caused by volcanic or fumarolic activity. Water released by such activity may be juvenile lunar water. It should resemble terrestrial water in its δD value and should have a $\delta^{18}O$ of $+5$ to $+8$ per mil, as we have found for the water extracted from rock 66095.

Note added in proof: Epstein and Taylor have reported (*13*) that they did not detect $\delta^{18}O$ in their aliquot of sample 66095, and they conclude that the water in this lunar rock is terrestrial. We do not know the reason for the apparent disagreement between their results and ours. Since we used two different techniques to extract the water for analysis with similar results, we do not believe that our experimental techniques can be the problem. Epstein and Taylor analyzed samples that had been stored for a year longer than ours. Perhaps exchange with terrestrial water occurred during this period. The positions of our respective samples in the original lunar boulder from which the astronauts broke off sample 66095 may be important. In spite of the excellence of the data of Epstein and Taylor, we believe that our analysis and conclusions must remain unchanged.

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Scatological Origin of Microvertebrate Fossil Accumulations

Abstract. *Small-mammal bone found in Recent carnivore droppings (scat) is identical in appearance with that in many Mesozoic and Tertiary microvertebrate fossil collections. Such fossil specimens passed into or through the digestive tracts of carnivores before being left as scat that was later reworked into sedimentary rocks. The term "coprocoenosis" is proposed for such an assemblage. Caution is urged in drawing conclusions about the composition of paleocommunities because carnivores can catch prey representing several different communities and leave a mixed assemblage in a particular depositional environment.*

A typical Mesozoic or Tertiary microvertebrate collection consists of isolated mammalian and reptilian teeth, upper and lower jawbones, and other fragmentary skeletal remains. Most of the fragmentary limb bones have sharp breaks on their edges, some of which may have occurred during the collection process (*1*), but most of which, judged by the abundance of such fragments, must have occurred immediately prior to deposition (*2*).

Remains are found in sands and clays, and in spite of their fragmentary nature the small bones show little evidence of abrasion. Most interpretations of these accumulations assume that the animals lived and died near a stream or lake and that their bones were disaggregated by running water once the soft tissues had decomposed (*3*). That would explain the presence of whole limb bones (which occur rarely), but it is difficult to envision a stream that would fragment or shatter bones into small pieces and yet leave the bones free of evidence of abrasion. It is also difficult to explain how bones could have been fragmented in lake deposits, far from any source of hydraulic energy. Trampling of the bones by large tetrapods might be postulated if the ground surface were hard, but it is difficult to see how bones 1 or 2 cm long could be broken into pieces when they are pushed into soft muds.

I suggest that most or all microvertebrate fossil accumulations first passed into or through the digestive tracts of carnivores (mainly mammalian, but including predacious fish, reptiles, and birds) and were deposited as fecal droppings (scat) in or near a stream, lake, or other basin, where they were subsequently covered by sediment. I propose the term "coprocoenosis" for such an accumulation (*4*).

Using Pearson's (*5*) technique, I extracted bone fragments from bobcat, coyote, and badger scat that was collected in southeast Wyoming and northeast Colorado. Bones so obtained are totally clear of soft tissues and show little evidence (other than breakage) of what they have undergone (Fig. 1c). Because bone will break down readily in an acid environment, its residence time in the carnivore stomach must be relatively short. Nor do carnivores thoroughly masticate the small mammals they consume. One scat sample (Fig. 1a) contained a still articulated, although broken, radius and ulna of the plains pocket gopher *Thomomys bottae*. Another contained the perfectly preserved ribs of the tiny deer mouse *Peromyscus*. Bones of large mammals such as deer, on the other hand, are fragmented and heavily chewed. The chewed edges of such pieces give them a water-worn appearance, and if found in a sedimentary deposit such material might mislead a worker to assume that hydraulic action had been involved in its development.

The similarity between bony remains in disaggregated scat and microvertebrate fossil collections is striking (Fig. 1d). Not only is there a similar size range, but certain bones show breaks at identical loci.

There are records of identifiable mammal bones found in coprolites (fossil scat, Fig. 1b), although such occurrences are not common. Lundelius (*6*), however, discovered coprolites and bone fragments in Australian caves where they were left by marsupial carnivores (*7*). Not surprisingly, his material is identical in appearance with disaggregated placental carnivore scat.

To judge whether scat deposition can account for so many microvertebrate fossils, I refer again to Pearson (*5*), who obtained over 5000 rodent jaws from scat that had accumulated over a 9-month period on a 35-acre (14-hectare) study plot. That is an annual accumulation rate of over 100,000 jaws per square mile (400 per hectare).

The scat accumulation hypothesis explains why birds, bats, and arboreal mammals are so rare in Tertiary microvertebrate collections (*8*). When they do occur, they probably reflect capture by flying predators (*9*).

I suggest that reconsideration be given to the depositional environments in which microvertebrate remains occur. Unless the stratigraphic or other paleontologic evidence warrants it, it is not necessary to assume that water was involved in any way in the formation of such accumulations. Especially in cases where water is postulated solely to account for the origin of bone breccias, other depositional environments (eolian, for example) should be considered as well.

In addition to all the other things it may represent, a microvertebrate collection may also be a reflection of the taste preferences of carnivores, as well as a measure of their ability to catch certain prey. Pearson (*5*) found that although house mice (*Mus musculus*) were twice as abundant as meadow mice (*Microtus californicus*) in his study area, only 7 percent of the *Mus* were eaten by predators, compared to 88 percent of the *Microtus*.

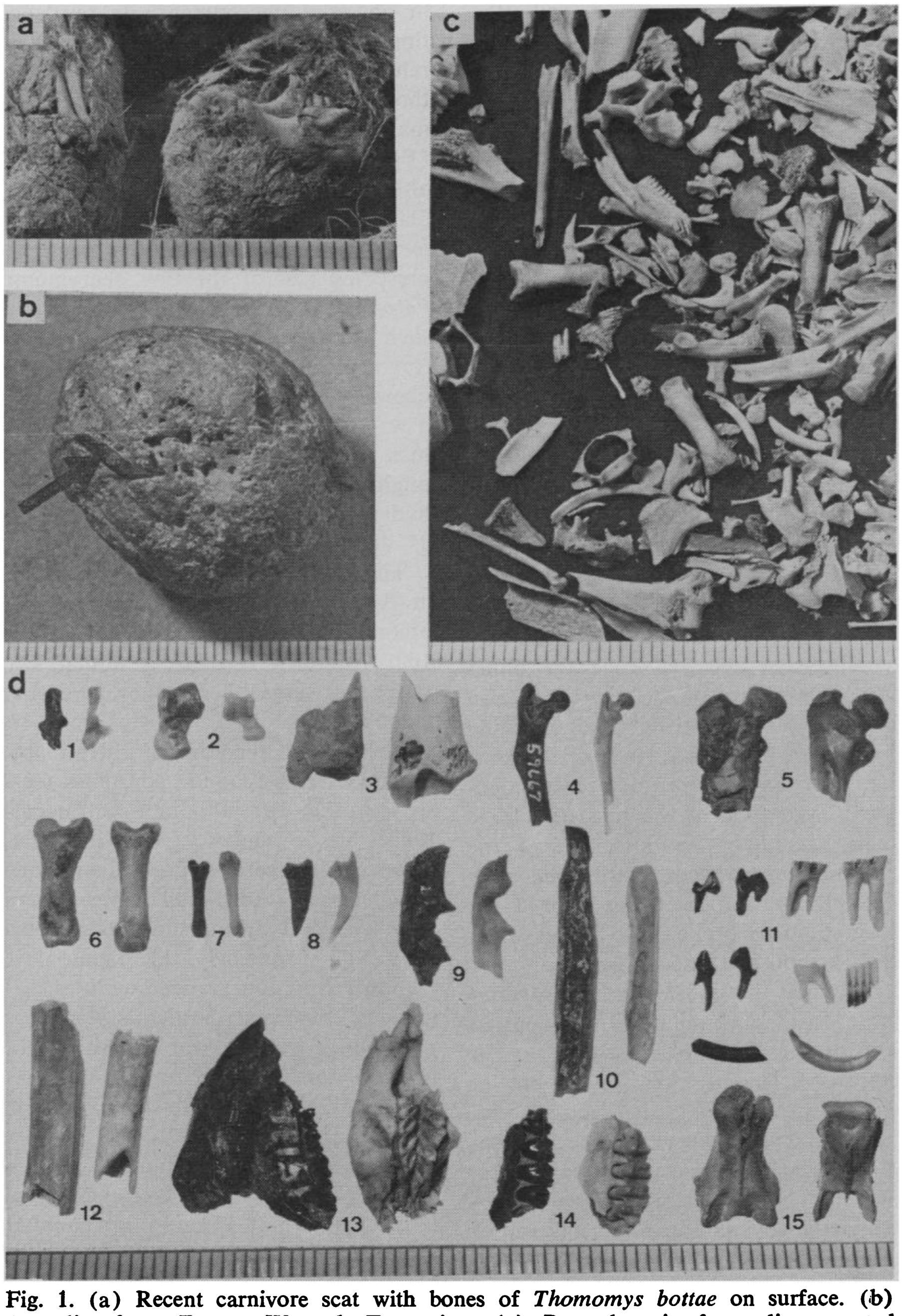

Fig. 1. (a) Recent carnivore scat with bones of *Thomomys bottae* on surface. (b) Coprolite from Eocene Wasatch Formation. (c) Bone breccia from disaggregated Recent carnivore scat. (d) Comparison of early Eocene microvertebrate remains with bones and teeth from Recent scat. In all pairs, fossils are on the left; 1, calcanea; 2, astragali; 3, tibial fragments; 4, femurs; 5, femoral heads; 6 and 7, phalanges; 8, ungual phalanges; 9, ulnar fragments; 10, longitudinally split long bones; 11, isolated premolars, molars, and incisors; 12, long bone fragments; 13, mandibles; 14, maxillae; and 15, caudal vertebrae (scale in millimeters).

The greatest difficulty for paleoecological inference raised by my hypothesis is that carnivores can catch prey in one region and carry them in their digestive tracts a considerable distance before leaving the remains in another depositional environment (*10*). The distance involved is probably no more than a few miles, but, in any case, caution is suggested before sweeping conclusions are drawn about the composition of ancient communities on the basis of microvertebrate fossil evidence.

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