A MULTI-MEDIA SOLUTION TO COMPLEX MOLDING AND CASTING OF INTERNAL AND EXTERNAL SURFACES OF A FOSSIL *HOMO ERECTUS* CRANIUM FROM JAVA

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INTRODUCTION: Replication of complex fossil specimens poses a number of difficulties, including endangering the original specimen (breakage involved in demolding), tearing the mold during removal of the original or the cast, and making correct decisions about choice of materials and methods to maximize integrity of the fossil, longevity of the mold, and fidelity of the cast.

Typical materials used for molding of vertebrate fossils include RTV silicone rubber, paste silicone rubber, latex rubber, and polyurethane rubber. These vary widely in hardness or flexibility, price, compatibility with different casting compounds, shelf life, and modes of application. Casts are typically poured, painted, rotated, or injected into molds, and are typically made of epoxy or polyester resins, urethanes, or plaster, and may incorporate a range of fillers (marble dust, glass beads, talc, fiberglass). These also vary widely in price and applicability. Ideally, molds will provide a good compromise between price, flexibility, longevity, and compatibility with many different casting compounds. Similarly, casts should provide a good balance between price, accuracy of reproduction, and compatibility with the molding system. Molding is an inherently dangerous process for original fossils, and should only be undertaken where necessary, when the risk of loss of morphological information is outweighed by other concerns (accessibility, broad educational exposure, inability of the original specimen to stand up to frequent handling).

Difficulties for molding specimens with complex morphology can be solved using several techniques, most commonly by constructing multi-piece molds to accommodate deep insets and overhangs. Any multi-piece mold can be reduced to a series of two-part molds. For larger, more complicated specimens, molding material can be painted on in layers and kept thin, to enhance flexibility. A representative series of molding solutions for replication of complex specimens is presented here.

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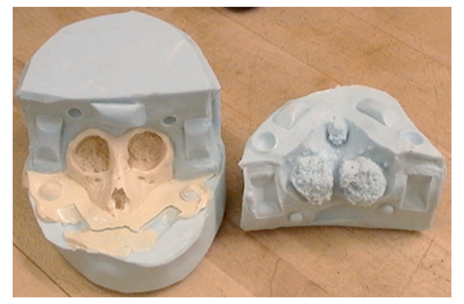

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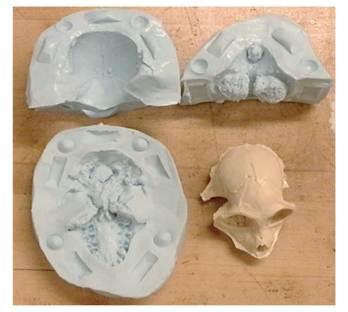

Figures 1 and 2. Mold and cast of small fossil anthropoid cranium. Excavated orbits created paired deep insets, necessitating dividing the top half of the cranium into separate front and back parts. The mold was made using RTV silicone in solid pours, and the cast is composed of solid polyester resin mixed with talc and pigment. No damage was incurred during the removal of the original specimen from the mold, or by subsequent pulls of casts (six casts were made). By painting in the first resin layer by brush, we avoided having air bubbles form along the surface. Polyester resin provides reasonably good detail, is dimensionally stable, and can be painted using a variety of oil- and water-based paints.

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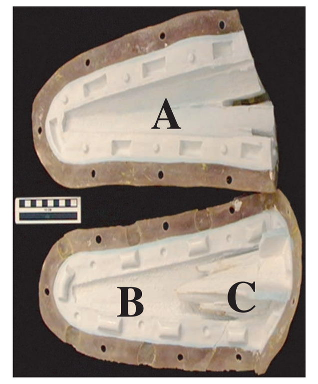

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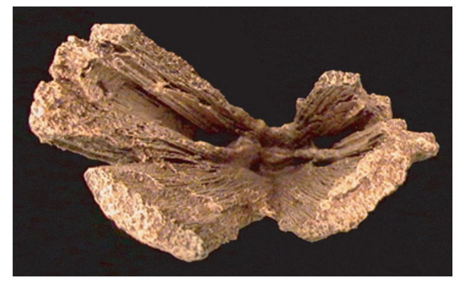

Figures 3-5. Mold set up, mold, and cast detail of a bill-fish rostrum. The problem faced with this specimen is a deep posterior inset lined with finely detailed structure. The solution was to elaborately block the specimen in the clay set up, to permit eventual construction of a third mold piece focused specifically on the area of greatest depth and detail. The mold was made of three pieces, each layered on (three layers), with a fiberglass-and-polyester resin mother-mold to support each part. The replicate was cast as a polyester resin/talc and fiberglass hollow cast; several layers were painted on, and the final layer was done in finishing resin with fiberglass matte. The cast detail image shows successful capture of the posterior, internal morphology of the rostrum.

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Figure 6. Original specimen, sauropod vertebra, and six piece mold. The left-hand mold piece is actually four mold parts bolted together. The problem faced is that there are deep insets encircling the entire specimen, and an open vertebral foramen. The foramen was molded using a solid silicone rubber plug, which is keyed to alternate sides of the mold; the mold pieces were layered on, and several hollow-cast replicates were made. The number of mold pieces ensured that no damage occurred during the process, to the original or casts.

***HOMO ERECTUS* CRANIUM REPLICATION PROJECT:** We received a urethane cast of a new *Homo erectus* cranium (Tjg 1993.05) from Tanjung, Sangiran Dome, central Java, to be remolded and recast. The original was molded in a solid block of silicone rubber, and was then cut out. The silicone pieces were reassembled, and only a single cast was possible before the mold suffered damage from tearing. **Figure 7** shows the urethane cast that we started with. The challenge in this project was that the endocranial cavity of the braincase is deep and substantially overhung by segments of the basicranium, making it difficult to conceive of a mold that could reproduce both the external and internal surfaces of the specimen.

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Because of the curvature of the braincase, basicranial overhangs, and deep details of the orbital region, we decided to use latex rubber, thinned with water and reinforced with gauze, to make the mold parts. The thin aspect of the mold parts allowed sufficient flexibility to permit the internal braincase portion to be collapsed on itself for removal.

Figure 8. Step one: the urethane cast of the cranium was sunk into insulation foam and embedded in a clay frame so that its internal surface, basicranium, and orbital region could be molded first. We used a non-oil based, non-toxic reusable clay (Kleen Klay), and took great care to create smooth, precise parting lines along the flash lines from the original molding and casting. Lock tabs for proper alignment of mold pieces were made by cutting rolls of clay in half and tapering the ends (positive tabs) and by pressing the end of an X-acto knife handle into the clay (negative tabs). A low clay wall surrounds the area to which the latex was applied. The clay surface was coated with white shellac thinned by isopropyl alcohol in a 1:1 ratio.

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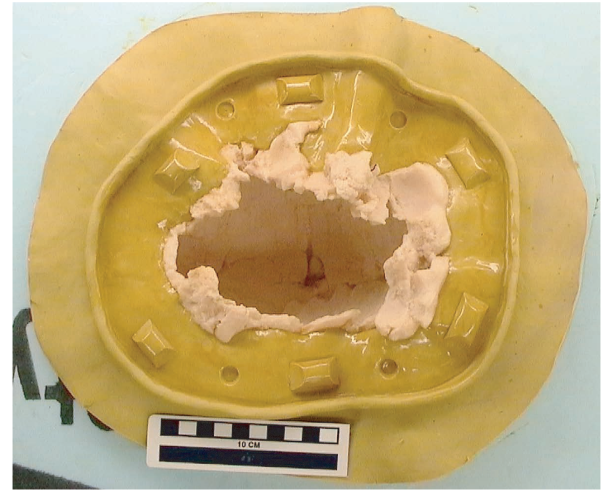

The thinned latex rubber was painted on, and each layer was allowed to dry completely before application of the next layer. Eleven layers were applied, with two layers of gauze interspersed within the latex. Care was taken to prevent pooling of latex within the braincase. The resulting mold segment is very thin, strong, flexible, and has captured the details of the specimen with accuracy, while lacking any obvious bubbling or other surface defects.

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Figures 9 and 10. Details of the first mold segment of the inner surface of the endocranial cavity. On the left (Figure 9), lateral view of the inner surface of the mold segment, showing the total thinness of the mold layers, and detail and eccentric shape of the braincase surface. On the right (Figure 10), superior view of the outer surface of the mold segment, showing the depth of the braincase, surrounded by overhangs. This posed a critical problem: how to apply a supporting mother-mold on the outside of this mold segment, which could be removed safely from within the endocranial cavity without damaging the overhangs. The mother-mold needed to be sufficiently stiff to support the mold during the casting process, but have enough "give" to remove it prior to de-molding.

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Figure 11. Silicone plug insert and mother-mold to support the first mold segment, of the inside of the braincase. Note that the silicone pieces have been cut into four sections and labeled "A-D." The mother-mold is constructed of finishing polyester resin and two layers of fiberglass matte.

The solution: After applying a parfilm separator to the outer surface of the mold (especially the area of the deep endocranial "pocket"), a thixotropic RTV silicone rubber was applied by spatula to the deep, overcut "pocket," filling it nearly completely except for a rounded core area. We used a tin-based ultrafast catalyst with a working time of approximately 10 minutes to thicken the rubber. The durometer hardness of the silicone is 40 when set. Once the silicone cured, we removed the low clay wall from around the mold area, constructed another low clay wall around the remaining clay base flange, and applied a dish soap separator over the entire mold area, including the silicone plug. Finishing polyester resin and two layers of fiberglass were appliced into the central core and over the entire mold and clay base flange, to create a stiff, supporting mother-mold.

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Figure 12. Lateral view of the fiberglass and polyester resin mother-mold, including its projecting core for support of the silicone plug within the braincase.

For eventual removal of the mother-mold, silicone plug, and latex mold from the endocranial cavity of the specimen, the mother-mold could be lifted straight out of the braincase core and off of the mold. The silicone plug was then cut into four equal, pie-shaped segments (taking care not to score the underlying latex mold). These were labeled (Figure 11), and the corresponding areas of the latex mold were also labeled (Figure 10), for ease of re-fitting the plug later. Once it was cut, the slices of the plug could be readily removed one at a time, and the latex mold could then be collapsed on itself and pulled gently out of the inside of the braincase. Figure 12 shows the mother-mold with its internally projecting core, once the silicone plug slices have been removed.

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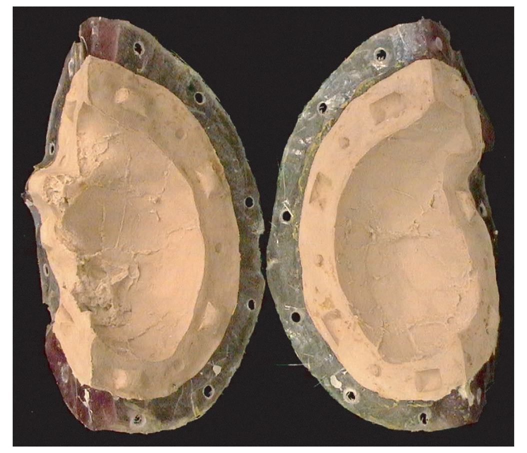

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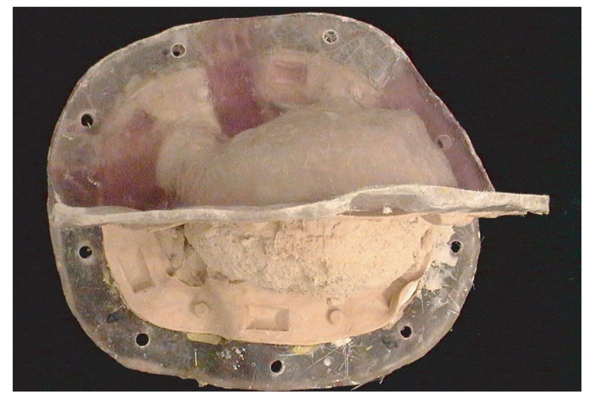

Figures 13 and 14. Once the endocranial-basicranial mold section, plug, and mother-mold were completed, the specimen was turned rightside up, and divided sagitally by a clay wall into two halves, following the original flash line. After applying shellac to the exposed latex mold from the first mold section, a thin latex mold was created for each half of the outer surface of the cranium, also comprised of eleven layers of thinned latex interspersed by two applications of gauze for tear strength. Where the cranium curved back into itself near its lower margin, plaster plugs were made on the outside of the mold, to prevent the overlying mother-mold from locking into the specimen. The plaster plugs and latex were covered in parfilm prior to the application of finishing polyester resin and fiberglass for the accompanying mother-mold segments. Figure 13 shows the two mold halves of the top of the cranium, with their mother-molds. Figure 14 presents a cut-away of the completed mold, with one mold half removed, to show the endocranial surface of the first mold segment. Note that lock tabs encircle each mold segment, for proper alignment of the three mold sections together.

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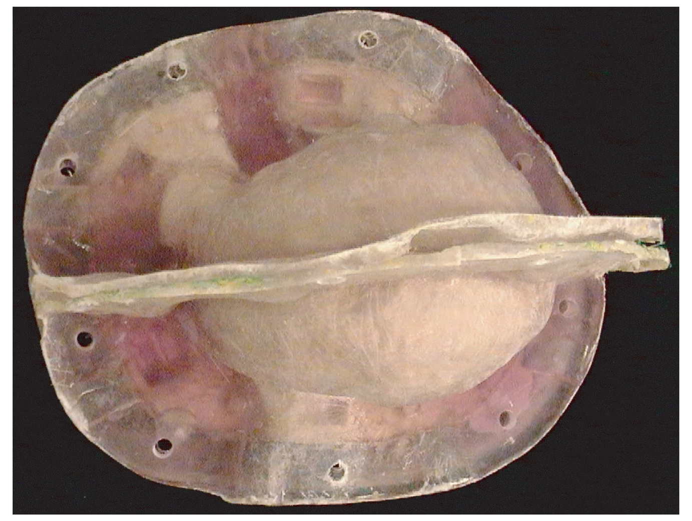

Figure 15. Completed mold of *Homo erectus* cranial specimen Tjg 1993.05 from Sangiran. Note the holes perforating the mother-mold, made with a 7/32" drill bit, for bolting the mold sections together during casting, and for storage. The incorporation of mother-mold flanges to accommodate bolt holes makes it easier to insert bolts, and keep them clear of resin spillover during casting.

Casts were made using a hollow cast technique that permits superior control against failure or collapse of mold sections, and against formation of air bubbles in the cast. The casting material consisted of laminar polyester resin in a ratio of 10:6 with talc, and colored with white and raw sienna pigments, creating a natural bone-like appearance. Latex molds have to be thinly coated with parfilm prior to casting with resins, to protect them from heat. Three layers of casting material were painted on the surface of each mold section. The fourth application was thickened with additional talc after catalyzing, to fill in rugose or uneven surfaces. Each layer was allowed to partially set before adding the next one. Immediately following the application of the fifth layer, fiberglass matte pieces were cut to conform to the inner surfaces of each mold segment, and then tightly tamped into place with finishing polyester resin. A final application of talced, pigmented resin was applied along the edges of each mold section, before closing using bolts and wing nuts (see Figure 15).

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Figure 16. Original urethane cast (right) and two second-generation polyester resin and fiberglass casts from our mold. Note dimensional stability and good capture of surface detail.

The resulting casts (**Figures 16-18**) are strong, retain surprisingly good surface detail for being second generation, are relatively light-weight, and can be painted with a much wider variety of oil- and water-based paints than can be applied to urethane casts. Dimensional stability is good, with size differences between the original urethane cast and polyester casts negligible and insignificant. With proper care, including maintenance away from light sources and in constant, low humidity and mild temperature, the latex mold should have a long shelf life and be capable of producing additional copies of the cranium. In addition, the entire process is cost efficient, with little of any type of material needed for production of the mold and subsequent casts.

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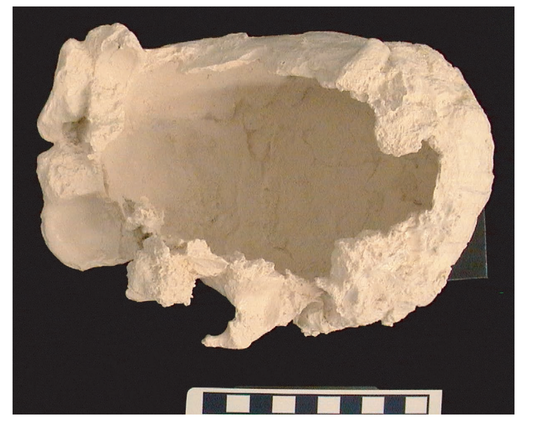

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