PEARCE-SELLARDS
SERIES
NUMBER 46

CORYPHODON
(Mammalia, Pantodonta)
FROM THE HANNOLD HILL FORMATION EOCENE OF TRANS-PECOS TEXAS

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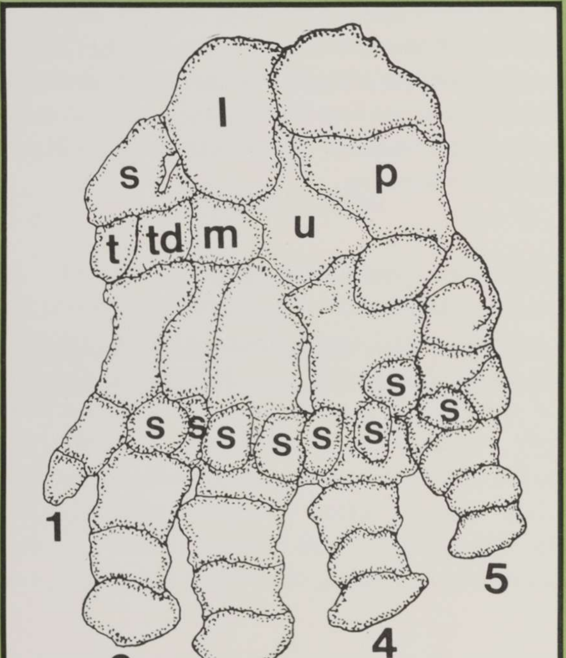

JANUARY 1989
TEXAS MEMORIAL MUSEUM, UNIVERSITY OF TEXAS AT AUSTIN

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The Pearce-Sellards Series is an occasional, miscellaneous series of brief reports of Museum and Museum associated field investigations and other research. All manuscripts are subjected to extramural peer review before being accepted. The series title commemorates the first two directors of the Texas Memorial Museum: Dr. J. E. Pearce, Professor of Anthropology, The University of Texas at Austin, and Dr. E. H. Sellards, Professor of Geology, The University of Texas at Austin. Both professors are now deceased.

CORYPHODON (MAMMALIA, PANTODONTA)
FROM THE HANNOLD HILL FORMATION, EOCENE OF TRANS-PECOS TEXAS

by Spencer G. Lucas

ABSTRACT

Specimens of the large extinct pantodont *Coryphodon* from the Hannold Hill Formation, Brewster County, Texas belong to a single species, *Coryphodon molestus*. A sample of *Coryphodon molestus* from one locality in the Hannold Hill Formation consists of three adults and at least one juvenile. The sample aids in documenting sexual dimorphism in *Coryphodon molestus* and provides circumstantial evidence of gregarious behavior in that species. The presence of *Coryphodon molestus* in the Hannold Hill Formation indicates a late Gray Bull through Lost Cabin (Wasatchian) age. This is consistent with assignment of a late Gray Bull or Lysite age to the entire Hannold Hill vertebrate fauna.

INTRODUCTION

Coryphodon Owen, 1845 is one of the most widely distributed early Cenozoic mammals. Its fossils are known from upper Paleocene and/or lower Eocene strata in western Europe (England, Belgium, and France), North America (western United States, Ellesmere Island), and eastern Asia (People's Republic of China, Mongolian People's Republic). Fossils of *Coryphodon* are plentiful in Wasatchian (early Eocene) localities in Montana, Wyoming, Utah, Colorado, New Mexico, and Texas. The wide distribution, abundance, and ease with which it can be recognized should thus make *Coryphodon* extremely useful in intra- and intercontinental correlation. However, the lack of a useful and current species-level taxonomy of *Coryphodon* (Osborn, 1898, last revised the genus) has undermined its biostratigraphic applicability.

This paper is an outgrowth of a recent taxonomic revision of *Coryphodon* (Lucas, 1984a). It identifies, describes, and discusses the biostratigraphic significance of the *Coryphodon* specimens from the Hannold Hill Formation in Big Bend National Park, Texas. Wilson (1967) first described *Coryphodon* specimens from the Hannold Hill Formation, and Hartnell (1980a) briefly reviewed these specimens. As Wilson (1967:165-166) noted, however:

> It is exasperating that the most plentiful and best-preserved mammalian remains found in Big Bend National Park are not capable of being identified as to species. As other workers have pointed out, the taxonomy of the genus is

greatly in need of revision but to do this would be a major undertaking and is not in the province of this paper. Until such revision is done, however, it is impossible to do more than guess whether the Big Bend material constitutes a new species or with which of the many species of *Coryphodon* the material should belong.

It is my hope that this paper will solve the problem Wilson recognized.

First and foremost, I thank John Andrew Wilson for the opportunity to study the *Coryphodon* specimens from the Hannold Hill Formation and for the information he provided on these specimens. Numerous colleagues in the United States, Europe, and China facilitated my studies of *Coryphodon*. The research reported here was supported by National Science Foundation Grant DEB–7919681. This paper is a contribution of the Vertebrate Paleontology Laboratory of the Texas Memorial Museum. Publication No. N. S.–1 of the Texas Memorial Museum.

ABBREVIATIONS

AMNH	American Museum of Natural History, New York
AW	anterior width
cm	centimeters
L	maximum length
N	number of specimens
PW	posterior width
TMM	Texas Memorial Museum, Austin
USNM	National Museum of Natural History, Smithsonian Institution, Washington, D.C.
W	maximum width
s	standard deviation
$\bar{x}$	mean

GEOLOGICAL CONTEXT

Maxwell and Hazzard (1967:102) named the Hannold Hill Formation for Hannold Hill on south-central Tornillo Flat (Schiebout, et al. [1987])consider the Hannold Hill Formation to be a member of the Tornillo Formation, but here I follow Maxwell and Hazzard). They described the unit as predominantly clay with interbedded sandstones and conglomerates that contain most of the vertebrate fossils known from the formation. Fossil vertebrates were discovered in the Hannold Hill Formation in 1950 (Wilson et al., 1952), and the *Coryphodon* specimens described here were collected from the following four localities:

- Locality TMM 40143 (T4 of Wilson, 1967) is on the north side of the upper Tornillo Creek crossing and east of the highway at the fossil exhibit. This locality is about 121 m above the base of the Hannold Hill Formation (Wilson, 1967) and was a quarry site from which most of the Hannold Hill specimens of *Coryphodon* were collected.
- Locality TMM 40144 (T5 of Wilson, 1967) is "two low pink mounds 50 yards [45 m] east of the main highway, south edge of Tornillo Flat" (Wilson, 1967:165). This locality is approximately 141 m above the base of the Hannold Hill Formation (Wilson, 1967).
- Locality TMM 40154 (T6 of Wilson, 1967) is "in lignite bed 20 yards [18.3 m] west of highway opposite two prominent mesas (brown topped) which are on east side of Tornillo Creek, Tornillo Flat" (Wilson, 1967:165). Its stratigraphic position in the Hannold Hill Formation is uncertain (Wilson, 1967).
- Locality TMM 40568 (T7 of Wilson, 1967) is "50 yards [45.8 m] east and the area to the south of Grapevine Spring, southwest corner of Tornillo Flat" (Wilson, 1967:165). Like TMM 40154, its stratigraphic position in the Hannold Hill Formation is uncertain (Wilson, 1967).

A fifth *Coryphodon* locality in the Hannold Hill Formation (TMM 41392), discovered subsequent to 1967, is recorded in TMM records as being on the western side of Tornillo Flat, 0.25 mile [0.42 km] north of the outcrop of the Exhibit Sandstone Member of the Hannold Hill Formation. Its stratigraphic position within the Hannold Hill Formation has not been determined.

SYSTEMATIC PALEONTOLOGY

Class Mammalia Linnaeus, 1758
Order Pantodonta Cope, 1873
Family Coryphodontidae Marsh, 1876 (1873)
Genus *Coryphodon* Owen, 1845
Coryphodon molestus (Cope, 1874)

Coryphodon sp.: Wilson, 1967, p. 165, figures 117, 118.

Referred specimens: TMM 40143-5, mandible with left and right I_1–M_3 (Figures 3C, 4A); 40143-8, coronoid of mandible; 40143-10, mandible fragments and tusk fragment; 40143-11, left M^1; 40143-12, skull with left and right I^1–M^3 (Figure 2A); 40143-18, left C; 40143-30, skull with left and right P^1–M^3 (Figures 1, 2B; Wilson, 1967, Figure 117) and mandible with left and right I_1–M_3 (Figures 3A, 4B; Wilson, 1967, Figure 118); 40143-191, tip of C; 40143-192, various teeth and tooth fragments; 40143-199, left I_1, left P_4, and postcranial fragments; 40143-201, various tooth fragments; 40143-208, right mandible with M_{2-3}, left premaxilla with I^{1-3}, molar and postcranial elements; 40143-7, articulated right manus (Figure 5); 40143-15, tibia and fibula; 40143-16, clavicle; 40143-17, ulna; 40143-27, patella; 40143-96, humerus; 40143-99, juvenile humerus; 40143-101, juvenile ?tibia; 40143-102, juvenile humerus; 40143-103, juvenile humerus; 40143-167, pelvis; 40143-196, juvenile atlas; 40143-199, vertebrae; 40143-206, femur; additional postcranial material is catalogued under 40143-3, -4, -5, -9, -13, -19 through -26, -28, -29, -31 through -95, -97, -98, -100, -104 through -166, -168 through -172, -176 through -190, -194, -198, -200, -202 through -205, -207, -209, -210. 40144-4, left I^1, two molar fragments, and left P^4; 40144-2, -6, and -7, postcranial elements. 40154-6, badly crushed left ramus fragment with incomplete M_3. 40568-1, mandible fragments with premolar and M_1 roots. 41392-1, left mandible with I_3 and C, left and right P_2–M_3 (Figure 3B); 41392-2, skull fragments and indeterminate bone fragments.

Description: Two complete skulls of *Coryphodon*, TMM 40143-12 and 40143-30 (Figure 1), are known from the Hannold Hill Formation. These specimens clearly show cranial and dental features characteristic of *Coryphodon:* broad skull roof with parasagittal crests above and behind the orbits; large and heavy premaxillae; long postglenoid processes that are close to the mastoid process; very large canines that, with the incisors, form an arc that flares outward in hippopotamus-like fashion; large and spatulate incisors; suboval to trapezoidal M^{1-3} that essentially lack ectoflexi; M^{1-3} protolophs that connect the protocones to the parastyles; M^{1-3} paracones that are labially placed and small (so that the anterior V of the W-shaped ectoloph characteristic of most Paleocene pantodonts is absent); and M^3 broader than M^2, which in turn is broader than M^1.

The Hannold Hill Formation *Coryphodon* skulls conform well to the skull of AMNH 48163, a skull of *C. molestus* described by Lucas (1984a) from the lower

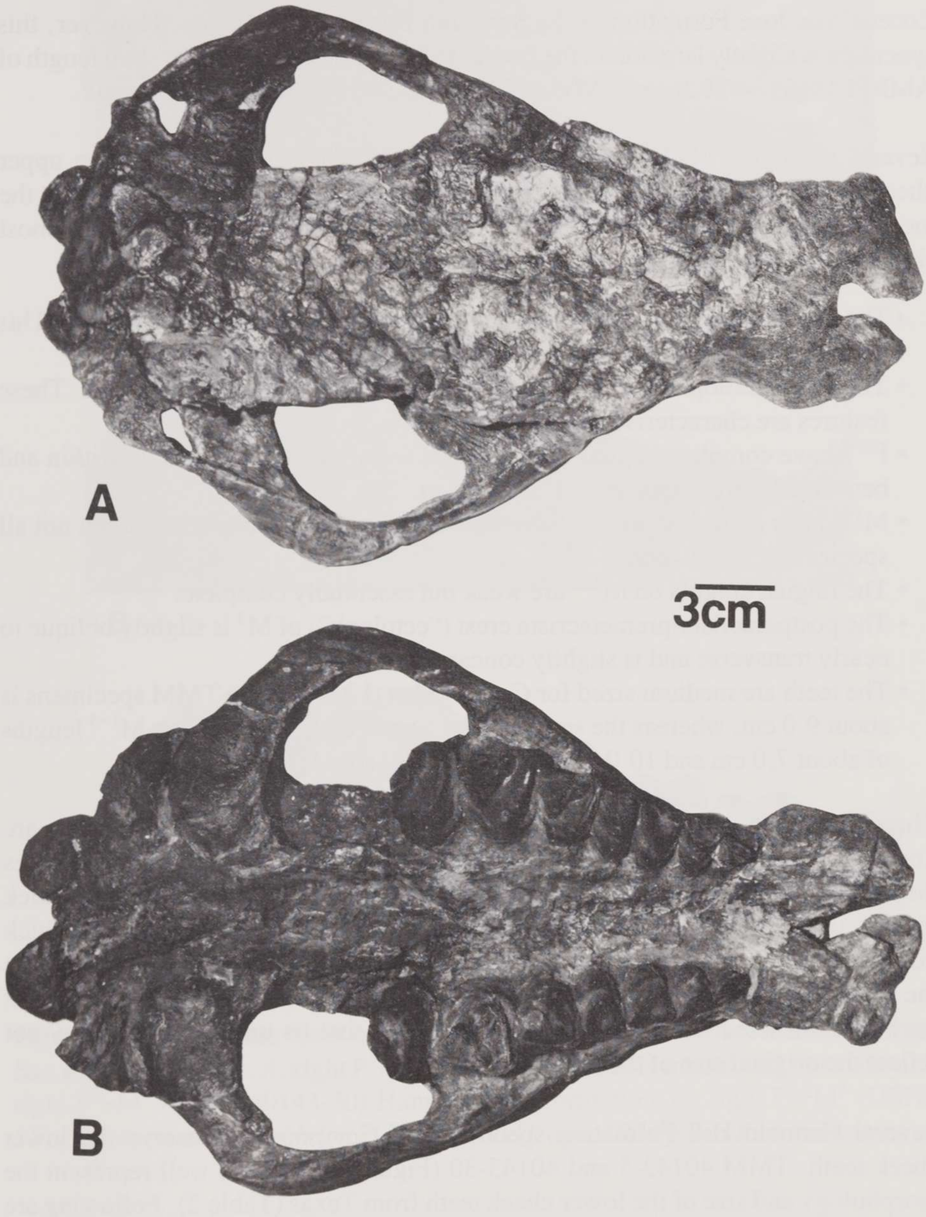


Figure 1. Skull of *Coryphodon molestus* from the Hannold Hill Formation (TMM40143-30). *A*, dorsal view; *B*, ventral view.

Eocene San Jose Formation in the San Juan Basin, New Mexico. However, this specimen is slightly larger than the two TMM specimens (maximum skull length of AMNH 48163 = 39.0 cm; TMM 40143-12 and 40143-30 = 32.0 ± cm).

Several Hannold Hill Formation specimens of *Coryphodon* preserve the upper cheek teeth. TMM 40143-12 and 40143-30 (Figures 2A and 2B) well represent the morphology and size of the upper cheek teeth from Texas (Table 1). The most significant features of these teeth are listed below.

- The DP^1 is small, and well separated from the upper canine by a diastema. This tooth lacks a permanent successor in *Coryphodon*.
- The P^{2-4} ectolophs are V-shaped, and their protocones are isolated. These features are characteristic of all *Coryphodon*.
- P^{2-4} have complete lingual cingula. This feature is highly variable within and between different species of *Coryphodon*.
- M^{1-3} have complete postprotocristae. This feature is found in most but not all species of *Coryphodon*.
- The lingual cingula on M^{1-3} are weak but essentially complete.
- The postparacrista-premetacrista crest ("ectoloph") of M^3 is slightly oblique to nearly transverse and is slightly concave posteriad.
- The teeth are medium sized for *Coryphodon* (LM^{1-3} of the TMM specimens is about 9.0 cm, whereas the smallest and largest *Coryphodon* have M^{1-3} lengths of about 7.0 cm and 10.0 cm, respectively [Table 1]).

Three mandibles of *Coryphodon* — TMM 40143-5, 40143-30, and 41392-1 — are known from the Hannold Hill Formation (Figures 3*A, B,* and *C)*. These mandibles display features characteristic of all *Coryphodon,* including a well-fused and thick mandibular symphysis that extends posteriorly to about the DP_1/P_2 juncture, thick horizontal rami, and a hippopotamus-like flare in the chin region like that seen in the skull. It should be noted that the symphysis of TMM 40143-30 (Figure 3*A)* has been reconstructed in large part with plaster and that its unusual width may not reflect the original size of the specimen.

Several Hannold Hill Formation specimens of *Coryphodon* preserve the lower cheek teeth. TMM 40143-5 and 40143-30 (Figures 4*A* and *B)* well represent the morphology and size of the lower cheek teeth from Texas (Table 2). Following are the most significant features of these teeth.

- The small DP_1 is well separated from the lower canine by a diastema. Like its counterpart in the upper dentition, it lacks a permanent successor in *Coryphodon*.
- The double-rooted P_{2-4} have well-defined trigonids, and low and short talonids. They increase in size posteriorly, as shown in Table 2.
- The M_{1-2} is nearly bilophodont, with transverse talonid lophids (hypolophids) connecting the hypoconid and hypoconulid (the entoconid is absent), weak cristida obliquae, and small posterior cingulids.

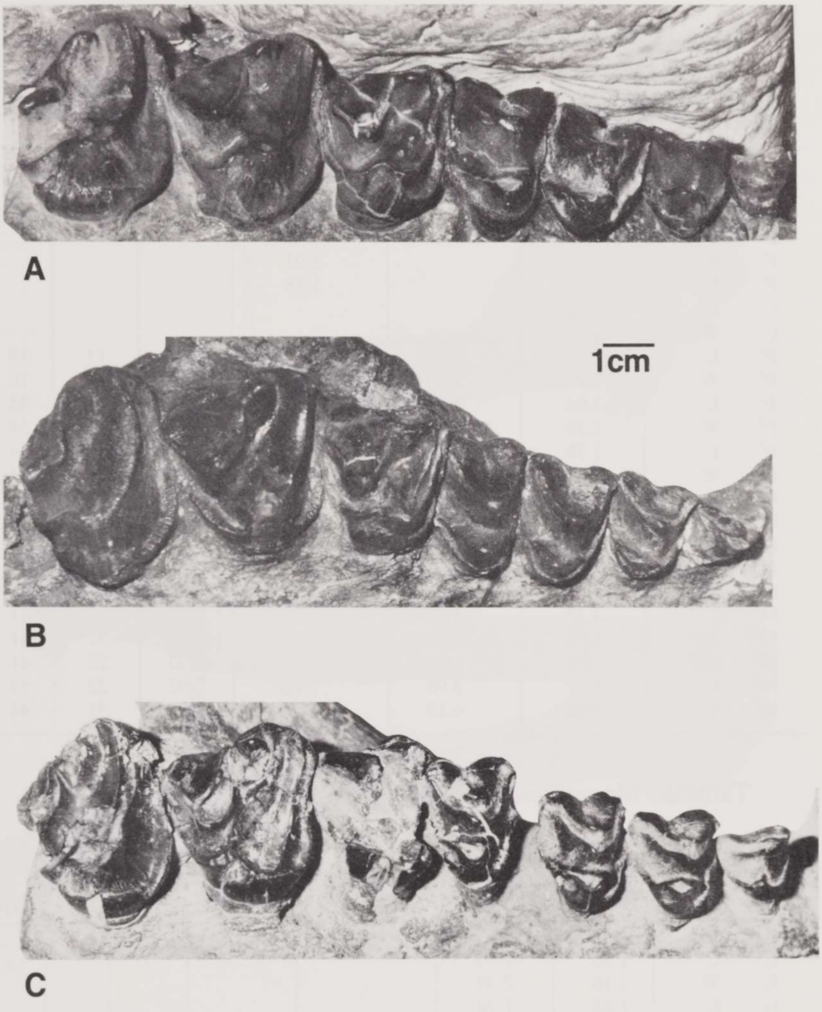


Figure 2. Upper cheek teeth of *Coryphodon molestus* from the Hannold Hill and San Jose Formations. *A*, right P^1–M^3(TMM 40143-12) Hannold Hill Formation; *B*, right P^1–M^3 (TMM 40143-30) Hannold Hill Formation; *C*, right P^1–M^3 (USNM 111, holotype of *Coryphodon elephantopus* [Cope, 1874]) San Jose Formation.

- The M^3 is less nearly bilophodont, with hypolophids that are slightly oblique to a transverse plane. The entoconids may be present as small cuspids (e.g., TMM 40143-30), the cristida obliquae are prominent, and the posterior cingulids may be large (e.g., TMM 40143-5) (Figures 4*A* and *B*).

The M_3 talonid is somewhat variable in the TMM specimens, ranging from one condition in which the hypolophid is nearly transverse, the entoconid is absent, and the cristid obliqua is relatively weak (TMM 40143-5) to another condition in which the hypolophid is slightly oblique, the entoconid is present, and the cristid obliqua is relatively strong.

Table 1. Measurements of upper teeth of *Coryphodon molestus*

		TMM 40143-12	TMM 40143-30	TMM 40143-208	*Coryphodon molestus* x̄	s	N
I^1	W	1.85					
I^1	L	1.36					
I^2	W	2.20		1.92			
I^2	L	1.63		1.48			
I^3	W	1.97		1.93			
I^3	L	1.40		1.35			
C	L	2.73					
C	W	3.13					
P^1	L	1.39	1.32		1.32	.13	18
P^1	W	0.90	1.02		1.10	.28	18
P^2	L	2.04	1.76		1.72	.17	35
P^2	W	2.56	2.14		2.23	.21	34
P^3	L	1.98	1.82		1.78	.15	34
P^3	W	2.84	2.55		2.52	.25	34
P^4	L	2.08	1.69		1.77	.17	36
P^4	W	2.94	2.73		2.61	.17	36
M^1	L	2.38	2.67		2.53	.16	39
M^1	AW	3.08	2.90		2.98	.20	39
M^1	PW	3.12	3.01		2.99	.17	36
M^2	L	3.36	3.18		2.98	.24	41
M^2	AW	3.93	3.52		3.47	.27	41
M^2	PW	3.52	3.29		3.33	.22	41
M^3	L	3.22	2.98		2.92	.22	45
M^3	W	4.28	4.12		3.81	.31	44

Table 2. Measurements of lower teeth of *Coryphodon molestus*

		TMM 40143-5	TMM 40143-30	TMM 40143-208	TMM 41392-1	*Coryphodon molestus* x̄	s	N
I_1	W	1.75	1.95					
I_1	L	1.36	1.35					
I_2	W	2.16	2.39					
I_2	L	1.62	1.74					
I_3	W	2.04	2.02		2.03*			
I_3	L	1.28	1.18		1.21*			
C	L	1.98	2.90*		1.90*			
C	W	1.70	2.68*		1.70*			
P_1	L	1.88*	1.48			1.33	.19	20
P_1	W	0.89	0.83			0.83	.10	20
P_2	L	2.02	2.05		1.92	1.77	.21	25
P_2	W	1.45	1.44		1.28	1.22	.14	27
P_3	L	2.04*	2.15		1.94	1.89	.17	32
P_3	W	1.67	1.68		1.46	1.43	.14	31
P_4	L	2.08	2.33		2.01	1.93	.17	37
P_4	W	1.66	1.86		1.64	1.61	.16	37
M_1	L	2.45	2.48	2.10*	2.37	2.55	.21	38
M_1	AW	1.74	1.83	1.43*	1.77	1.81	.16	37
M_1	PW	1.76*	1.86	1.65*	1.78	1.82	.13	38
M_2	L	3.15*	2.85	2.56*	3.30	3.11	.26	39
M_2	AW	2.37*	2.34		2.30	2.23	.18	40
M_2	PW	2.35*	2.29		2.15	2.23	.19	43
M_3	L	3.95*	4.00		3.42	3.59	.28	39
M_3	AW	2.44	2.80	2.35*	2.59	2.45	.21	41
M_3	PW	2.38	2.38		2.22	2.30	.22	39

* = uncertain measurement.

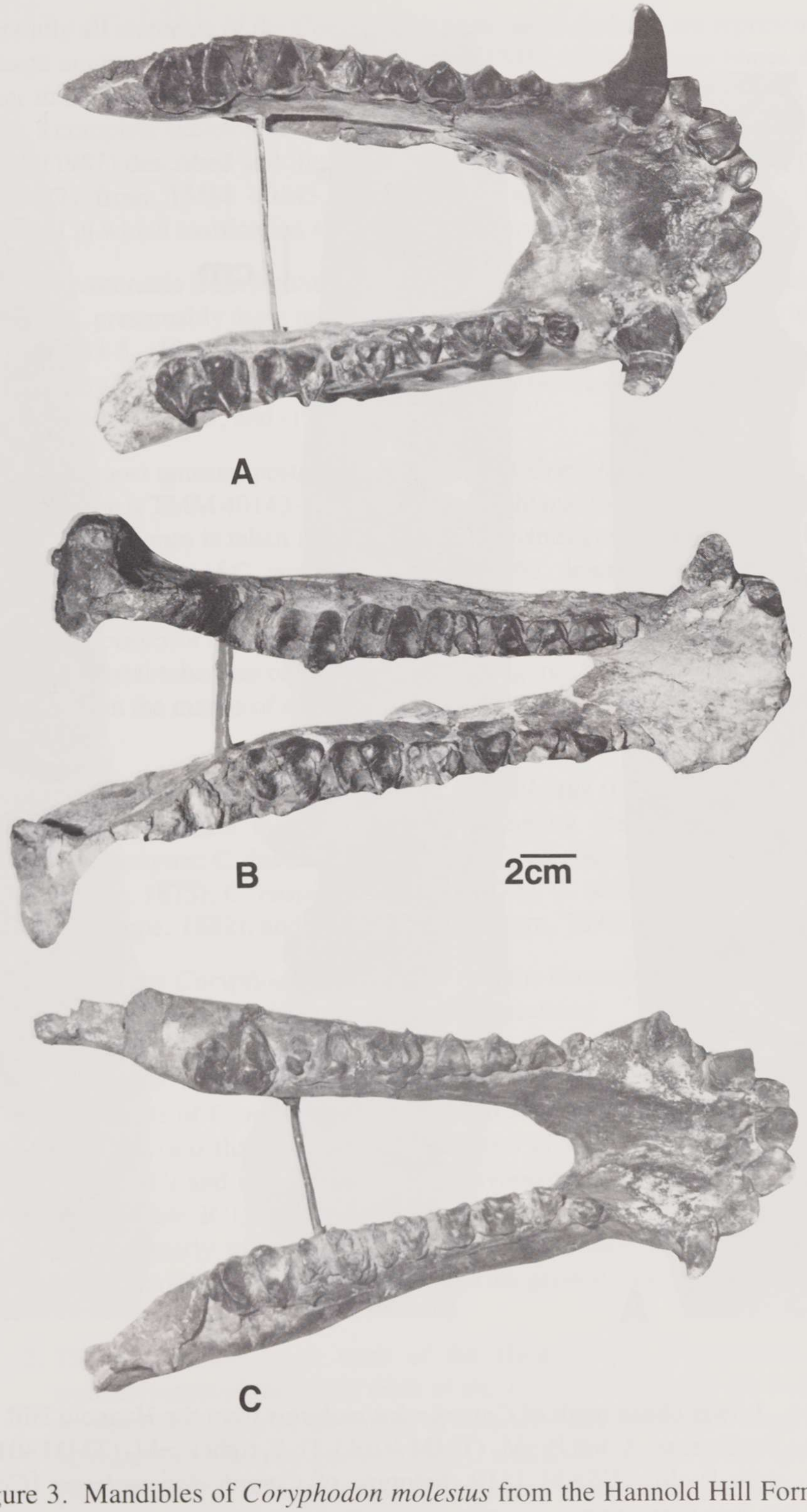


Figure 3. Mandibles of *Coryphodon molestus* from the Hannold Hill Formation. *A*, TMM 40143-30; *B*, TMM 41392-1; *C*, TMM 40143-5.

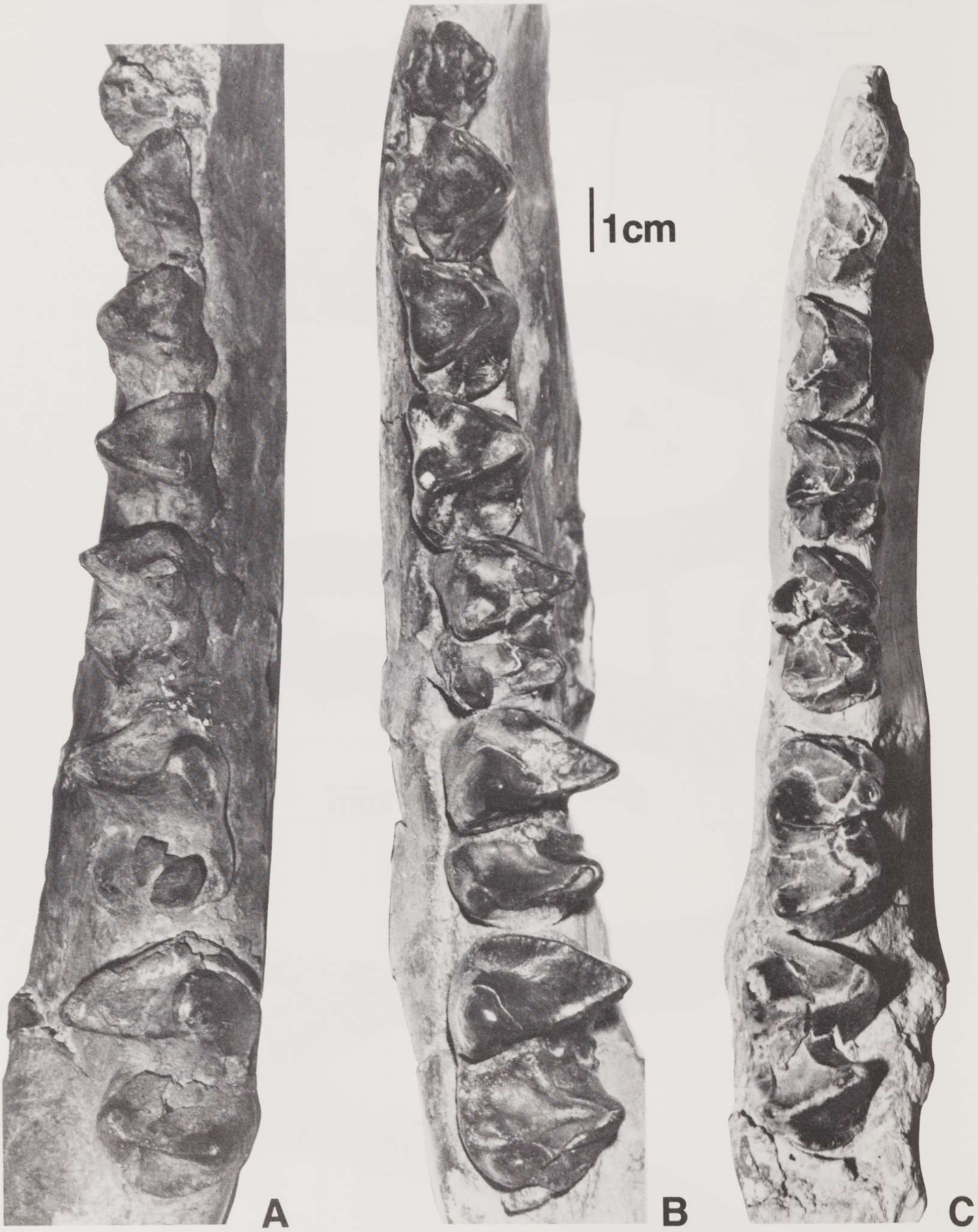


Figure 4. Lower cheek teeth of *Coryphodon molestus* from the Hannold Hill and San Jose Formations. *A*, left P_1–M_3 (TMM 40143-5); *B*, right P_1–M_3 (TMM 40143-30); *C*, right P_1–M_3 (USNM 1119, holotype of *Coryphodon molestus* [Cope, 1874]) San Jose Formation.

Essentially all elements of the *Coryphodon* postcranial skeleton are represented in the large amount of postcranial material from TMM 40143. These bones do not appear to be appreciably different in size and morphology from those of AMNH 48163, a complete skeleton of *C. molestus* described by Lucas (1984a). Lucas and Schoch (1987) described and illustrated a pathologic tibia (40143-15) and patella (40143-27) from TMM 40143. These bones apparently pertain to a single individual in which ossification of the patellar ligament occurred.

The adult postcrania from locality TMM 40143 need represent no more than three individuals, presumably those represented by the three mandibles from this locality (TMM 40143-5, -30, and -208). The presence of at least one juvenile *Coryphodon* at this locality is indicated by isolated deciduous incisors and postcranial specimens (TMM 40143 -99, -103, and -196).

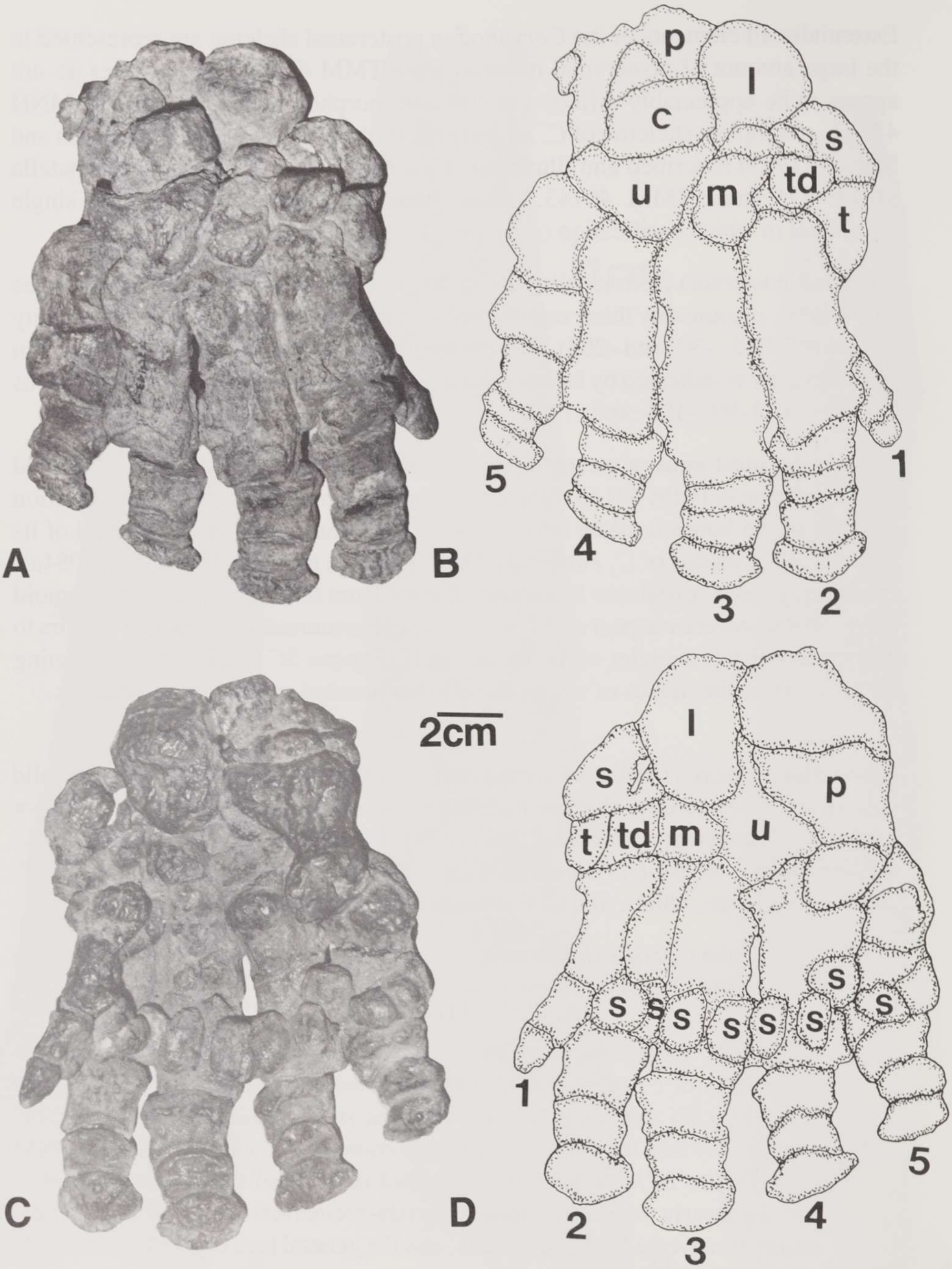
Perhaps the most unusual postcranial specimen of *Coryphodon* from the Hannold Hill Formation is TMM 40143-7, an articulated right manus (Figure 5). If distortion of some of the bones is taken into account, this manus conforms well in all of its features to the manus of *C. molestus,* AMNH 48163, described by Lucas (1984a). However, it does reveal one feature not known from that manus: paired sesamoid bones on the posterior aspect of the manus. These sesamoids are attached in pairs to the postero-distal tubercles of the metacarpals (Figures 5*C* and *D),* thus indicating the presence in the manus of strong flexors that inserted around these tubercles.

Discussion: Lucas (1984a, b) recognized *C. molestus* (Cope, 1874) as a valid species of *Coryphodon* that includes the following species names as junior subjective synonyms: *C. lomas* (Cope, 1874), *C. elephantopus* (Cope, 1874), *C. latidens* (Cope, 1875), *C. cuspidatus* (Cope, 1875), *C. obliquus* (Cope, 1877), *C. curvicristis* (Cope, 1882), and *C. wortmani* (Osborn, 1898).

Assignment of the *Coryphodon* specimens from the Hannold Hill Formation to *C. molestus* is justified by the following two considerations:

1. The close morphological similarity of the Hannold Hill specimens to specimens of *C. molestus* from the San Jose Formation, San Juan Basin, New Mexico that include the holotypes of *C. molestus* (USNM 1119, Figure 4*C)* and its junior subjective synonym, *C. elephantopus* (USNM 111, Figure 2*C)*. Particularly important features of this shared similarity are the nearly transverse postparacrista-premetacrista crests on M^3, the nearly transverse M_3 hypolophids, and the general lack of an M_3 entoconid.

2. The size of the cheek teeth of the Hannold Hill *Coryphodon*. Most measurements of the cheek teeth of the Texas *Coryphodon* are within one standard deviation of the mean of measurements of North American *C. molestus* presented by Lucas (1984a), which include the TMM specimens (Tables 1 and 2). This provides a compelling metric argument for assigning the TMM *Coryphodon* to *C. molestus*.



NOTE: c = cuneiform; l = lunar; ma = magnum; p = pisiform;
s = sesamoid; sc = scaphoid; t = trapezium;
td = trapezoid; u = unciform

Figure 5. Articulated right manus of *Coryphodon molestus* from the Hannold Hill Formation (TMM 40143-7). *A* and *B*, dorsal views; *C* and *D*, ventral views.

PALEOBIOLOGICAL IMPLICATIONS OF HANNOLD HILL *CORYPHODON*

Locality TMM 40143 is one of four *Coryphodon* "quarries" (probably multiple-individual death assemblages) known from the western United States (Lucas, 1981, 1984a). The presence of these associations and the great abundance of *Coryphodon* fossils in some stratigraphic units (especially the San Jose Formation of the San Juan Basin, New Mexico: Lucas, 1977) suggests some sort of gregarious behavior among members of a *Coryphodon* species. Like the other *Coryphodon* quarries, TMM 40143 contains juvenile as well as adult individuals. This supports the idea that juvenile *Coryphodon* were integral members, and perhaps the focal point, of *Coryphodon* social groups.

Sexual dimorphism in *Coryphodon* was originally suggested by Hébert (1856), Osborn (1898), and Patterson (1939). Lucas (1984a), in an examination of specimens from a *Coryphodon* quarry in the San Jose Formation, detected a bimodal size distribution of canines suggestive of sexual dimorphism. Putative male *Coryphodon* have significantly larger canines and more robust skulls and postcrania than do putative female *Coryphodon*.

Among the specimens from TMM 40143, TMM 40143-5 has much smaller lower canines than does TMM 40143-30 (Table 2; also compare Figures 3*A* and *C*). This is consistent with the pattern documented by Lucas (1984a) and suggests that TMM 40143-5 is a female *C. molestus,* whereas TMM 40143-30 is probably a male.

If TMM 41392-1 (Figure 3*B*) belonged to the same population as the *C. molestus* specimens from TMM 40143, it also is a female, based on the size of its lower canines.

AGE OF HANNOLD HILL FORMATION

Wilson et al. (1952) and Wilson (1967) first proposed a Wasatchian age for the fossil vertebrates from the Hannold Hill Formation, and Hartnell (1980a, b) and Rapp et al. (1983) upheld this conclusion. The presence of *C. molestus* confirms a Wasatchian age since this species is only known from Wasatchian strata in the western United States (Lucas, 1984a).

In the Willwood Formation of the Bighorn Basin in northern Wyoming, *C. molestus* first appears at the base of the *Bunophorus* interval zone (= late Gray Bull: Schankler, 1980) and disappears in the middle *Heptodon* range zone (= late Lysite: Schankler, 1980). *C. molestus* is present in the Lysite and Lost Cabin Members of the Wind River Formation, Wind River Basin, Wyoming (Lucas, 1984a). In addition, *C. molestus* occurs throughout the San Jose Formation in New Mexico (Lucas, 1984a, c). Taken together, these occurrences of *C. molestus* indicate that it was present from late Gray Bull through Lost Cabin time in the Eocene of the western United States. This brackets the age of the Hannold Hill *C. molestus,* but a more precise age determination cannot be made from the *Coryphodon* specimens alone.

Other fossil mammals known from the Hannold Hill Formation are *Phenacolemur* cf. *P. praecox, Phenacodus primaevus, Hyopsodus miticulus, Hyopsodus* cf. *H. wortmani, Hyracotherium vasacciense,* and *Paramys excavatus* (Rapp et al., 1983: Table 2). All of these taxa except *Phenacolemur* cf. *P. praecox* and *C. molestus* are present in the Lysite-age Almagre local fauna of the San Jose Formation (Lucas et al., 1981). Thus, it would be tempting to assign a Lysite age to the Hannold Hill vertebrate fauna. However, *Phenacolemur praecox* is a Clarkforkian to Gray Bull Wasatchian taxon (Rose, 1981). Therefore, the most that can be said of the age of the Hannold Hill vertebrate fauna seems to be that it is unquestionably Wasatchian and probably of late Gray Bull or Lysite age.

LITERATURE CITED

Cope, E. D. 1874. Notes on the Eocene and Pliocene lacustrine formations of New Mexico, including descriptions of certain new species of vertebrates. Ann. Rept. Chief of Engineers, 1874 (2)2, Appendix FF3 of Appendix FF:115-130.

__________. 1875. Systematic catalogue of Vertebrata of the Eocene of New Mexico collected in 1874. Rept. Engineer Dept. U.S. Army [Wheeler]:1-37.

__________. 1877. Report upon the extinct Vertebrata obtained in New Mexico by parties of the expedition of 1874. Rept. U.S. Geog. Surv. West of the 100th Merid. [Wheeler] 4, 2:1-370.

__________. 1882. Contributions to the history of the Vertebrata of the lower Eocene of Wyoming and New Mexico, made during 1881. Proc. Am. Phil. Soc. 20:139-197.

Hartnell, J. A. 1980a. The vertebrate paleontology, depositional environments, and sandstone provenance of early Eocene rocks on Tornillo Flat, Big Bend National Park, Brewster County, Texas. Unpublished M.S. thesis, Louisiana State University, Baton Rouge, Louisiana.

__________. 1980b. Fauna from the Eocene of the Hannold Hill Formation, Big Bend National Park, Brewster County, Texas. Geol. Soc. Am., Abstr. Programs 12:179.

Hébert, E. 1856. Recherches sur la faune des premiers sediments tertiaires Parisiens (mammiferes pachydermes du genre *Coryphodon)*. Ann. Sci. Nat. (Paris) (4)6:87-136.

Lucas, S. G. 1977. Vertebrate paleontology of the San Jose Formation, east-central San Juan Basin, New Mexico. New Mexico Geol. Soc. Guidebook 28:221-225.

__________. 1981. Drought and vertebrate fossil assemblages: A *Coryphodon* (Mammalia; Pantodonta) quarry from the early Eocene of New Mexico. Geol. Soc. Am., Abstr. Programs 13:202.

__________. 1984a. Systematics, biostratigraphy and evolution of early Cenozoic *Coryphodon* (Mammalia, Pantodonta). Unpublished Ph.D. dissertation, Yale University, New Haven, Connecticut.

__________. 1984b. Synopsis of the species of *Coryphodon* (Mammalia, Pantodonta). New Mexico J. Sci. 24:33-42.

__________. 1984c. Biostratigraphic significance of *Coryphodon* species from the Regina Member (lower Eocene), San Jose Formation, San Juan Basin, New Mexico. New Mexico Geol. 6:84.

__________, and R. M. Schoch. 1987. Paleopathology of early Cenozoic *Coryphodon* (Mammalia; Pantodonta). J. Vert. Paleontol. 7:145-154.

__________, R. M. Schoch, E. Manning, and C. Tsentas. 1981. The Eocene biostratigraphy of New Mexico. Geol. Soc. Am. Bull. 92:951-967.

Maxwell, R. A., and R. T. Hazzard. 1967. Stratigraphy. *In:* Geology of Big Bend National Park, Brewster County, Texas, eds. R. A. Maxwell, J. T. Lonsdale, R. T. Hazzard, and J. A. Wilson. Univ. Texas Bur. Econ. Geol. Publ. 6711:23-156.

__________, J. T. Lonsdale, R. T. Hazzard, and J. A. Wilson. 1967. Geology of Big Bend National Park, Brewster County, Texas. Univ. Texas Bur. Econ. Geol. Publ. 6711:1-320.

Osborn, H. F. 1898. Evolution of the Amblypoda, Part 1: Taligrada and Pantodonta. Bull. Am. Mus. Nat. Hist. 10:169-218.

Patterson, B. 1939. A skeleton of *Coryphodon*. Proc. New England Zool. Club 17:97-110.

Rapp, S. D., B. J. MacFadden, and J. A. Schiebout. 1983. Magnetic polarity stratigraphy of the early Tertiary Black Peaks Formation, Big Bend National Park, Texas. J. Geol. 91:555-572.

Rose, K. D. 1981. The Clarforkian land-mammal age and mammalian faunal composition across the Paleocene-Eocene boundary. Univ. Michigan Pap. Paleontol. 26:1-197.

Schankler, D. M. 1980. Faunal zonation of the Willwood Formation in the central Bighorn Basin, Wyoming. Univ. Michigan Pap. Paleontol. 24:99-114.

Schiebout, J. A., C. A. Rigsby, S. D. Rapp, J. A. Hartnell, and B. R. Standhardt. 1987. Stratigraphy of the Cretaceous-Tertiary and Paleocene-Eocene transition rocks of Big Bend National Park, Texas. J. Geol. 95:359-375.

Wilson, J. A. 1967. Early Tertiary mammals. *In:* Geology of Big Bend National Park, Brewster County, Texas, eds. R. A. Maxwell, J. T. Lonsdale, R. T. Hazzard, and J. A. Wilson. Univ. Texas Bur. Econ. Geol. Publ. 6711:157-169.

__________, R. A. Maxwell, J. T. Lonsdale, and J. H. Quinn. 1952. New Paleocene and lower Eocene vertebrate localities, Big Bend National Park, Texas. Univ. Texas Bur. Econ. Geol. Report Invest. 14:7.

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