RESTORATION AND THREE-DIMENSIONAL ASSEMBLY OF A NEARLY COMPLETE, ARTICULATED EOCENE PROTOCETID WHALE SKELETON FROM PAKISTAN

William J. Sanders, John F. Graf, Iyad Zalmout, Munir Ul-Haq, and Philip D. Gingerich

University of Michigan Museum of Paleontology and the Geological Survey of Pakistan
Paleobiological Reconstruction

--Paleobiological reconstruction of fossil vertebrates is enhanced by recovery of associated skeletal elements and accuracy of restoration and assembly
Geographic and Geologic Context

Habib Rahi Formation, early middle Eocene, ca. 48 myr (nearshore sediments of the Tethys Sea)

Kunvit area, near Rakhni, in the Sulaiman Range, eastern Balochistan
Productivity of Habib Rahi Formation in the Kunvit Area, Lakha Kach syncline, eastern Balochistan

Partial skeleton of *Rodhocetus balochistanensis*

Partial skeleton of *Artiocetus clavis*
Locality of new skeleton, GSP-UM 3551

Near-shore marine sediments; platy marl and limestone of the Habib Rahi Formation
Excavation of GSP-UM 3551

Removing overburden the old-fashioned way

Cranial fragments on surface

Long bones exposed and consolidated with PVAc
Jacketing and removal
Preparation phase I: manual preparation of blocks within jackets

--consolidate
--airscribe
--minor reconstruction
--leave in association
Preparation phase II: silicone molding, polyester casting, and assembly of bone blocks

Assembled blocks (minus posterior caudals)

- ribs
- vertebrae
- manus
- left forelimb
- skull
- right forelimb
GSP-UM 3551: all blocks from field jackets cast and assembled
Preparation phase III: extraction of skeletal elements from blocks, re-molding, casting

Skull set in clay for part I of mold

Original bones set in clay, laminated with silicone rubber, and mother molded with polyester + fiberglass

Originals and casts of lumbar vertebrae L1-L6
Preparation phase IV: restoration on casts, re-molding, casting model skeletal elements for mount

Left innominate, GSP-UM 3551

Cast models, left and right innominates, GSP-UM 3551
Phase IV: dentary restoration from cut cast pieces and “scaffolded” anterior reconstruction.

Scaffolded anterior dentaries built on inverted cranium with teeth spaced accordingly.

Restored mandible, GSP-UM 3551

Cast model skull, GSP-UM 3551
Phase IV: restoration of vertebral series

Cervical vertebral series restoration

Thoracic vertebral series restoration

Lumbar vertebral series restoration
Phase IV: restoration of vertebral series

Original caudal vertebrae, Ca5-Ca8

Cast model, caudal vertebral series GSP-UM 3551
Molding, casting restored model elements for final mounting (Phase V)

Restored model series of thoracic vertebrae T7-T10 set in clay for molding

Restored model of left dentary with i1-m3 in completed silicone mold and fiberglass + resin mothermold, side I
Working mount assembly of skeleton of GSP-UM 3551

Reconstructed in hindlimb-dominated, forelimb-assisted swimming mode
Acknowledgements

--National Geographic, NSF, and The University of Michigan for funding

--The Geological Survey of Pakistan and people of Pakistan for collegial interaction and kind hospitality

--Dan Erickson, Mike Cherney, and John Klausmeyer for help with reconstruction and mounting

--Numerous students for their hard work and diligence, notably Aaron Wood, Carly Manz, Amber Heard, Darcy Shapiro, Isabel Wiesenfeld, Ian Winklestern, Kristina Galdes, Michael Adams, and Katie Slivensky

--Special thanks to Bonnie Miljour for her superb illustrations

--Kudos to the Society of Vertebrate Paleontology for creating a permanent Preparators Session

--Dedicated to the memory of the late Karl Sanders, who would have enjoyed seeing this whale brought “back to life.”

THE END!