maintain a vertical face for very long and tends to flow out of the box within a few hours. Shear strengths average 53 ± 12 g cm^{-2} (12 measurements).

We interpret the structural features of the box cores as indicating undisturbed sediment in the shallow parts, creeplike deformation in the lysocline zone, and appreciable flow on the lower flanks of the plateau. This flow is thought to be general, but may be relatively fast in shallow, wide, flat-bottomed channels. We cored in one such channel at a depth of 4410 m and found sandy ooze and unexpectedly well-preserved foraminifera. The fines had been removed, perhaps during repeated washing of the sediment while it flowed over irregularities in the "stream bed."

The shear strengths of sediments accumulating above the lysocline on the Ontong-Java Plateau are greater than most other reported values for near-surface marine sediments (*11*). This is possibly due to incipient cementation by mobilized (metastable?) carbonate, although we have no direct evidence for this process at the present time. Lysoclinal and sublysoclinal sediments in the vicinity of the plateau exhibit shear strengths that are more typical of most marine sediments. Application of infinite-slope stability analysis (*12*) to the topography and strength of the plateau sediments indicates that the sediments should be stable and not subject to slumping. Therefore, the large-scale mass movement of these pelagic carbonates cannot be readily explained, and may result from complex interactions involving dissolution, thixotropic properties of the sediments, and liquefaction triggered by earthquakes in the nearby Solomon Trench.

In summary, we observed mass movement of deep-sea carbonates on two scales: (i) large-scale slumping and sliding and (ii) flow (or creep) of near-surface sediment. We propose that both phenomena owe much to dissolution processes, the first showing a depth dependence of topographic morphology, the second showing a depth dependence of preserved burrow patterns and of shear strength.

If our interpretations are correct, there are critical implications for the stratigraphy of deep-sea carbonates and for carbonate geochemistry. Concerning the explanation of missing sections in Deep-Sea Drilling Project cores (*13*), the removal of large sheets of ooze as a consequence of earthquakes or dissolution of downslope support, or both, has to be considered as a mechanism producing hiatuses, in addition to the direct influence of bottom currents on erosion of carbonates from the sea floor.

Our results raise questions that need to be resolved in two major areas: (i) To what extent is such mass wasting episodic over large areas of the sea floor, in response to bottom water action, and to what extent is it regional, resulting from tectonic events? and (ii) What are the conditions (slope, type of ooze, and depth range) under which carbonate transfer by mass movement occurs, and what are the applicable rates of such transfer to abyssal depths?

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References and Notes

1. J. Murray and A. F. Renard, *Deep-Sea Deposits Based on the Specimens Collected During the Voyage of H.M.S. "Challenger" in the Years 1872–1876, Report Voyage "Challenger"* (Longmans, London, 1891; Johnson Reprint, New York, 1965).
2. M. N. Bramlette, in *Oceanography*, M. Sears, Ed. (AAAS, Washington, D.C., 1961), p. 345; W. H. Berger, *Mar. Geol.* **8**, 111 (1970).
3. Tj. H. van Andel and P. D. Komar, *Geol. Soc. Am. Bull.* **80**, 1163 (1969); D. A. Johnson and T. C. Johnson, *Deep-Sea Res.* **17**, 157 (1970); D. A. Johnson, *Geol. Soc. Am. Bull.* **83**, 3121 (1972); G. de V. Klein, *Initial Rep. Deep Sea Drill. Proj.* **30**, 423 (1975).
4. E. L. Winterer, P. F. Lonsdale, J. L. Matthews, B. R. Rosendahl, *Deep-Sea Res.* **21**, 793 (1974).
5. L. W. Kroenke, R. M. Moberly, E. L. Winterer, G. R. Heath, *Initial Rep. Deep Sea Drill. Proj.* **7**, 1161 (1971); L. W. Kroenke, *Hawaii Inst. Geophys. Tech. Rep. HIG-72-5* (1972).
6. J. E. Andrews *et al.*, *Initial Rep. Deep Sea Drill. Proj.* **30**, 753 (1975).
7. Scripps Institution of Oceanography, Eurydice Expedition, Leg 9, R.V. *Washington*, Guam (3 April 1975) to Majuro (5 May 1975).
8. The apparatus was described by R. R. Hessler and P. A. Jumars [*Deep-Sea Res.* **21**, 185 (1974)]. We also took gravity and piston cores; these will be reported on elsewhere.
9. See X. LePichon, J. Ewing, R. E. Houtz, *J. Geophys. Res.* **73**, 2597 (1968). Our empirical equation relating sound velocity to two-way travel time is $V_t = 1.54 + 1.6t - 0.2t^3$, where V_t is the velocity corresponding to the depth in the sediment for which the two-way travel time is t. This equation yields a slightly lower velocity gradient than that presented by G. L. Maynard, "Seismic wide angle reflection and refraction investigation of the sediments of the Ontong Java Plateau" [thesis, University of Hawaii (1973)].
10. S. O. Schlanger and R. G. Douglas, *Spec. Publ. Int. Assoc. Sedimentol.* **1**, 117 (1974).
11. G. H. Keller, *in Proceedings of a Conference on Civil Engineering in the Oceans* (American Society of Civil Engineers, New York, 1968), p. 391; D. G. Anderson, *Nav. Civ. Eng. Lab. Tech. Note N-1177* (1971).
12. See D. G. Moore, *J. Sediment. Petrol.* **31**, 343 (1961).
13. T. C. Moore, Tj. H. van Andel, C. Sancetta, N. Pisias, in *Marine Plankton and Sediments*, W. R. Riedel and T. Saito, Eds. (Micropaleontology Press, American Museum of Natural History, New York, in press).
14. Supported by the Office of Naval Research, contract USN-N-00014-69-A-0200-6049. T.C.J. was supported at Scripps Institution of Oceanography by a postdoctoral fellowship from the National Science Foundation, Oceanography Section, grant DES 75-04335, during most of the period of this research. We thank our colleagues at the Hawaiian Institute of Geophysics, especially J. E. Andrews, G. H. Sutton, and G. P. Woollard, for providing access to unpublished data. G. de Vries Klein made helpful suggestions for improvement of the manuscript.

29 December 1975; revised 17 February 1976

Fossil Peccary from the Pliocene of South Africa

Abstract. ?Pecarichoerus africanus, *new species, from Langebaanweg, Cape Province, is the first fossil peccary to be described from Africa and represents the youngest record of the peccary family in the Old World.*

The superfamily Suoidea is comprised of two families, the peccaries (Tayassuidae) and the true pigs (Suidae). Peccaries are now confined to the New World (*1*), where they are also not uncommon as fossils, while the pigs are, and apparently always have been, an Old World group. In 1927 peccaries of Tertiary age were identified in Europe (*2*), which broke down the traditional view that they had always been restricted to the Americas. A few years later a fossil peccary was also recorded from Asia (*3*). Several Oligocene and Miocene peccaries are now known in Europe (*4*), but there is still only one Asian species, which is Miocene in age. Although true pigs feature in both the living and extinct faunas of Africa, the fossil peccary described here is the first to be identified on this continent. It also represents the most recent record of its family in the Old World.

The new peccary is from the Pliocene Varswater Formation exposed in an open-cast phosphate mine, E Quarry, at Langebaanweg, 105 km north-northwest of Cape Town (*5, 6*). Although this formation has not been dated in absolute terms, comparisons between its fauna and radiometrically dated ones in East Africa suggest an age of between 4 million and 5 million years. Even the latest of the Eurasian peccaries predates the Langebaanweg species by several million years. The Varswater Formation has yielded the largest and most diverse assemblage of Pliocene fossils known anywhere in Africa (*7*), and included among the mammals are several in addition to the peccary which belong to groups otherwise known only, or mainly, from Eur-

Table 1. Dimensions of ?*Pecarichoerus africanus* holotype detention (SAM-PQ-L 31139).

Tooth	Length (mm)	Breadth (mm)	Tooth	Length (mm)	Breadth (mm)
$\underline{C}$	5.7	4.2	$\overline{C}$	5.1	2.8
P^1	4.3	2.3	P_1	4.4	2.2
P^2	5.6	3.3	P_2	4.9	2.7
P^3	5.5	4.4	P_3	5.5	3.1
P^4	5.2	6.0	P_4	6.1	4.1
M^1	6.9	6.9	M_1	7.4	4.8
M^2	8.5	7.4	M_2	8.9	5.9
M^3	8.2	7.2	M_3	10.0	6.1
P^1–P^4	21.0		P_1–P_4	20.4	
M^1–M^3	23.8		M_1–M_3	26.0	

rasia and North America. They are a bear (*8*), a giant wolverine (*7*), a percrocuta (*5*, *9*), a boselaphine (*10*), and what may be a member of the family Procyonidae (red panda, raccoon, and so forth) (*7*).

The peccary specimens, all of which are in the South African Museum, Cape Town, include elements of both the skull and the postcranial skeleton. Until recently only a few fragmentary specimens of this species were known and they were thought to belong to a miniature pig (*5*), but new and better material led to the revised identification being suggested by Gentry and Cooke (*11*). Since pigs and peccaries have many characters in common, it is possible that other African fossils have been similarly misidentified.

Only two of the more significant new specimens are dealt with here. They are SAM-PQ-L 31139, a fragmented skull including the complete left upper and lower dentitions (Fig. 1), and SAM-PQ-L 30702, an incomplete left metatarsal III/IV (Fig. 1).

The cranial characters of the Langebaanweg peccary are not known since only small fragments of the skull of L 31139 and other available specimens are preserved. Several incomplete mandibles are represented, but even the best specimen (L 31139) lacks all those parts posterior to the third molars. The mandible is peccary-like in that it is not laterally expanded in the region where the canines emerge, evidently because these teeth are relatively small and only slightly divergent.

The left upper and lower dentitions of L 31139 are complete; the individual teeth are well preserved, none are very worn, and in size and morphology they are typical of known specimens of this species. The dental formula is 3:1:4:3/2:1:4:3. The enamel on all teeth is smooth.

The incisor formula (3/2) differs from those in all living peccaries and pigs, that for peccaries being 2/3, while in pigs it varies according to the species. For example, in the African bushpig (*Potamochoerus porcus*) it is 3/3, in the European wild boar (*Sus scrofa*) it is 2/3, and in the warthog it is 1/2. The crowns of the upper incisors are more pointed than those of living peccaries and pigs. The third upper incisor (I^3) is a little smaller than the second (I^2), while both are appreciably smaller than the first (I^1). The two lower incisors are similar in size, but the second (I_2) does not project as far forward as the first (I_1).

The upper canine ($\underline{C}$) is short, only very slightly curved, and oval in cross section, with the lingual surface being somewhat flattened. The orientation of this tooth in the jaw is not known for certain, but it must have pointed more or less straight down in order to have occluded effectively with the lower canine ($\overline{C}$). The lower canines are longer than the uppers, are triangular in cross section, and curve upward and outward from the mandible. They diverge only slightly from one another as in living peccaries, but in contrast to the condition in pigs, where the canines are markedly divergent. In respect of its canines the Langebaanweg species is peccary- rather than piglike.

This species, unlike almost all living peccaries and pigs, lacks postcanine diastemas in the upper and lower jaws. The Indian pygmy hog (*Sus salvanius*) is exceptional among living suoids in this respect. Since the pygmy hog and the fossil species are not closely related, but are of similar size, the absence of diastemas may simply be a size-related character.

There is a full complement of well-developed and functional premolars in the fossil species. The first three premolars, both uppers and lowers (P_1^1 to P_3^3), are double-rooted, single-cusped, and relatively high-crowned. The P^3 has a prominent cingulum developed postero-internally. The upper and lower fourth premolars (P_4^4) are also relatively high-crowned, but have more complex crowns, while the P^4 has three roots. Both have two cusps situated side-by-side, and in P^4 they are flanked posteriorly by a prominently developed cingulum while in P_4 there is a small accessory cusp situated at the posterior end of the tooth. The premolars differ in number, size, or morphology from those of all living suoids.

The upper and lower molars (M_1^1 to

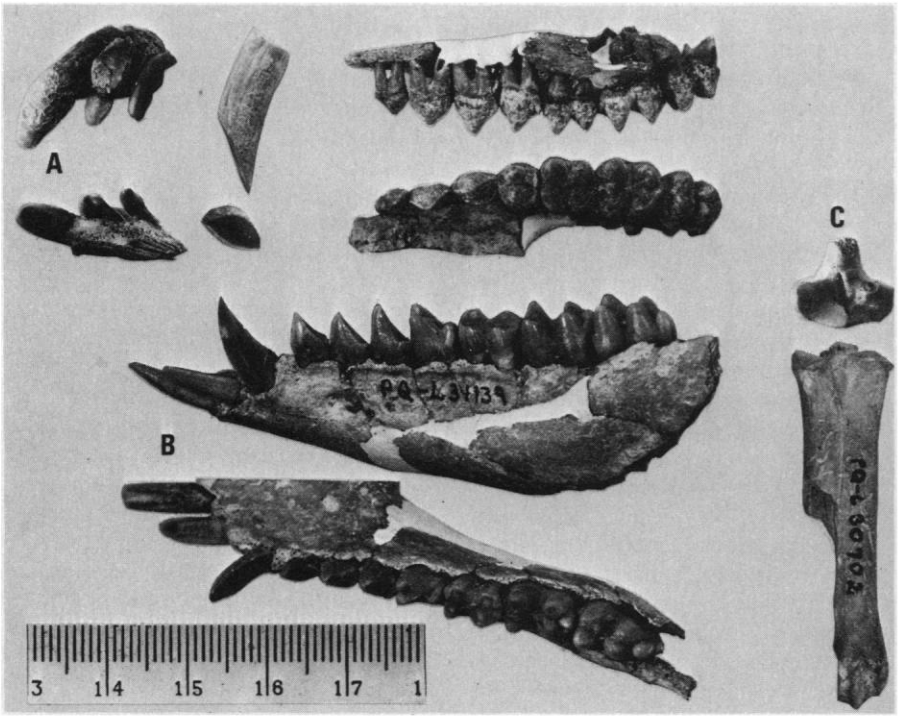

Fig. 1. (A and B) Lateral and occlusal views of left upper and lower dentitions of ?*Pecarichoerus africanus* (holotype, SAM-PQ-L 31139). (C) Proximal and anterior views of ?*Pecarichoerus africanus* metatarsal (SAM-PQ-L 30702).

M_3^3) have crowns basically comprised of four principal cusps, which are supported by four roots in the uppers and two roots in the lowers. The upper molars have a transverse ridge of enamel developed anteriorly and a shorter, buccally directed oblique ridge developed posteriorly, the latter apparently being an incipient or vestigial talon. The lower molars have a single accessory cusp situated posteriorly (talonid), which is progressively more prominent from M_1 to M_3. The molar morphology is perhaps closer to that of the collared peccary (*Dicotyles tajacu*) than any other living peccary or pig.

The nature of the canines, and to a lesser extent the molar morphology, provides the only dental evidence that the fossil species was a peccary rather than a pig.

The most useful of the postcranial bones recovered to date is the metatarsal III/IV, L 30702. Although the distal part of metatarsal III is lost, the specimen is otherwise complete and well preserved. the two metatarsals are completely fused proximally, and evidently fusion was progressively less distally, although it was to some extent present along the entire lengths of the shafts. Since proximally fused central metatarsals are characteristic of peccaries, but are never found in pigs, L 30702 is particularly important in indicating the position of the Langebaanweg species within the suoid superfamily. The fossil apparently differs from the corresponding bones in living peccaries in the greater degree of fusion between the two bones. While this may simply be an ontogenetic character, it is possible that this species, the most recent of the Old World peccaries, was more advanced in this respect than its living counterparts in the Americas.

Measurements of the specimens discussed above are given in Tables 1 and 2.

The Langebaanweg peccary is not identical to any previously described fossil species. Contemporary and younger New World peccaries are clearly only distantly related, and in these instances the geographical factor alone is sufficient to preclude the possibility of direct phyletic relationships. Since there are no recorded Eurasian peccaries younger than Miocene, it is likely that at least since this time the peccaries of the Americas have had no links with the Old World.

The fact that the Langebaanweg species is also far removed from Eurasian peccaries in terms of both time and geography makes it unlikely that it is conspecific with any Eurasian species. The remarkably small size of the Langebaanweg species sets it apart from all Eurasian peccaries with the exception of the Oligocene *Palaeochoerus paronae* (*4*, *12*). In this instance the age and dental differences are sufficient to render the size similarity irrelevant. Other European species do share at least some dental characteristics with the new fossil. For example, the cheek-tooth morphology of the Oligocene *Doliochoerus quercyi* (*4*) is essentially similar to that of the Langebaanweg species. Even in this instance there are significant differences such as the more molariform P_4 and more prominent M_3 talonid in *D. quercyi*, which is also a larger and appreciably older species.

Table 2. Dimensions of ?*Pecarichoerus africanus* metatarsal (SAM-PQ-L 30702).

Dimension	Measurement (mm)
Length	46.6
Proximal transverse diameter	12.8
Proximal anteroposterior diameter	11.3

Of all the described Eurasian species, the one which is most similar to the Langebaanweg species, at least in respect of upper molar morphology, is *Pecarichoerus orientalis* from the Chingi zone (Miocene) of the Siwalik Hills of India (*3*). This similarity is perhaps not surprising since affinities between the faunas of the Siwaliks and Africa are already recognized, while the past zoogeographic links between sub-Saharan Africa and southern Asia are still reflected by the similarities between the modern faunas of these regions.

Although similar, the Langebaanweg species and *P. orientalis* are not identical. Unfortunately, comparisons between the two species are essentially limited to the M^3's, since this is the only recorded tooth of *P. orientalis* which is not very worn. The Langebaanweg species is the smaller of the two, while its M^3 usually lacks oblique ridges of enamel running between the anterior and posterior pairs of cusps. Some of the upper molars from Langebaanweg do have traces of such enamel ridges, and it is conceivable that they were more prominent and constant in ancestral species.

The Langebaanweg species is here tentatively referred to *Pecarichoerus*. While there are only slender grounds for this step, the only reasonable alternative, that of placing it in a new genus, would serve no useful purpose, may ultimately be proved unnecessary, and would in the meantime obscure the possibility that the African and Indian species are phyletically connected. There is no obvious reason why the Langebaanweg species could not have been descended from *P. orientalis* or, more probably, an earlier African *Pecarichoerus*. On the other hand, the observable differences between the two species, which may be ascribed to their difference in age and geographical separation, indicate that they are not conspecific.

?*Pecarichoerus africanus*, new species

Holotype: South African Museum specimen PQ-L 31139.

Hypodigm: The type, a metatarsal III/IV (SAM-PQ-L 30702), and other specimens in the South African Museum's collections.

Known distribution: Langebaanian (Pliocene), in the Pelletal Phosphorite Member of the Varswater Formation, E Quarry, Langebaanweg, South Africa (*5*, *7*).

Diagnosis: A *Pecarichoerus* smaller than *P. orientalis* and with oblique ridges between the principal cusps of the upper molars reduced or absent.

Dental formula 3:1:4:3/2:1:4:3; enamel on all teeth smooth; no postcanine diastemas; I^1 appreciably larger than I^2 and I^3; I_1 and I_2 approximately equal in size; $\underline{C}$ short, nearly straight and apparently pointed downward; $\overline{C}$ short, curved, and pointed upward and slightly outward; P_1^1 to P_3^3 double-rooted, single-cusped, and relatively high-crowned; P^4 triple-rooted with paired principal cusps flanked posteriorly by a prominent cingulum; P_4 double-rooted with paired principal cusps flanked posteriorly by a smaller accessory cusp; M^1 to M^3 quadricuspid, each tooth with a transverse enamel ridge anteriorly and a smaller, oblique one posteriorly (talon); M_1 to M_3 quadricuspid, each tooth with a centrally situated posterior accessory cusp (talonid). Metatarsals III and IV completely fused proximally.

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References and Notes

1. R. M. Wetzel, R. E. Dubos, R. L. Martin, P. Myers, *Science* **189**, 375 (1975).
→ H. S. Pearson, *Philos. Trans. R. Soc. London* **215**, 389 (1927).
3. E. H. Colbert, *Am. Mus. Novit.* **635**, 1 (1933).
4. L. Ginsburg, *Palaeovertebrata* **6**, 55 (1973).
5. Q. B. Hendey, *Ann. S. Afr. Mus.* **63**, 1 (1974).
6. A. J. Tankard, *Trans. Geol. Soc. S. Afr.* **77**, 265 (1975).
7. Q. B. Hendey, *Ann. S. Afr. Mus.*, in press.
8. ———, *ibid.* **59**, 115 (1972).
9. ———, *S. Afr. J. Sci.* **71**, 187 (1975).
10. A. W. Gentry, *Ann. S. Afr. Mus.* **65**, 145 (1974).
11. ——— and H. B. S. Cook, personal communication.
12. G. Dal Piaz, *Mem. Inst. Geol. Univ. Padova* **8** (part 9), 1 (1930).
13. I thank H. B. S. Cooke (Dalhousie University), J. M. Harris (Kenya National Museums), A. W. Gentry [British Museum (Natural History)], R. G. Klein (University of Chicago), S. C. Savage (Bristol University), and L. Van Valen (University of Chicago) for assistance in preparing the manuscript of this paper. C. A. Repenning (U.S. Geological Survey) provided skeletal material of a modern peccary. The South African Museum's Langebaanweg Research Project is aided by Chemfos Limited, the South African Council for Scientific and Industrial Research, and the Wenner-Gren Foundation for Anthropological Research (grant 2752–1834).

12 January 1976