QUATERNARY RESEARCH **47,** 356–358 (1997)
ARTICLE NO. QR971891

SHORT PAPER

Implications of Subfossil Coleoptera for the Evolution of the Mima Mounds of Southwestern Puget Lowland, Washington

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Received November 8, 1994

The origin of Washington State's Mima Mounds has been debated for over a century, with numerous mechanisms being postulated. Subfossil Coleopteran (beetle) remains recovered from the base of a mound at Mima Prairie consist of species that would be expected in rodent burrows and nests; all but one species are obligate burrow inhabitants. These results suggest the past presence of fossorial rodents (probably pocket gophers, *Thomomys mazama*) in the mounds, although none live there at present. Whether or not the gophers created the mounds, they may well have been instrumental in maintaining mound geometry until very recently.

Large, enigmatic earth mounds are distributed over the surface of Mima Prairie in west-central Washington, about 2 km WSW of Littlerock in southwestern Thurston County (46°53′N, 123°03′W; Fig. 1). Individual mounds are typically 2.5–12 m in diameter and 0.3–2 m high. They consist of organic-rich gravelly sandy loam overlying thick outwash sand and gravel (Fig. 2). Various authors have attributed the origin of the Mima Mounds to periglacial processes, differential erosional processes, seismic shaking, and earth-moving activities of pocket gophers (*Thomomys mazama*) (Washburn, 1988, and references therein; Berg, 1990).

A periglacial origin has important paleoclimatic implications, requiring a mean annual temperature of <0°C during formation following recession of the Puget Lobe of the Cordilleran Ice Sheet, about 14,000 yr B.P. However, no independent evidence supports such cold temperatures in this region at that time (Barnosky, 1984, 1985).

Washburn (1988) agreed with LeConte (1877) that the mounds at Mima Prairie probably were created by the combined effects of fluvial erosion and vegetational anchoring. He was undoubtedly correct, however, in cautioning that similar mounds elsewhere may have different modes of origin, a caution overlooked by some workers and rejected by Berg (1990), who recently proposed that the mounds were created by seismic vibration of unconsolidated sediments above a relatively rigid, shallow substrate.

Hallet and Sletten (1994) argued, based on slope retreat studies, that the mounds must be either of recent origin or continuously regenerated. An early postglacial origin is thus eliminated from contention unless modern processes maintain mound relief.

Subfossil coleopteran (beetle) remains in Quaternary sediments have proven valuable in reconstructing Quaternary paleoenvironments (Coope, 1986; Elias, 1994). Berg (1991) suggested that if the mounds had a biological origin, evidence for this should be found within the mounds. This study was undertaken in hopes that coleopteran remains might be recovered from mound sediments and contribute to an understanding of their origin.

Ten kilograms of sediment was collected from the base of a typical mound on the prairie margin. Extraction of insect fragments followed standard techniques (Coope, 1986). Remains recovered were identified by comparisons with modern specimens. Twelve identifiable fragments of three species of Coleoptera (beetles) were recovered from the sample (Table 1). Most of the recovered specimens were from *Ptomaphagus nevadicus* Horn (= *P. thomomysi* Hatch) (Leiodidae). Abundant fine charcoal was also recovered.

Morychus oblongus is a dry grassland species that feeds on mosses and is present in the modern Mima Prairie fauna (P. J. Johnson, personal commun., 1979). Histerid beetles are generally associated with decaying organic matter (Arnett, 1968); *Geomysaprinus copei* has been collected from pocket gopher burrows (Hatch, 1961).

Ptomaphagus nevadicus is an obligate burrow inhabitant known from burrows of pocket gophers, marmots, ground squirrels, and burrowing owls (Peck, 1973). This species is represented by a minimum of three individuals in the fauna.

Although the fossil beetle fauna from Mima Prairie is small, some tentative conclusions can be drawn. The Mima Mound fauna is represented by taxa exclusively consistent with rodent burrows in a grassland environment. *Ptomaphagus* and *Geomysaprinus* are apparently obligate burrow inhabitants, and it is likely that fragments of *Morychus* were brought into burrows with grass and moss to line nests.

Both the pollen record and the radiocarbon dating of the mounds indicate that significant mixing of the mound sedi-

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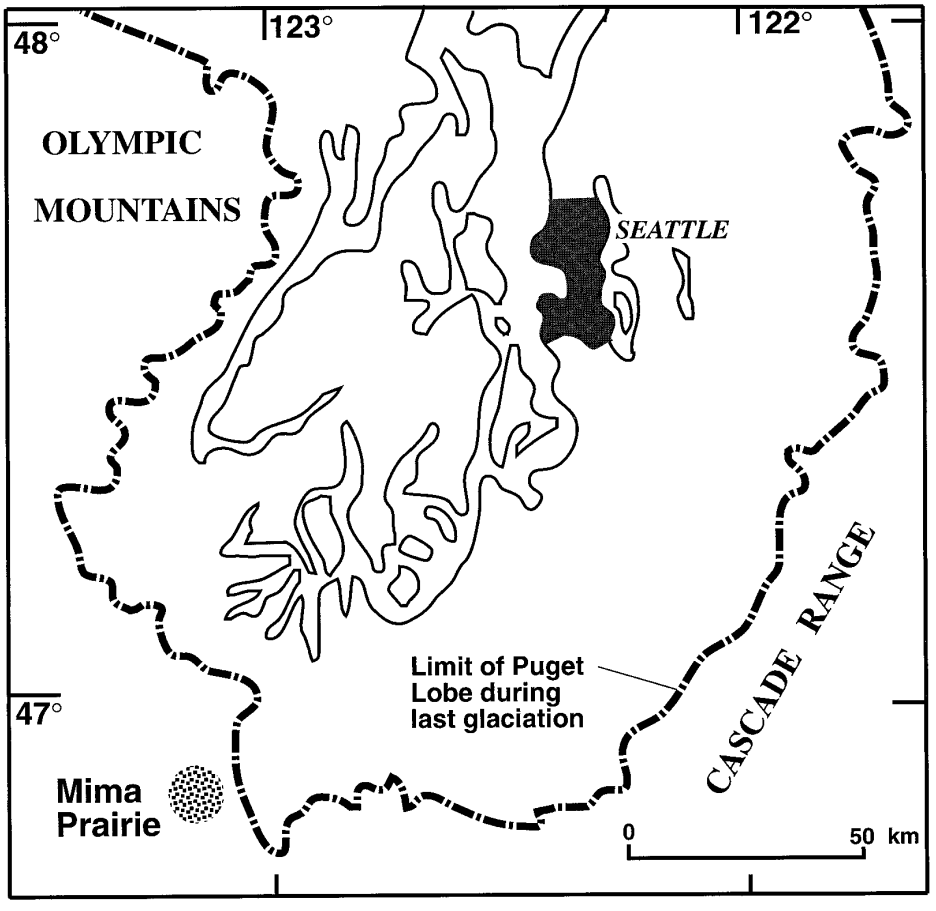

FIG. 1. Map of Puget Lowland showing location of Mima Prairie. Limit of Puget Lobe during Fraser Glaciation after Thorson (1980) and Clague *et al.* (1980).

ments has occurred (Washburn, 1988). Charcoal found in the sample studied here also indicates significant mixing has taken place. All data are consistent with extensive burrowing.

The fact that pocket gophers do not now live in Mima Prairie (although they are found nearby) is one counterargument to the hypothesis that they created the mounds. However, local natural extirpations do occur among pocket go-

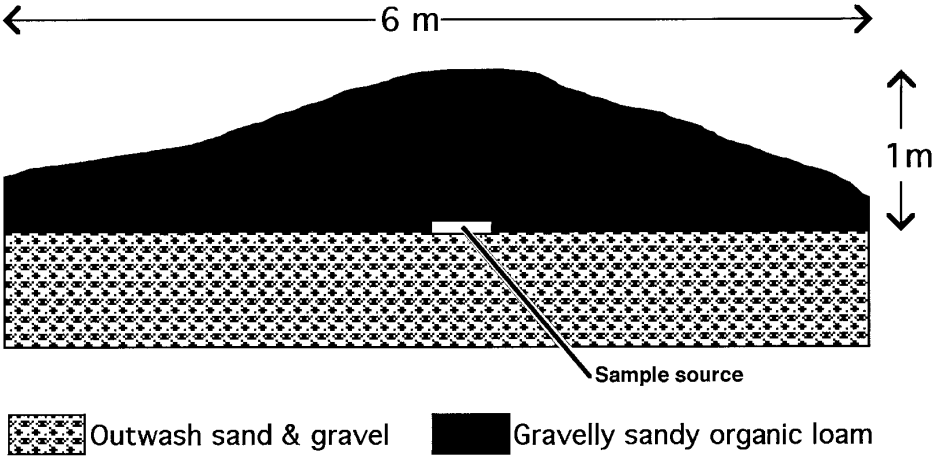

FIG. 2. Diagrammatic section through the Mima mound sampled for this study, showing source of sample used in analysis.

TABLE 1
Fossil Coleopteran Remains from Mima Mound Sediments[a]

Class insecta	
Order Coleoptera	
Family Leiodidae	
Ptomaphagus nevadicus Horn (3)	1 Head 3 Pronota 5 Elytra
Family Histeridae	
Geomysaprinus copei Horn (1)	Left elytron
Family Byrrhidae	
Morychus oblongus LeConte (1)	Left elytron base metasternum

[a] Numbers in parentheses refer to minimum numbers of individuals of each species represented.

phers; distributions at Niwot Ridge on Colorado are winter snowpack-dependent (Thorn, 1982), and >99% mortality was reported in 1958–1959 in Gunnison County, Colorado (Hansen, 1962). Such a local extirpation could explain their total absence from the prairie today; the prairie's isolation from potential colonizer gopher populations by surrounding forest and water could be sufficient to prevent recolonization.

Washburn (1988) concluded that the mounds had been created by fluvial erosion coupled with root anchoring of what would become mound sites, followed by subsequent opening of forests as Holocene climate became warmer and drier. However, Hallet and Sletten (1994) showed that had these mounds been created early in postglacial time, they would by now be less than 10% of their original height, because of progressive slope degradation. Hence, they either must be much more recent in origin or continually regenerated. No large streams flow through the prairie to enhance mound relief, and Berg's (1990) seismic shaking model is difficult to accept, both for reasons cited by Saucier (1991) and because Berg failed to consider in his analysis any lateral strength afforded mound sediments by dense turf.

Earth-moving activities of pocket gophers (Dahlquest and Scheffer, 1942; Cox and Gakahu, 1986; Cox and Scheffer, 1991) seem a plausible mechanism for either creating the mounds or maintaining mounds originally created by other processes early in postglacial time. This study provides clear evidence for the past presence of gophers on the prairie. Therefore, the pocket-gopher hypothesis for the origin of the Mima Mounds can no longer be arbitrarily dismissed (e.g., Berg 1990, 1991).

ACKNOWLEDGMENTS

P. J. Johnson, R. Wenzel, and S. B. Peck assisted in identifying the specimens from Mima Prairie and provided ecological information for the taxa represented. G. R. Coope provided encouragement and assistance in the early stages of this work. A. L. Washburn, S. A. Elias, B. Hallet, and G. W. Cox provided valuable criticism of an early draft of this paper. Financial assistance was provided in part by a grant from the Natural Sciences Research Fund of Colby College.

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