FORUM

Comment and Reply on "Formation of Mima mounds: A seismic hypothesis"

COMMENT

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In the lower Mississippi Valley, geologists jokingly(?) believe that there are nearly as many ideas about the origin of pimple mounds as there are mounds themselves. The reason for this plethora of theories is attributable to the popular belief that, because they are so morphologically similar, they must be of common origin, but unfortunately no single theory is compatible with all their observable characteristics. Such is the case with Berg's (1990) hypothesis when he implied (but did not overtly state) that the mounds in the south-central United States from Texas and Louisiana to Missouri are of a seismic origin because of their proximity to the New Madrid seismic zone (Algermissen, 1969).

Basic to Berg's hypothesis of a seismic origin is the presence of unconsolidated fine sediments (e.g., loess) on a relatively rigid planar substratum. Seldom is this the case in the south-central United States. Pimple mounds occur in huge numbers on substrata that vary from thin residual soils (Ozark Plateau) to Quaternary alluvium (valley-train deposits of the Mississippi Valley) more than 100 m thick and that represent fluvial, deltaic, and marine environments of deposition. Of greater significance, the mounds generally are composed of the same soil type as the substratum—commonly silt or silty loam, but ranging from clean fine sand (relict beach ridges of southeastern Texas) to highly plastic clay (parts of northeastern Texas). In the latter area, Quaternary fluvial terrace clays are commonly >10 m thick and overlie loose sands and gravels rather than a rigid substratum. The terrace surfaces exhibit some of the best developed fields of pimple mounds I have ever seen (Saucier, 1967).

A little-recognized but highly significant aspect of the distribution of pimple mounds in the south-central United States is their presence by the tens of millions adjacent to and west of the Mississippi River, but their complete absence to the east. Landforms and deposits of similar origin and composition are present on both sides of the river, and certainly seismic activity in the New Madrid zone affected both areas equally. Pimple mounds in the lower Mississippi Valley area apparently do not occur on Holocene deposits younger than 3–5 ka (Saucier, 1978; O'Brien et al., 1989). This is inconsistent with seismic activity in the area which included a devastating series of shocks in 1811–1812 that was perhaps the strongest in more than 1 ka (Saucier, 1989). The density of pimple mounds declines eastward with increasing distance from the Ozarks in Arkansas on given landforms and/or deposits. This is in sharp contrast to sand blows and other earthquake-induced liquefaction phenomena in Arkansas that reach their peak development in the northeastern part of that state.

I have postulated that a biological origin is most consistent with the known characteristics of pimple mounds in the Mississippi Valley area (Saucier, 1978), but I do not believe that this is necessarily true in other areas. A seismic hypothesis may be tenable in some areas, but so may other hypotheses. I was intrigued recently by a magnificently developed field of "mini"-mounds of silt that formed on a planar, rigid substratum (a concrete sidewalk) in front of my office building when silt-laden water 10 cm deep from a local flash flood rapidly receded within the curbs after a heavy rainstorm. Although I am at a loss to explain the causal mechanism, the resultant pattern of mound development was strikingly similar to that shown by Berg (1990) in his Figure 4. Is this perhaps the genesis of a new hypothesis?

As a minor point, I note a serious distortion in Berg's Figure 1 of the seismic risk zones of Algermissen (1969). The zone of major and moderate risk shown in the central Mississippi Valley area is offset about 100 km too far to the east. In reality, the axis of the zone of major risk straddles the Mississippi and Ohio rivers from southern Illinois southward.

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REPLY

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Saucier's Comment raises several legitimate issues about my hypothesis suggesting a seismic origin for Mima mounds (Berg, 1990). The popular belief that, due to their morphological similarity, a common cause is likely, however, is in my opinion a valid one.

A planar substrate of some sort is a feature in most mound areas. In some cases the substrate consists of bedded gravel deposits, as at Mima prairie and a few locations in the Channeled Scabland of eastern Washington (Berg, 1990). I believe that the apparent lack of substrates in the Mississippi River area and elsewhere may be just that. Discrete "stiff" sandy-loam layers (Saucier, 1989) or clay layers may perform the function of planar substrates. On the pimpled plains of eastern Oklahoma, "The loess-like material of the mounds rests with a sharp contact on a flat nearly level floor that commonly consists of heavy clay or claypan, lighter in color than the material composing the mound. In places the material approaches the consistency of hardpan" (Knechtel, 1952). A critical point, perhaps not emphasized sufficiently in my paper, was that a reflective surface is required to provide the interference pattern. Seismic waves traveling across the terrain uninterrupted would have no permanent effect on the surface sediments except to produce sand blows if of sufficient magnitude. The effect would be like shaking a rug on the floor and having a rug wave roll over the surface. Whereas the magnitude of seismicity necessary to form mounds is unknown, I believe that it would be comparable to that required to produce sand blows.

That mounds are abundant on the west side of the river and absent on the east side is a most intriguing fact that I was not aware of prior to Saucier's Comment. A possible explanation is the paucity of high-magnitude seismicity on the east side compared to the west. This point is well supported by Figure 1 here, which shows that the largest magnitude seismic activity in historic time has occurred on the west side of the Mississippi in the New Madrid seismic zone.

Seismicity as evidenced by sand blows is also much more prevalent on the west side of the Mississippi than the east within the New Madrid seismic zone. Sand blows and mounds may share one characteristic; i.e., being formed by seismic activity and relatively unchanged by subsequent seismicity. Sand blows depend on structural openings in the subsurface. Subsequent events likely would reactivate preexisting openings in the subsurface, so that sand blows observed may represent only the latest seismicity in the area (Saucier, 1989). In the Charleston, South Carolina, area "paleo" sand blows have been documented in the subsurface, indicating prior seismic activity of sand-blow magnitude.

Sand blows, which require some structural communication with the surface, are features quite different from the mounds. They appear to be, in simplest terms, the result of hydraulic action, produced by seismicity,

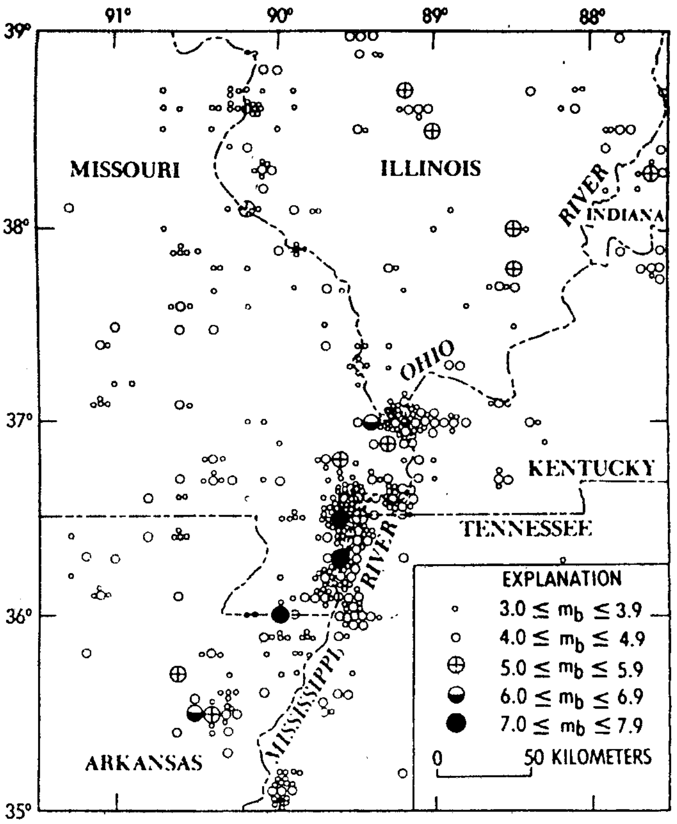

Figure 1. Epicenters of 488 earthquakes of magnitude m_b = 3–7 occurring in central Mississippi Valley from 1811 to mid-1974 (Stauder, 1982).

which pumps liquefied sediments to the surface through structural openings during seismic disturbances. Areas that abound in both sand-blow features and mounds occur in the New Madrid seismic zone (R. Saucier, 1990, personal commun.).

Mima mounds appear to be dependent on rebound structures in the subsurface to provide the interference patterns required. This dependence suggests that subsequent seismicity in a given area will not materially alter the preexisting mound morphology. A simple experiment (Berg, 1990) demonstrates this idea: repeated vibration of the experimental board produced no changes in the mounds.

That mounds do not occur on Holocene deposits younger than 3–5 ka (Saucier, 1978; O'Brien et al., 1989) is not remarkable, owing to the likelihood that seismic activity in the New Madrid zone has had a long history, and the mounds could have formed in the distant past. Their decline eastward in density with increasing distance from the Ozarks, in spite of continued sand-blow activity in the region, may merely signify a decrease in the magnitude of seismicity.

Although I cannot deny that multiple causes may prove to be valid for mound formation in some areas, I do not favor a biological origin for these features in any area. It seems to me that a biological origin should reveal itself within the structure of the mound. Also, such an origin should reveal contemporary activity, unless the critters responsible became extinct or changed their habits. Further, a biological cause should show some mounds in various stages of development. Most mounds appear to be of similar dimension in a given area, suggesting a specific constructional episode or episodes. Biological evidence that I have examined in the field leads me to believe that biological activity in mounds is, in the main, destructive of mound integrity.

The observation by Saucier of "mini"-mounds on a sidewalk outside his office after a flash flood was most interesting—particularly that they looked exactly like my experimental mounds. Is it possible that the weight of the water carried by the flash flood produced vibrations in the concrete slab which formed the mounds? It seems reasonable that they might form under some depth of water if the other requirements were met.

That all known mound areas are within or proximal to areas that have experienced seismic activity is extremely compelling to me. If I were to undertake a further search for mounds, I would confine my search to such areas until mounds were documented totally unrelated to seismicity. In the meantime I am left with the classic comment of our profession: "Much more work remains to be done," or the statement by Carl Sagan: "The absence of evidence is not evidence of absence."

COMBINED REFERENCES CITED

Algermissen, S.T., 1969, Seismic risk studies in the United States: Proceedings, World Conference on Earthquake Engineering, 4th, Santiago, Chile, v. 1, p. 14–27.

Berg, A.W., 1990, Formation of Mima mounds: A seismic hypothesis: Geology, v. 18, p. 281–284.

Knechtel, M.M., 1952, Pimpled plains of eastern Oklahoma: Geological Society of America Bulletin, v. 63, p. 689–700.

O'Brien, M.J., Lyman, R.L., and Holland, T.D., 1989, Geoarchaeological evidence for prairie-mound formation in the Mississippi alluvial valley, southeastern Missouri: Quaternary Research, v. 31, p. 83–93.

Saucier, R.T., 1967, Geological reconnaissance of the Sulphur River and Cypress Creek basins, Texas: U.S. Army Engineer Waterways Experiment Station Technical Report 3-798, 54 p.

——1978, Sand dunes and related eolian features of the Lower Mississippi River alluvial valley: Geoscience and Man, v. 19, p. 23–40.

——1989, Evidence for episodic sand-blow activity during the 1811–1812 New Madrid (Missouri) earthquake series: Geology, v. 17, p. 103–106.

Stauder, W., 1982, Present-day seismicity and identification of active faults in the New Madrid seismic zone, *in* McKeown, F.A., and Pakiser, L.C., eds., Investigations of the New Madrid, Missouri, earthquake region: U.S. Geological Survey Professional Paper 1236-C, p. 22.