Journal of the Arkansas Academy of Science

Volume 28 Article 28

1974

Sand Boils: A Modern Analogue of Ancient Sand Volcanoes

John Glynn Williams
University of Arkansas, Fayetteville

Sand Boils: A Modern Analogue of Ancient Sand Volcanos

JOHN GLYNN WILLIAMS
Department of Geology, University of Arkansas, Fayetteville, Arkansas 72701

ABSTRACT

Sand boils are springs that form on the lowland side of an artificial levee containing a river at extremely high flood stage. Hydrostatic pressure generated by the column of river water between the levees causes failure in the sediment of the channel wall and allows water to be forced laterally beneath the levee and out onto the adjacent flood plain. Sand is transported by the moving water and is ejected onto the flood plain at points where the sediment is structurally weak to produce the boils. The sand deposit forms a characteristic sedimentary structure similar to sand volcanos of the ancient sedimentary record. Mechanisms similar to those that produce sand boils may have been involved in the genesis of these structures.

INTRODUCTION

Sand boils are springs that form on the land side of an artificial levee containing a river at extremely high flood stage. Hydrostatic pressure generated by the column of river water exerts a downward force that is too great for the wall material of the river channel to contain, and thus water is forced through the wall material of the channel. The water travels laterally and upward from the channel to the flood plain surface outside the levee and forms sand boils. Sand boils remain active as long as the hydrostatic pressure is sufficient to move water to flood plain surface and to keep the passageway flushed of sediment. As the flood waters recede, the hydrostatic pressure decreases and the flushing process ceases to operate. Sand transported by the water in the flushed zone slumps back into the boil, producing a depression surrounded by a ring of sand. This sedimentary structure resembles a doughnut.

SAND BOILS OF THE MISSISSIPPI RIVER

Geomorphic Setting. Several sand boils developed during the spring of 1973 near Lake Village, Arkansas. The boils occurred at the south end of Lake Chicot, an oxbow lake, on the landward side of the Mississippi River levee (Fig. 1). Numerous small boils developed near the edge of the lake bed adjacent to an old natural levee and one large boil was situated several hundred feet south of the others.

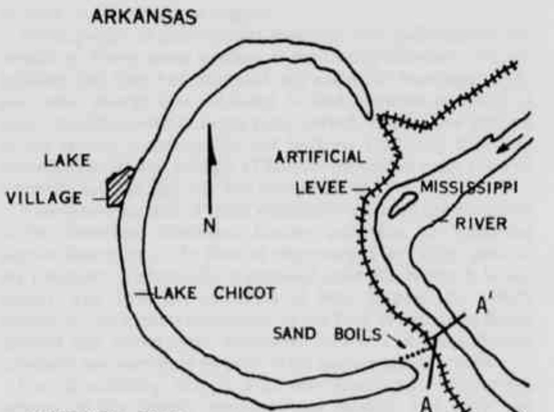

Figure 1. Map view of southeastern Arkansas showing location of sand boils near south end of Lake Chicot and Greenville Bridge, and section A-A′ of Figure 2.

History of Activity. During the winter and spring of 1973 there was an excessive amount of rainfall in the drainage basin of the Mississippi River. This rainfall occurred locally near Lake Village, Arkansas, as well as regionally throughout the basin. Local and regional flooding resulted. During February 1973, the Mississippi River at the Greenville Bridge southeast of Lake Village was at an elevation of 121 ft (MSL) compared to the normal water level of 95 ft. Lake Chicot, an oxbow lake formed by the meandering Mississippi, was at an elevation of 113 ft compared to the normal water level of 95 ft (Fig. 2). Inundation of both the landward and the river sides of the levee by flood waters produced saturated conditions in the soils and sediments of the flood plain. During the spring, regional rainfall remained excessive while local rainfall diminished. Thus flood levels continued on the Mississippi River whereas the water of Lake Chicot returned to normal levels (Fig. 2). High water on the river side of the levee and low water on the landward side created a difference in hydrostatic pressure beneath the river and lake. With the competence of the ground already low because of the water saturation and increased pore pressure, water began migrating through the sediment adjacent to the river and seeping out at the surface on the landward side of the levee. Initially there was little seepage, but as flushing of sediment continued, the flow of water increased. Eventually the flow became sufficient to create a sand boil. After the sand boil

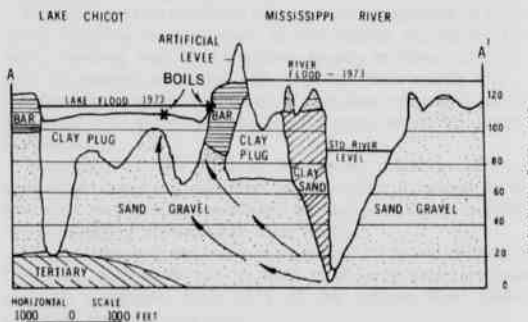

Figure 2. Section A-A′ showing normal water levels in Lake Chicot and Mississippi River, flood-stage water levels in Lake Chicot and Mississippi River, and sedimentological setting of the area. Trace is in Figure 1.

activity ceased, the area was blanketed with up to 5 in. of very fine grayish-brown sand that came from more than 20 sand boils in the area. The pressure gradient that motivated the flow is proportional to the difference in elevation between the water level of the river and the surface of the flood plain outside the levees.

By July 1973, the Mississippi River had returned to normal water level (Fig. 2). This resulted in normal and equal hydrostatic pressure beneath the river and the adjacent flood plains outside the levees. In the absence of a pressure gradient, the boils ceased to be active.

Geologic Factors. A buried point bar sand body approximately 80 ft below the surface of the sand boil was the source of the blanket of sediment that covered the ground downslope from the boils (Fig. 2). Five inches of sand was deposited in less than one week. A cross section of the area shows that the numerous small boils occurred along the surface trace of the clay plug - natural sand levee interface (Fig. 2). As the oxbow lake filled in, finer grained sediments were deposited upward to the surface of the lake forming the plug. They were flanked shoreward by bar deposits. As bar sedimentation preceded the clay accumulation by a considerable period of time, it would be reasonable to assume that the clay plug - sand levee contact would be very sharp and would provide a path for the water to follow. One large boil, however, occurred in the homogeneous clay sediment of the plug. This boil was above a thinned zone of clay sediment that overlies the point bar deposits at depth. The weakness of this zone may have caused it to fail at the point of minimum thickness. Also, vibrations from a nearby bridge and highway may have agitated the water-saturated clay, causing it to behave as a thixotropic clay-water mixture, which yielded to the hydrostatic pressures from below.

Sedimentary Structures. When the boils ceased to flow, circular doughnut-shaped structures were left (Fig. 3). As the

Figure 3. Photograph of large sand boil showing characteristic doughnut-shaped structure. Sand boil is presently inactive.

sand-laden water moved from a high-energy sand boil environment to the low-energy flood plain site, the sand-size sediment was deposited near the boil opening forming the structure. Away from the sand boil and downslope, finer sand was deposited. This circular structure is analogous to an ancient sand volcano (Pettijohn and Potter, 1964). Although the sand volcano is attributed to slumping as the mechanism for differing pressures (Gill and Kuenen, 1957), the origin seems readily related to that of modern sand boils. Ancient boils would be characterized by disrupted bedding as well as a sandy sedimentary intrusion cutting through clayey sedimentary rocks. Ancient boils could be present in a claystone or shale-sandstone succession where the sandstone is overlain by shale and intrusions of sandstone extend upward into the shale bed. Hydrostatic or lithostatic pressure differentials can be a part of the driving mechanism if the sedimentary rocks indicate fluvial environments similar to the Lake Chicot site.

CONCLUSIONS

When hydrostatic pressure becomes high enough for forced water migration through sediment, sand boil development is possible. In ancient sedimentary rocks a doughnut-shaped sandstone structure that is above a shale interval and is attached to a neck extending down into the shale disrupting bedding may be the product of sand boil processes.

ACKNOWLEDGEMENT

The writer expresses his gratitude to Dr. D.L. Zachry for his suggestions in making this a better paper.

LITERATURE CITED

FISK, H.N. 1947. Fine-grained alluvial deposits and their effects on Mississippi River activity. Corps of Engineers, Mississippi River Commission, plate 55.

GILL, W.D., and PH. H. KUENEN. 1957. Sand volcanos on slumps in the Carboniferous of County Clare, Ireland. Geol. Soc. London Quart. J. 117:441-460.

PETTIJOHN, F.S., and P.E. POTTER. 1964. Atlas and glossary of primary sedimentary structures. Springer-Verlag, New York. Plate 114.