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# 3D CASTS FROM NATURAL MOLDS: A CASE STUDY IN FOSSIL FROGS

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**Abstract.** The technique presented in this paper points to the recovery of three dimensional rigid casts from natural molds of fossil organisms. The study of organisms preserved as molds in the rock (usually in slabs) is difficult, even if the natural mold is highly detailed. Traditionally, casts were made from each side of the natural mold, resulting in positive, soft partial specimens embedded in the rock. These kind of casts did not solve some issues related to the preservational mode and exposure of the natural molds. The application of this technique turns a natural rigid mold into a soft silicone rubber mold to make a final three dimensional rigid cast of the whole specimen devoid of sediment. This technique provides casts that preserve the details of the natural mold. The obtained casts allow and facilitate scientific anatomical studies but also provide excellent specimens for museum exhibition or educational purposes.

**Key words.** Silicone rubber. Resin. Replicas. Molding technique. Slabs. Museum.

**Resumen.** RÉPLICAS 3D A PARTIR DE MOLDES NATURALES: UN CASO DE ESTUDIO BASADO EN FÓSILES DE RANAS. La técnica que presentamos en esta contribución apunta a la obtención de réplicas rígidas de fósiles que se preservaron en las rocas como moldes naturales. El estudio de organismos preservados de esta forma (comúnmente en lajas) es dificultoso, aun si el molde tiene una excelente preservación. Tradicionalmente, dicha dificultad se ha resuelto realizando copias de los moldes naturales, obteniendo positivos (réplicas) parciales y flexibles del espécimen. Este tipo de copias facilitan el estudio pero no resuelven todos los problemas relativos a la preservación en sí misma y a la exposición del ejemplar fósil. La técnica que aquí desarrollamos convierte, mediante una serie de pasos intermedios, un molde natural rígido en uno flexible del que a su vez se obtienen copias rígidas, tridimensionales y libres de sedimento del espécimen fósil, que conserva todos los detalles del molde natural. Las copias obtenidas sirven no solo para facilitar el estudio anatómico morfológico de los restos fósiles sino también como material didáctico y de exhibición de gran calidad.

**Palabras clave.** Caucho de silicona. Resina. Copias. Técnicas de molde. Lajas. Museo.

It is frequent for fossil frogs to be preserved as natural molds, where the skeletal remains are lost leaving their impression on the rock. This makes morphological observation difficult, even if the preservation of this natural mold is good, not only because the specimen is exposed in negative form but also because some structures extend laterally inside the sediment and cannot be directly observed. Also, when the slabs are broken apart, the fracture plane cuts the specimen randomly, which usually distorts the real silhouette of the elements. To recover the positive morphology, casts are usually made from the fossil negative (natural mold) using different materials, such as silicone rubber (Kelly and McLachlan, 1980; Benton and Walker, 1981), latex (Heaton, 1980), or alginate (Brand and Dupper, 1982). However, they result in the obtention of independent positive part and counter part of the specimen, which usually carries interpretive incongruences, especially owing to the random fracture of the slabs. The technique that follows is relatively simple and points to recover the morphology of the whole specimen with a three-dimensional cast devoid of sediment, solving the aforementioned problems. Kelly and McLachlan (1980) presented a technique to obtain a 3D cast directly from the natural molds. It was conceived for simple morphologies (such as bivalves), which may even require a planned breakage of the fossil to remove the positive; for larger slabs this turns impracticable: the extended contact surface would make them to stick to one another if filed with silicone. Besides, slender bones would not hold their shape if casted in silicone rubber; instead, they would bend. Nowadays, only the CT scans goes in the direction of obtaining a 3D cast preventing the damage of the fossil. However, the technique is not always available or affordable and sometimes the size of the rock containing the fossils is larger than the receptacle of the tomograph. Besides, some fine details of the surface of the bones are better observed from the rubber cast than from the CT images (Ascarrunz *et al.*, 2016). The aim of the procedure presented in this contribution is to replicate the natural mold, through an intermediate mastercast, into a flexible silicone mold with locks from which a rigid full cast can be obtained.

This procedure involves one step more than regular molding and casting technique but if high quality materials are employed and carefully applied the final cast will retain great detail.

## MATERIAL AND METHODS

We herein use the definitions of Kelly and McLachlan (1980, p. 448) for cast and mold, respectively: "*The exact reproduction, whether natural or synthetic of the whole or part of any organism or structure*" and "*The impression, whether natural or synthetic of the whole or part of any organism or structure*".

The specimens for which this technique was developed consist of natural molds of frogs of the species *Calyptocephalella canqueli* Schaeffer, 1949, from the Puesto Baibián locality, Chubut province, Argentina (Muzzopappa and Báez, 2009) and a frog under study from Río Pichileufú locality, Río Negro province, Argentina. The sediments bearing the fossils constituted the bottom of lakes of Paleogene age. The preservation of the skeletal elements is very detailed owing to the fine grained matrix in which they remained as molds and, remarkably, they show little deformation or flattening usual in lake deposits.

## OBTAINING 3D RIGID CASTS FROM NATURAL MOLDS

### *Preparing the specimen*

The specimen (schematically represented in Figure 1.1 as a slab and counter slab containing the natural mold of a frog humerus) must be cleaned and prepared for the molding process removing any debris from the natural mold (*e.g.*, carbon layer, sectioned pieces of bones that hinder the surface of the mold, lacquer or other such materials that may have been used to protect the specimen during collection or preparation) and also from the slab surface since all parts of the mold must fit together perfectly. Seal all the cracks to avoid the silicone from leaking into them. Apply a thin and even layer of B72 (or similar) over the entire surface of both the sediment and the impressions of the specimen (a thick layer would obscure details of the fossil). It will function not only as a protection of the specimen but also as a release agent after the silicone rubber step is completed.

### *Clay beds and locks*

One of the slabs must be embedded in plasticine in order to extend its surface outwards (Fig. 1.2) and to generate room for the locks to be placed (see below).

Although we find that in many cases slab and counter slab fit together accurately even if being mostly flat, sometimes this fitting is not sufficient when transferred to the silicone version of the mold; therefore, locks will be added. Prepare paired locks (plugs and sockets; Fig. 1.2) that fit together perfectly. We made them in epoxy putty so that they remain stable during the process, not bending or deforming. Also, their bases must be deep to be well embedded in the plasticine to avoid a possible posterior dislocation. These plug and socket locks were selected to facilitate the flowing of excess material in the final, casting step.

One side of the locks is embedded in the clay bed (Fig. 1.2); after that, the other side of the locks are secured in place (Fig. 1.3). Then, the counter slab is fitted upon the slab (Fig. 1.4); this must be carefully done so that the final piece results without shifts of the sides.

For the clay bed of the counter slab, the plasticine is heated to make it softer so that it can be applied without moving the elements (Fig. 1.5). Pieces of paper, film or aluminium foil, for instance, should be used to prevent both clay beds from sticking to one another. Once the clay is cooled, both sides must be carefully taken apart. (Fig. 1.6)

The following steps (Figs. 1.7– 8, 2.1–4) will be described for one side but should be performed on both slabs to obtain

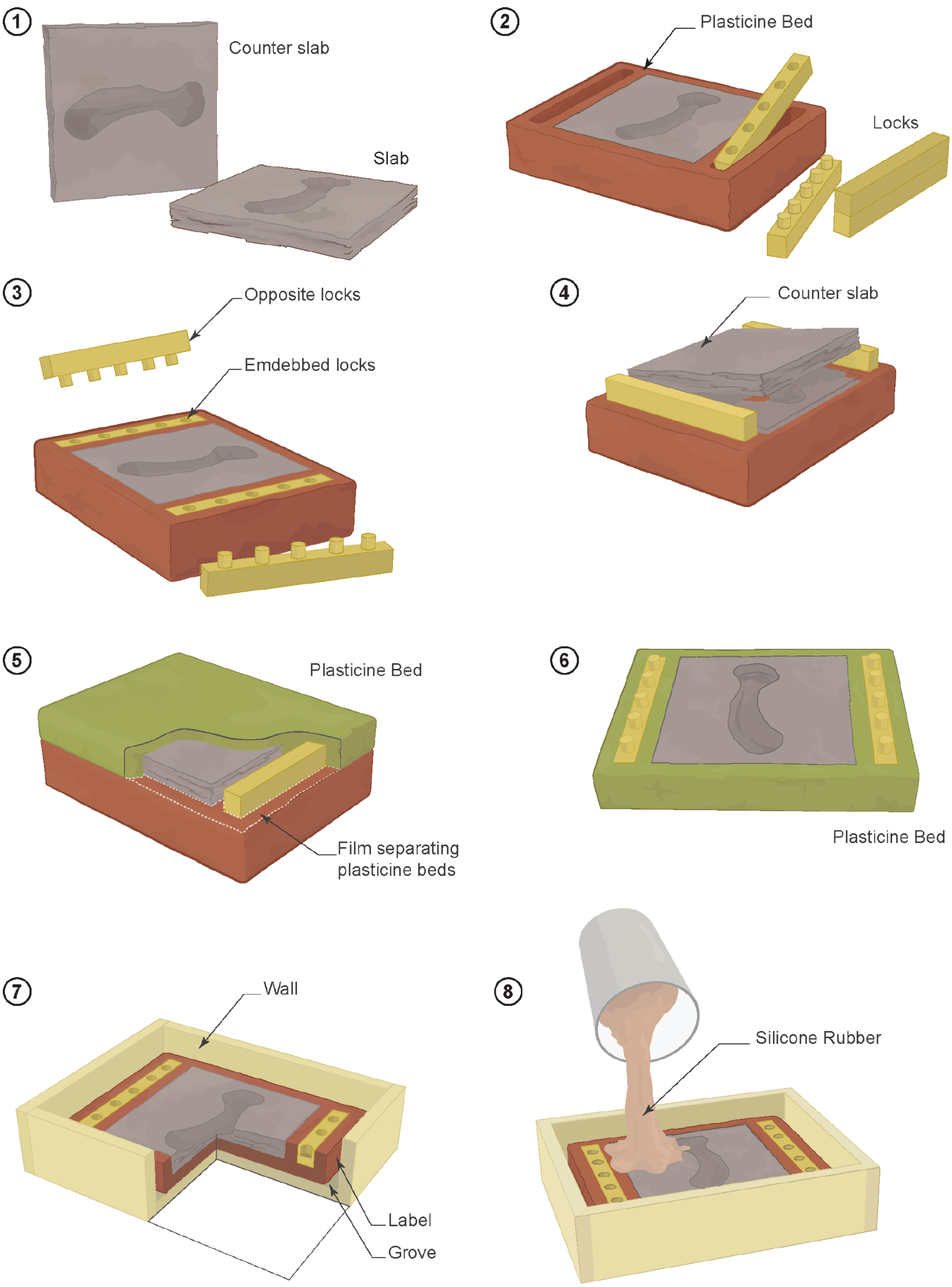


**Figure 1.** Schematic step-by-step representation of the technique, part I. Steps **7–8** must be performed on the slab and counter slab independently. **1,** Slab and counter slab bearing the fossil natural mold; **2,** slab embedded in plasticine and placement of locks; **3,** one side of the locks embedded into the plasticine bed; **4,** fitted counter slab and the other side of the locks; **5,** plasticine bed for the counter slab; **6,** counter slab and opposite locks embedded in plasticine bed; **7,** making of the groove, wall and labelling; **8,** silicone rubber poured inside the contention wall. [planned for page width]

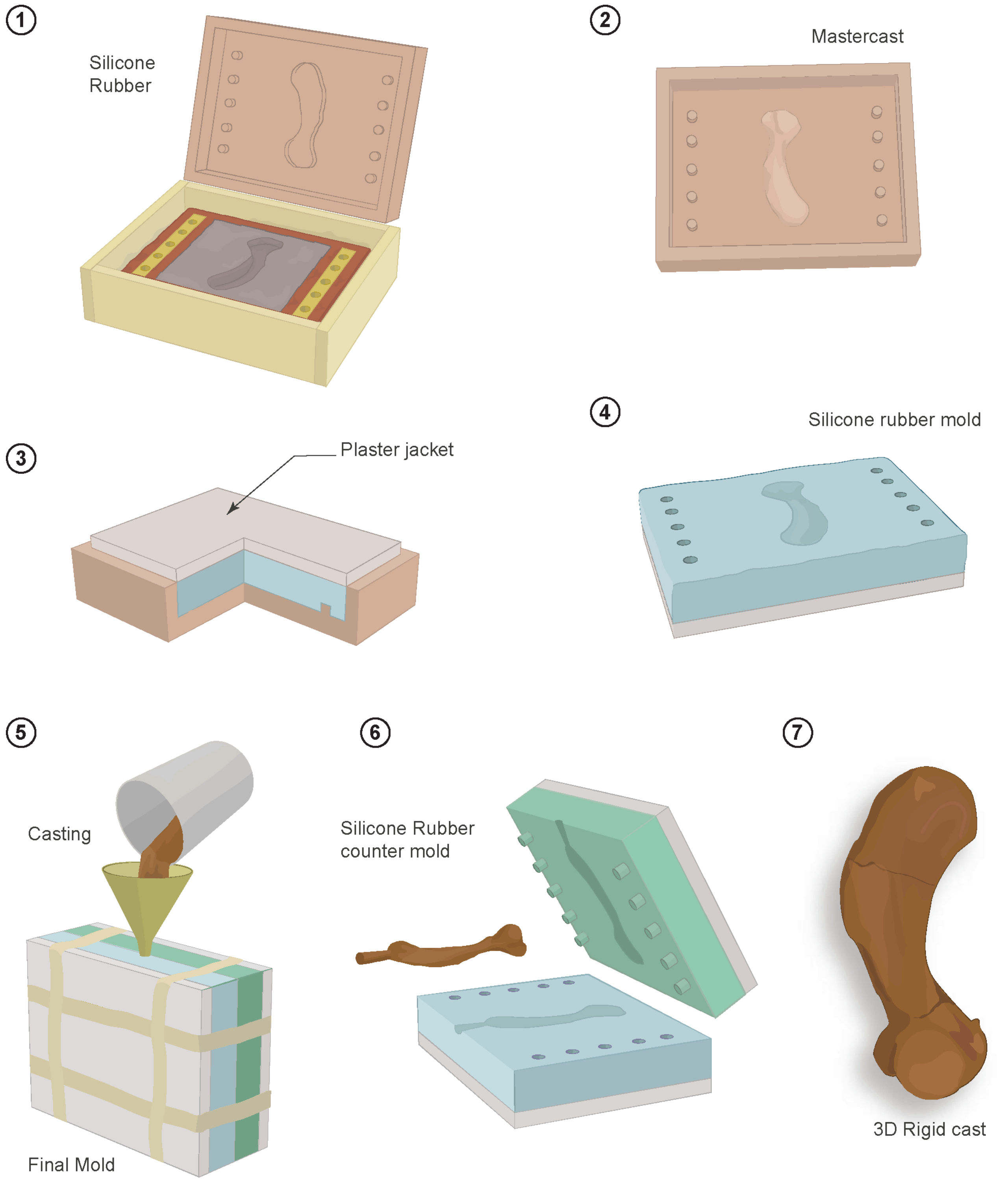


**Figure 2.** Schematic step-by-step representation of the technique, part II. Steps **1–4** must be performed on the slab and counter slab independently. **1,** De-molding of the silicone rubber from the slab; **2,** mastercast obtained after de-molding the silicone rubber; **3,** making of the silicone rubber mold from the mastercast; **4,** one side of the silicone rubber mold; **5,** making the rigid cast from the final silicone rubber mold; **6,** de-moulding the fossil replica; **7,** final 3D rigid cast of the fossil. [planned for page width]

the complete mold of the specimen. Variations of these following steps are discussed below.

Surrounding the locks, a groove should be excavated in the clay (Fig. 1.7). This groove, which will function as the contention wall when pouring the fluent silicone rubber in further steps, must be deeper than the deepest points of the natural mold and the sockets. Before applying the silicone, it is suggested to label the mold by engraving the collection number of the specimen in the clay, in the slab side of the groove, so that the collection number is easy to recognize when the mold is stored.

Finally, build a wall along the external border of the layer of clay (Fig. 1.7), the contention barrier for the poured silicone rubber used in the next step. This wall must be taller than the highest point of the mold and the plugs.

### *Mastercast*

Prepare the silicone rubber. First, a very thin layer should be poured over the specimen (Fig. 1.8); the silicone could be forced to enter into the cavities by pumping air with a blowpipe, preventing air bubbles from being trapped. Once a thin layer is made and the absence of bubbles is assumed, the rest of the silicone rubber can be poured over. Only after the silicone rubber is cured, it can be de-molded (Fig. 2.1) (with caution, to prevent any damage of the fossil). In case the silicone rubber gets stuck, a few drops of alcohol would help release it.

The piece obtained at the end of this step consists on the mastercast (Fig. 2.2). We here define mastercast as a cast which includes not only the fossil but also the surrounding surface and the locks, from which a new mold can be obtained.

### *Making the final mold*

Apply a release agent over the surface of the mastercast. Prepare silicone rubber and repeat the previous step (Fig. 2.3). Make a plaster jacket over the surface of the silicone rubber. After the plaster solidifies, de-mold the mastercast; now the parts of the mold (Fig. 2.4) are ready for the casting stage.

Prepare the product to make the final piece; it could be either plaster, resin or the preferred casting material. Proceed as with a regular mold: fill the mold cavities and close it. When releasing the piece, a 3D specimen of both sides combined, rigid and free of sediment would be obtained (Fig. 2.5–7).

## DISCUSSION

The procedure as described herein uses the 'poured mold' technique, in which the silicone rubber is poured in a contained volume forming a rubber block. However, if using the 'layered mold' technique, in which the silicone rubber is painted in successive layers and backed by a rigid (plaster or plastic) jacket, the elaboration of the groove and the wall around the clay bed could be simplified or even omitted.

For the sake of clarity, we used a simplified ideal slab; however in lab, it is frequent to face many different situations. We believe that the technique as described here can be easily modified or adapted according to different scenarios. For large slabs containing a small fossil, it would be not necessary to make a large mastercast; instead of surrounding the whole slab with clay, build a wall on the slab surface delimiting the desired area and reaching out to the nearest borders for locks placement. When proceeding like this, the making of the groove and the walls indicated above (Fig. 1.7) have to be modified. The contention wall for the silicone rubber at each step has to be elaborated independently. Hence, the contention wall to make the mastercast should be built on the sediment surrounding the desired section of the slab and the locks, while the contention wall to make the silicone rubber mold must be erected around the mastercast.

Sometimes, the slabs containing the fossils are broken into more than two parts; in those cases, the different parts of the fossil can be either assembled as to obtain two sides or be treated independently adding locks between all the parts. Also, it can occur that some parts of the slabs containing the natural mold are missing; in this situation, the gaps produced by the missing parts can be filled with clay (providing that this does not affect the fitting of the parts by the clay not surpassing the surface of the slab), which will result in a positive 'block' of missing information in the final piece. There are other cases in which some elements of the skeleton show up in the edges of the slabs; the holes produced by these in the final silicone rubber mold can be used as pouring holes for the casting material.

When several elements of the skeleton are preserved in a single slab, either semi or disarticulated, the application of the technique will result in the obtention of independent casts of the isolated elements. In case the relative position of the different elements is intended to be preserved, this can be achieve by connecting the elements through clay strips placed over one side of the mastercast before making the silicone rubber mold (Reuil, 2001). With this modification, the different elements of the skeleton will be connected to each other by 'lines' in the final cast.

The goal of the technique is to recover the natural molds contained in the geological record. Here, we focused on slabs. However, natural molds occur in a variety of rocks and the technique can be applied to these by making the proper adaptations in accordance to the particularities of the fossil. The technique can also be extended to make rigid endocasts of broken skulls.

## CONCLUSION

The objective regarding the molding process herein described is to transform the (natural) rigid mold into a (silicone rubber) flexible one; in other words, the technique allows to obtain a rigid cast from the rigid (natural) mold.

The technique constitutes a relatively easy, fast and economic way to recover a rigid cast from a natural mold, facilitating the study of the fossils preserved in this mode. Also, the specimens obtained are qualified for museum exhibitions and also for educational purposes. Once the mold is made multiple casts can be obtained from it without the need to intervene the original specimen.

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