drill machine with a flexible shaft, only its point is placed to the ??[†]. ??[††] instrument gives not a rotating but a striking movement. The stroke power is regulated by the rotation of a small collar, which presses on the spring of a hammer. The hammer strikes a cartridge, which contains a chisel. The whole instrument does not exceed the usual end-piece of a dental drilling machine in size and is hermetically protected from dust. The motor of a good construction 2 amp, 110 volts, 0.2 H.P. alternating current, asynchronous with ?? permits regulating the speed of the rotation and therefore the number of strikes. Altogether there are four (4) speeds; highest – 1500 rotations a minute. The practice showed that it is best to work at the highest speed, regulating the stroke power. We used our motors to a great extent and we highly recommend them for the preparation of thin objects, for they make the work much easier. But the motor gives a very insignificant stroke power, and the beginning of the work on the paleontological remnant will be very slow. If the object is very cracked or fragile, preparation with the Zimmerman motor should be avoided, because on the whole the motor gives a noticeable continuous vibration.

A definite help is a dental drilling machine with drills of different needles, which will be useful with all hard bone-bearing stones, with the exception of the pure flint stone. Because work with pressing instruments proceeds very slowly, takes much energy, and requires physical strength of the fingers, therefore a larger importance in

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† *nocpegembon*.
†† *Kyrarkobon*.

preparation is left to the striking instruments. These instruments are common chisels, with which the stone may be broken off, plus the help of a hammer.

Experience made us come to the conclusion that the most convenient form of chisel is one consisting of a straight steel shaft of round cross-section, with the sharpened end also round in cross-section. All other forms of filing of chisels are not good enough for preparation in hard stones. Somewhat better is the square form of chisel with the square end point. But with such a form, the chisel crushes the stone, makes radial cracks, a wide margin, and too much dust. It is also very bad for working on flat surfaces. The round chisel does not have all of these defects. We recommend the most useful sizes of chisels: l) for preliminary preparation of the largest objects and taking off the thick stone – length from 200 to 120 mm, width from 12 to 6 mm, 2) for middle-size objects and for contouring of basic bones – length from 150 to 80 mm, width from 5 to 4 mm; 3) for detailed preparation of the thinnest objects (for example basicranial part of the skull) – length from 120 to 70 mm with a width of 3 mm, and from 70 to 40 mm with a width of 2 mm, 4) special chisels a) for preparation of the narrow grooves of big skulls – length from 270 to 200 mm, width 5 mm, b) for very detailed work on the most important surface of the bone, chisels with length from 50–40 mm thickened gradually upward, with the width of the lower third not more than 2 mm, are used. For the same finishing work pentagonal needles for [blank] are very convenient. They must be shortened by filing off the rounded end to a width of 2 mm and a length of 80 or so mm. The thinner the chisel is the shorter it must be, otherwise they will bend and spring at strong strokes. Filing off the end of a chisel may be of two different types – a cove with a wide base for spongy, sticky, or very hard stones, and a cove with a narrow base for the rest. The steel for the chisels is best of the "[blank] or [blank]" type, tempering the point to a bluish color or dark orange for especially hard material. Particularly convenient are thin chisels that are thickened in the middle, for such chisels don't bend, don't spring, and are very convenient to hold. The other end of the chisel must not be tempered in any way, for otherwise during the work small pieces of steel will break off its end and injure the hands and face. The hammers for said chisels are of very simple form, in the shape of a short [blank].

The long axis of [blank] must not exceed the short one by much, so that the form of the hammer would be close to that of a cube. Such a hammer has a wide striking surface, does not break the wooden handle, and has a significant weight, being small in size. It is even more convenient if the hammer is slightly bent in the form of a curve along the radius of the stroke, and its striking surfaces inclined. The weight of the hammer must be in strict proportion with the weight of the chisel. On the whole a heavy hammer is less tiring and gives a much greater effect with less vibration. The proportion of the weight of the hammer to the weight of the chisel is about the following: for the chisels of the 1st class – hammer 3-4 times heavier than the chisel, for the 2nd class – 5 times as heavy as the chisel, and for the 3rd class – 8 times. For the first 2 classes of chisels, the hammer must be made of iron, because the steel ones slide off very easily and injure the hands of the worker. For the 3rd class of chisels, where the strokes are much weaker, a hammer of soft steel is better, as it flattens less than an iron one.

Good pliers of middle and small sizes are a great help; better with side cutting edges and a wide opening for convenient taking hold. They permit taking off the stone on the elevations and outgrowths without any strokes.

It is particularly important, especially for detailed anatomical preparation, to have a binocular scope (Zeiss or Leitz) on a universal stand with 2 pairs of objectives and eye-pieces, thus being able to magnify the objects from 5 to 30 times. With this kind of binocular the absolute cleaning of bone from stone is possible, including the ability to find the openings of nerves and blood-carrying tissues. Preparation under the binocular does not tire a worker, for it looks to him that big pieces of stone are being broken off and that work moves on very quickly. It is absolutely necessary to have at least one binocular in the laboratory.

Thus ends the number of basic instruments for the preparation of bones in hard stones. We do not mention different small instruments of general character – brushes, paint brushes, rubber cup holders for gypsum, scalpels, pincers and so on, because every worker must be acquainted with the generalities of the work. We recommend having a number of pincers for gluing thin pieces and also small, thin paint brushes for applying glue and covering the smallest and thinnest parts of the exposed bone with shellac.

The degree of the preservation of the bones has a very great importance in preparation of bones in hard stone. The types of preservation may be on the whole divided into the following groups:

I. Bones with the glass-like layer preserved.

(a) solid and hard, (b) hard and fragile,

(c) soft and solid, (d) soft and fragile.

II. Bones with glass-like layer destroyed; solidly attached to the stone and with the surfaces destroyed before their burial.

(a) hard and solid, (b) spongy and cracked,

(c) spongy and

of course, the best for work are the bones of the first type. The stone in these cases can be taken off very well and very clearly – groups (a) and (b) must be prepared (to the bone) by holding the chisel nearly perpendicular to the surface of the stone, group (c) is worked on by holding the chisel at an angle of 45º–50º, so as to lessen the pressure upon the bone. Group (d) is met very rarely and requires special care during preparation with pressing instruments. All of the last three groups of the first type require thorough saturation with shellac. The second type always [blank] the bone with the injured surface, because the broken off stone always carries with it a thin layer of the surface of the bone. It is common for locations where the material already had a destroyed surface as the result of the action of reagents before it was buried; and also for natural stones, when the material of the stone enters deeply into the bone and becomes attached to it. Such bones are best worked on by maximally thinning the stone around it and then breaking it off by frequent, small strokes and holding the chisel perpendicularly to the bone, for group (a). In these cases, for the removal of a thin layer of stone, nothing can substitute the Zimmermann motor by use of pressing needle, this kind of work will be well done. For groups (b) and (c), in order to thin the stone layer at first, it is necessary to saturate the bone with shellac and then break off stone by holding the chisel at a very sharp angle, nearly parallel to the surface of the bone. If, during the breaking off, the stone takes part of the bone, it is necessary to glue it back with liquid glass and after it dries to begin the preparation again. Sometimes it is necessary to glue the same piece over and over again, but as time goes on the layer of stone becomes thinner and thinner until finally the surface of the bone appears.

The hardness of the stone has no particular significance for the quality of preparation if the bone is well preserved. At the most it may slow the work. Particularly hard for work are only clearly [blank] structures. To prepare them, chisels are necessary, which become dulled after two–three strokes, and thus it takes a very long time for sharpening of these chisels. Preparation should be done by very strong, sharp strokes with the chisel nearly vertical to the surface of the bone, for otherwise it will only slide, without breaking off the stone. Although the work goes on very slowly, it is possible to achieve good results. A great help in the work is drilling of the stone in massive parts with carborundum drills of the drilling machine, or simply with drills with powdered carborundum so as to destroy the firmness of the stone, particularly if it is a glass structure. All others are well worked on by the chisels and needles. The best preservation of bones is noticed in homoferreous, dense stones, which were layered marls, sands and marls.

The stones consisting of layers are noticeable for the worst preservation of bones, usually deformed. Breaking off such layers must be done by careful strokes of the chisel along the plane of the layers. When getting close to the bone, the work should be done by strokes perpendicular to the plane of the layers. The hard-cracked stones should first be saturated with thick shellac or liquid ambroid. After a careful breaking off of the outside part of the stone, it is necessary to put an object into a gypsum case and prepare it as a typical massive stone, all the time covering it with shellac.

Soft, sticky layers are very easy for work – clays and marls that have a small carbonate part and some of the bituminous [blank]. Bones in such layers are soft but solid. They are easily prepared by a thin chisel with a heavy hammer (for the stickiness of the layer) or with pressing instruments. Partial soaking in water is very good, but it should be remembered that the bone will become soaked too, and there it should be carefully saturated with shellac.

In the Upper Permian continental strata are located the spongy, bone-bearing layers – sands, sandy marls, and conglomerates with a small quantity of cement. The bones in these layers are very fragile but perfectly preserved, including the glass-like layer. The stone breaks off the bone very well, although around the bone it is much harder. Preparation of bones in spongy stones is easy and pleasant, but it requires a particular carefulness with the bone and saturation with shellac. The use of chisels should only occur in the early stage of work, further work ought to be done with pressing instruments only. The use of the Zimmerman motor is possible, but there is always a danger of the appearance of cracks. With the observance of the necessary [blank] it is, for example, possible to remove all of the stone out of skull.

Long practice permitted our laboratory to perform a number of works that were considered impossible before. The hard sands of the Permian conditions of North Dvina no longer stand in the way of the appearance of the most complicated details. The authors of this article and T. A. Gatuer prepared a few skulls of Permo-Triassic Benthosauridae amphibians by completely cleaning the cranium and otic region from the stone. The deformed and very fragile skulls of the labyrinthodont *Platyops* from the calcareous layers of Chirkov-Shihovo, Viatsky district, were very successfully prepared. The bones of the Triassic labyrinthodonts from the city of Bolshoe Bogdo, located in hard calcareous layers, were prepared completely and successfully, especially thin preparation was done by F. M. Kuzmin from the hard sands; preparing the small bones of

Seymouriamorpha and Pelycosauria and also forms of benthosaurs (the length of a skull – 20 mm) with full details. The ability of good preparation is very important in the study of ancient Tetrapoda. It is also very important that in the future a close contact be established between Russian and foreign laboratories.

A new period of exact paleontology begins with a new, braver, and much more detailed preparation. Then let the experience collected by hard work not to go by without use, but let it document the history of development of higher animal forms upon the earth tell everything that they can.