components. This portion of the canyon also happened to be a zone of very low visibility owing to a turbid water mass blanketing the bottom. The turbid suspension was concentrated in a zone 4 to 5 m thick, and often caused zero visibility. The suspension was largely made up of biological material of varying sizes and shapes, but a brown coloration seen from the backscatter of the *Alvin*'s lights indicated that sediment also comprised a large portion of the turbid mass. A comparison of the visibility conditions found throughout the canyon indicates that the zone of high turbidity is confined to this part of the canyon. The possible damming influence of ridges trending across the canyon in this area may account for the localization of these conditions. These turbid conditions were not related to the sea state at the time of observation (state 3), but are believed to have resulted from much stormier conditions some time before the dives.

Most of the canyon consists of much finer material than the surface sediments reported for the surrounding continental margin (*11*). Only in the canyon head, where sands apparently enter from the surrounding continental shelf, are textures similar to those on the adjacent shelf.

A study of organic carbon in the canyon sediments indicates enrichment by a factor of 2 to 3 relative to that reported for deposits on the adjacent continental shelf, slope, and rise (*11, 12*). The organic carbon contents of 3.0 to 3.5 percent commonly found in the canyon are similar to those reported for areas of upwelling (*13*).

A study of biomass concentration in the canyon sediments and the determination of available food for these organisms indicates that concentrations of food are considerably higher in the canyon than elsewhere in the North Atlantic. Since there is no indication that surface productivity is any greater over the canyon than in adjacent waters, the nutrient-rich material apparently is moving out into the canyon from a shelfward source.

Although all the data have not yet been fully analyzed, they lend strong support to the hypothesis of long-term net transport down the canyon. The sediment and biological data reveal the presence of a tongue of fine-grained, nutrient-rich material extending out to the continental rise through the Hudson Canyon. It is suggested that these sediments are primarily carried in suspension out across the continental shelf and into the canyon, where they are further transported downcanyon. Some of this material may also be derived from resuspension of sediment eroded from the shelf break.

During lower stands of sea level the canyon displayed much higher current activity than is found today. Coring of turbidite sequences not only in the canyon but from its outer terminus reveals that the canyon served as a conduit for the transport of coarse-grained material from the continental shelf to the deep-sea floor during the Pleistocene (*14*). Although coarse sands and gravels are present in the canyon head and are being transported locally by bottom currents today, there is no indication that this material is carried very far down the canyon. Despite strong bottom currents, the Hudson Canyon is relatively less active in funneling coarse-grained material or large volumes of finer sediment to the abyssal plain than it was in the Pleistocene, and less active than the canyons off southern California today.

Although the 2.5 days of continuous bottom current measurements in the Hudson Canyon revealed periodic reversals of flow as well as a net transport up the canyon, a considerable amount of other evidence indicates that the long-term net transport may be down the canyon. Not only did the majority of current observations from the *Alvin* show predominant downcanyon flow, but the sediment and biological studies indicate that the flux of fine-grained, nutrient-rich sediment is directed into the canyon from the coastal zone.

Coarse sediment is transported as a traction load only in the canyon head and does not appear to move very far down the canyon. Canyon sediments are mainly silt, clayey silt, and silty clay, which are apparently carried into the canyon in suspension. This fine-grained material is transported across the outer continental shelf, bypassing the canyon head and largely being deposited in the central part. The blanket of very turbid water plus sediments of low cohesion and density found in this portion of the canyon attest to relatively high rates of sedimentation taking place at this time. Beyond this zone, finer sediments are carried to the outer limits of the canyon.

GEORGE H. KELLER
DOUGLAS LAMBERT
National Oceanic and Atmospheric Administration, Atlantic Oceanographic and Meteorological Laboratories, Miami, Florida 33149
GILBERT ROWE
NICHOLAS STARESINIC
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

References and Notes

1. H. C. Stetson, *Trans. Amer. Geophys. Union* **18**, 216 (1937).
2. J. V. A. Trumbull and M. J. McCamis, *Science* **158**, 370 (1967).
3. D. A. Ross, *Nature* **218**, 1242 (1968).
4. D. J. Stanley and G. Kelling, *U.S. Coast Guard Oceanogr. Rep. 22* (1968).
5. P. Fenner, G. Kelling, D. J. Stanley, *Nature* **229**, 52 (1971).
6. S. J. Niskin, *Mar. Sci. Instrum.* **3**, 123 (1965).
7. F. P. Shepard and N. F. Marshall, *Science* **165**, 177 (1959).
8. ———, *Amer. Ass. Petrol. Geol. Bull.*, in press.
9. M. Gennesseaux, P. Guibout, H. Lacombe, *C.R.H. Acad. Sci. Ser. D* **273**, 2456 (1971).
10. B. C. Heezen, M. Ewing, M. Tharp, *Geol. Soc. Amer. Spec. Pap. No. 65* (1959); R. M. Pratt, *Deep Sea Res.* **14**, 409 (1967).
11. J. C. Hathaway, *Woods Hole Oceanogr. Inst. Ref. No. 71-15* (1971).
12. H. L. Sanders, R. R. Hessler, G. R. Hampson, *Deep Sea Res.* **12**, 845 (1965).
13. G. T. Rowe, *Invest. Pesq.* **35** (No. 1), 127 (1971).
14. D. B. Ericson, M. Ewing, G. Wollin, B. C. Heezen, *Geol. Soc. Amer. Bull.* **72**, 193 (1961); D. R. Horn, M. Ewing, B. M. Horn, M. N. Belach, *Mar. Geol.* **11**, 287 (1971).
15. Funding for support of the submersible and surface vessel was provided by the Manned Undersea Science and Technology Office, National Oceanic and Atmospheric Administration. We acknowledge the significant contribution that the staff of the *Alvin* made to this study by their fine cooperation and unique capability.

4 December 1972; revised 19 January 1973

Cranial Anatomy of Oreopithecus

Abstract. *Reexamination of the 1958 skull of the late Miocene* Oreopithecus bambolii *revealed a cranial anatomy different from that widely accepted for this taxon. There is a sagittal crest, a high nuchal crest, a large gonial angle, and a high, rather vertical, occiput. This catarrhine was not a very large brained primate compared to known advanced hominoids.*

Oreopithecus, the late middle Miocene [10 to 12 million years ago; see Lorenz (*1*)] catarrhine primate from Tuscany, Italy, has been one of the most exciting fossil taxa. It has also been a most controversial problem for vertebrate paleontologists and physical anthropologists. This is primarily because of the alleged hominoid ties of this primate, which is nearly chimpanzee sized, and because of the crushed nature of the only existing cranium

(Fig. 1). During the past decades, thanks to Hürzeler's efforts, many new specimens of this genus have been salvaged from destruction from coal mines in Tuscany. This report is not addressed to the phylogenetic position or the way of life of *Oreopithecus bambolii* (2). Here we are only concerned with some important features of the 1958 skull previously overlooked and with the resulting views of the cranial anatomy of *Oreopithecus*. This is of some importance as it has been long debated whether *Oreopithecus* is hominid, hominoid, or cercopithecoid, on the basis of dental (*3, 4*), postcranial (*4–6*), and cranial (*6–8*) morphology and estimated cranial capacity (*9*).

In 1960 Hürzeler (*7*) published a reconstruction of the skull in which *Oreopithecus* was portrayed as having a very large, smooth, and rounded neurocranium with a nearly horizontally oriented occiput. This reconstruction shows the chimpanzee-sized *Oreopithecus* as a manlike primate with a relatively very large brain, an extremely short face, and a mandible which is astonishingly human. This reconstruction was either uncritically accepted or tacitly approved in later years by Straus (*6*), Simons (*10*), and Pilbeam (*11*), who published cranial reconstructions virtually identical to those of Hürzeler. One outstanding exception has been Coon, who said of the *Oreopithecus* cranium (*12*), ". . . the nuchal crest is higher [that is, than that shown by Hürzeler] and the mandible is blown out in the gonial region and . . . . [a]lthough there is no sagittal crest, the supraorbital ridges are very heavy." Subsequent authors, however, did not consider some of Coon's accurate observations.

Our examination of the flattened 1958 skull, that of a male, revealed a variety of features which, aside from Coon's astute remarks, have not been recognized or reported. These features reveal a character complex for the masticatory apparatus different from the previously advocated one, and a relative cranial capacity drastically different from the values previously suggested.

In the following brief account of the 1958 cranium only the salient features are detailed. The stereophotographs (Fig. 1) and the reconstruction (Fig. 2) show the various characters on the cranium. (i) There is a distinct sagittal crest (*13*). (ii) The nuchal crests, visible on the right side, are high on the skull, forming an angle of about 45° with the posteriorly extended plane of the palate. (iii) What has been previously considered the posterior base of the skull is crushed vertebrae, of which the atlas and axis are identifiable. (iv) The anteriorly crushed supraorbital ridges give the specimens the extreme short-faced appearance. (v) The zygomatic arches appear to have been laterally or dorsally bowed (or both) rather than ventrally arched. (vi) The angle of the mandible was an expanded rather than a reduced one.

Not one of the enumerated features of the cranium can be used to argue for

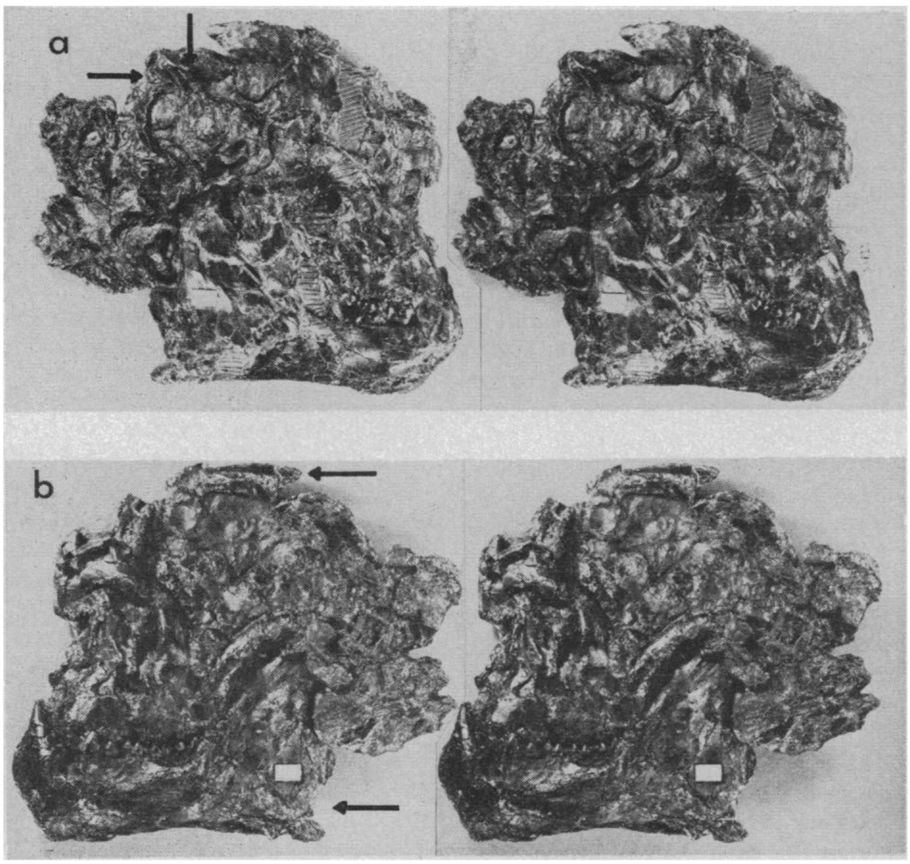

Fig. 1. Crushed cranium of *Oreopithecus bambolii* 1958 specimen. (a) Right side; (b) left side. The arrows show the sagittal and nuchal crests and the angle of the mandible. The scale on the mandible represents 1 cm.

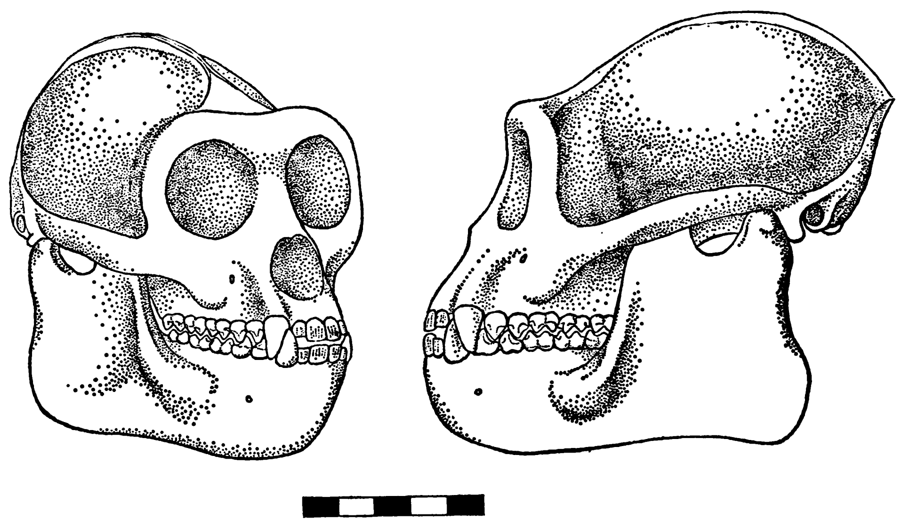

Fig. 2. Reconstruction of the cranium of *Oreopithecus bambolii*. The reconstruction should not be studied without Fig. 1. Units on the scale represent centimeters.

close phylogenetic ties of *Oreopithecus* with either pongids or hominids. The cranial features of *Oreopithecus* are unique, and by themselves are not proof for close phylogenetic ties with cercopithecoids either. Aside from the character complex of the masticatory apparatus, the various estimates for the cranial capacity of *Oreopithecus* have to be reconsidered. Some previous braincase volumes, based on plaster reconstructions, are exaggerated. Based on a scrutiny of the crushed skull, a sheer, almost arbitrary, estimate of 200 cm^3 or slightly more for the brain volume of *Oreopithecus bambolii* appears to be generous.

FREDERICK S. SZALAY

Department of Anthropology, Hunter College, City University of New York, New York 10021, and
Department of Vertebrate Paleontology, American Museum of Natural History New York 10024

ANNALISA BERZI

Museum of Geology and Paleontology, University of Florence, Florence, Italy

References and Notes

1. H. G. Lorenz, *Riv. Ital. Paleont. Stratigr.* **74**, 307 (1968).
2. A monographic account of this catarrhine, based on work begun during the summer of 1972 in Basel and Florence, is being prepared by F. S. Szalay and R. L. Decker.
3. P. M. Butler and J. R. E. Mills, *Bull. Brit. Mus. Natur. Hist.* **4**, 1 (1959); J. Hürzeler, *Schweiz. Palaeont. Abh.* **66**, 1 (1949); *Eclogae Geol. Helv.* **44**, 2 (1951); *Verh. Naturforsch. Ges. Basel* **65**, 88 (1954); *ibid.* **69**, 1 (1958); E. L. Simons, *Nature* **186**, 4727 (1960).
4. J. Hürzeler, *Colloq. Int. Centre Nat. Rech. Sci. 1961* (1962).
5. ———, *Ann. Paléont.* **54**, 2 (1968).
6. W. L. Strauss, Jr., in *Classification and Human Evolution*, S. L. Washburn, Ed. (Aldine, Chicago, 1963), pp. 164–177.
7. J. Hürzeler, *Triangle* **4**, 5 (1960).
8. W. L. Strauss, Jr., *Science* **126**, 345 (1957); *Anat. Rec.* **132**, 3 (1958).
9. ——— and M. A. Schon, *Science* **132**, 670 (1960).
10. E. L. Simons, *Sci. Amer.* **211**, 50 (July 1964).
11. D. Pilbeam, *The Ascent of Man* (Macmillan, New York, 1972).
12. C. S. Coon, *The Origin of Races* (Knopf, New York, 1962), pp. 210–211.
13. Some years ago A. Azzaroli pointed this out to one of us (A.B.).
14. Cost of this research was partly defrayed by Wenner-Gren grant 2916 and by NSF grant GS 32315 (both to F.S.S.). We are deeply grateful to A. Azzaroli of the University of Florence, Italy, for his kindness and permission to study *Oreopithecus*. We are grateful to M. Siroky for technical assistance with the manuscript, and to A. J. Cleary for the figures.

7 November 1972; revised 21 December 1972 ■

Solar Magnetic Sector Structure: Relation to Circulation of the Earth's Atmosphere

Abstract. *The solar magnetic sector structure appears to be related to the average area of high positive vorticity centers (low-pressure troughs) observed during winter in the Northern Hemisphere at the 300-millibar level. The average area of high vorticity decreases (low-pressure troughs become less intense) during a few days near the times at which sector boundaries are carried past the earth by the solar wind. The amplitude of the effect is about 10 percent.*

The solar magnetic sector structure appears to be related to the integrated area of regions of high positive absolute vorticity observed during the winter in the Northern Hemisphere at the 300-mbar level (a height of approximately 9000 m). The average area of high vorticity decreases during a few days surrounding the times at which sector boundaries are carried past the earth by the solar wind, the amplitude of the effect being about 10 percent.

The solar magnetic sector structure (*1*) is extended outward from the sun by the radially flowing solar wind. As viewed from the earth, the resulting interplanetary magnetic field can be divided into sectors such that within each sector the field polarity is either toward the sun or away from the sun. Adjacent sectors having opposite field polarities are separated by an exceedingly narrow boundary. Most commonly there are four such sectors, each having a width of approximately 90° in solar longitude, and the sector structure rotates past the earth with a period of about 27 days, corresponding to the synodic solar rotation.

The integrated vorticity area was measured by the vorticity area index of Roberts and Olson (*2*), which is calculated as follows. Absolute pressure–height contour maps for the portion of the Northern Hemisphere north of 20°N were used to compute absolute vorticity maps contoured at selected vorticity levels. These maps were prepared twice each day for the interval 1964 to 1970. A prominent feature of these vorticity maps was the association of regions of high positive vorticity with low-pressure troughs. The vorticity area index was defined as the sum of the area (in square kilometers) over which the absolute vorticity exceeded 20×10^{-5} sec^{-1} plus the area over which the vorticity exceeded 24×10^{-5} sec^{-1}. For virtually all the troughs there was some area over which the vorticity exceeded the lower value, and for the major troughs there was nearly always some area over which the higher value was exceeded. On each map the vorticity area index was summed to give one number (area) representing the integrated value for the Northern Hemisphere north of 20°N.

The average response of this hemispheric vorticity area index to the passage of a sector boundary by the earth was investigated by using the technique of superposed epochs. The zero days were defined as the times at which the sector boundaries tabulated by Wilcox and Colburn (*3*) swept past the earth. These are boundaries in which the polarity of the interplanetary magnetic field observed by spacecraft near the earth was in one direction (away from or toward the sun) for at least 4 days before the boundary, and in the opposite direction for at least 4 days after the boundary. The width of the boundary, as measured by the time required for it to sweep past the spacecraft, varied from a fraction of an hour to several hours. [Similarly defined sector boundaries during the year 1970 were added to the list of well-defined sector boundaries (*4*).] Boundaries observed during the winter months, November to March, were used in this analysis; a similar analysis has shown that the results

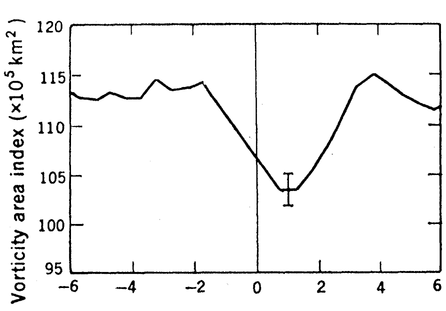

Fig. 1. Average response of the vorticity area index to the solar magnetic sector structure. Sector boundaries were carried past the earth by the solar wind on day 0. The analysis includes 53 boundaries during the winter months November to March in the years 1964 to 1970. The standard error of the mean (error bar) was calculated after subtracting a 27-day mean centered on each sector boundary, to remove long-term trends. The deviations corresponding to the individual boundaries are consistent with a normal distribution about the mean.