Visualizing Sea Level Rise and Early Bay Habitation

6000 B.P. to Present: The Emeryville Shellmound

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This animation visualizes two simultaneous processes, one natural and the other social. About six thousand years before present (B.P.) rising sea levels widened the extent of San Francisco Bay and created new shallow water habitats for oysters, mussels and clams. At about the same time, hundreds of shellmounds began to rise along the margin of the bay. Among the largest human constructions in Western North America, these mounds mostly consist of the discarded shells of bay shellfish. But these mounds were more than garbage dumps. Individual mounds contain dozens or hundreds of human remains, positioned and equipped with the rituals of a careful and intentional burial. The mounds also contain enormous quantities of ash and fire cracked rock as well as animal bones and other evidence of active living spaces. While they remain puzzles, the shellmounds are the best historical records we have of societies that flourished on the shores of San Francisco Bay for thousands of years. This intense inhabitation, this rootedness, is comparable to the oldest human agricultural settlements in the Near East or Asia.

In this visualization we sought to understand the relationship between rising sea levels that both created new food resources and opportunities for human societies but also claimed large expanses of the former river valley floors now drowned beneath San Francisco Bay. As late as the end of the nineteenth century, hundreds of shellmounds dotted the margin of San Francisco Bay.

This animation depicts the history of one site, called the Emeryville shellmound after the modern city that now rests on top of the mound. Among the first shellmounds to be extensively excavated, the Emeryville mound contains charcoal and other objects with radiocarbon dates covering several thousand years. Did rising sea levels force native people to raise their shellmounds to stay above the tides? The visualization suggests that no, mound building was unrelated to sea level rise. Instead, the shellmound people must have had their own reasons—population growth, war and peace, religious pilgrimage, disease?—that motivated the centuries of effort involved in building mounds and apparently, the end of active mound building about 850 years ago. We cannot know their reasons, but this animation attempts to visualize the temporal and spatial extent of native peoples work.

This visualization necessarily includes many assumptions. They are based on careful review and synthesis of archaeological work on the Emeryville shellmound.

Mound Height

Our visualized Emeryville mound has the cross sectional shape of an ellipse. It was wider than it was high, as 19th century photographs suggest. We assumed a radius of approximately 150 feet from the center of the mound and a maximum height of 66 feet at the apex of the mound. These numbers are based on estimates by the author of the definitive article on the Emeryville mound, University of California archaeologist W. Egbert Schenk.[1] They are speculative because the top of the shellmound was leveled in the late 19th century to allow for the construction of a dance pavilion. When archaeologists first encountered it, the mound had already been graded and flattened to support a dance hall and shooting gallery. Alameda County historian M.W. Wood, writing in 1883, suggested the shellmound rose to a height of 60 feet.[2] Our maximum possible height of 66 feet is based on Schenk's estimation of the maximum height of the mound he found, "if the cone had continued its slope to a definite point." In the final frames of the animation, we substitute a dashed line and a lower elevation to represent the mound as it appeared to archaeologists. We used 40 feet as a rough estimate of the height of the mound in the final frame because it is Schenk's best guess at the "maximum elevation attained from the mound" and close to his observation that the top of the mound ranged in "elevation from 36 to 38.8 feet" in 1926.[3]

Shape

Our basal radius of 150 feet is based on a maximum mound height of 66 feet and Schenk's observations about the mound shape and volume. The base of our visualized shellmound is only roughly circular. Schenk offers up a range of potential diameters for two separate conical sections. He mentions a range of diameters from 145 feet to 354 feet. The conical section that Schenk observed had "diameters of 150 to 250 feet and a height of 22 feet."[4] Our goal was to end with a plausible representation of the size of the shellmound (if not its shape). In order to do so we gave more weight to the height and the rate of accumulation. We used these assumptions to roughly calculate the radius and volume of the shellmound. We assumed the mound's total volume derived from accumulation of material at 33 cubic feet per person per year by a population of 100 people over the course of 1867 years. Estimates of the rate of accumulation are taken from Schenk.[5] The age of active building of the mound is based on later radiocarbon dates of 2717 B.P. and 850 B.P. at the bottom and top of the mound, respectively.[6] The resulting radius is speculative but within a plausible range.

Timeline

The visualization covers approximately 6000 years. We ended the visualization in 1926 because Schenk and his team

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excavated the Emeryville mound during parts of 1924 and 1925, and published their report in 1926. The following year most of the above surface portion of the Emeryville shellmound was razed for construction of a paint factory.

Rate of Sea Level Rise and Sea Level

We based the rate at which sea level rose on Brian Atwater's seminal work (Atwater 1977). Atwater claims sea level rose at a nearly constant rate of 0.1-0.2 cm/year for the last 6000 years. We averaged this to 0.15 cm/year for the whole time period of our visualization. Actual sea level rise almost certainly varied over this time period. We adopted Schenk's base level, taken from the 1924 California Pacific Datum. This does not precisely align with Atwater's data, but it is necessary to make sense of Schenk's mound height and diameter.

End Notes

1. Schenk, W. E. 1926. The Emeryville Shellmound: Final Report. U.C. Publications in American Archaeology and Ethnology 23, 147-282.

2. Schenk, 158.
3. Schenk, 161.
4. Schenk, 162.
5. Schenk, 209.
6. Broughton, J.M. 2004. Declines in mammalian foraging efficiency during the late Holocene, San Francisco Bay. IN: Prehistoric California: Archaeology and the Myth of Paradise, ed. by L. M. Raab and T. Jones, pp. 34-52. University of Utah Press.
7. Atwater, Brian. 1977. Late Quaternary depositional history, Holocene sea-level changes, and vertical crust movement, southern San Francisco Bay, California. U.S. Geological Survey professional paper 1014.

Nelson, N.C. 1909. "Shell mounds of the San Francisco Bay Region," University of California Publications in American Archaeology and Ethnology 7 no. 4, 309-348.

Uhle, M. 1907. "The Emeryville Shell Mound," University of California Publications in American Archaeology and Ethnology 7 no. 1, 1-84.

Supplementary Information is linked to the online version of the paper at http://www.stanford.edu/group/spatialhistory/cgi-bin/site/pub.php?id=11.

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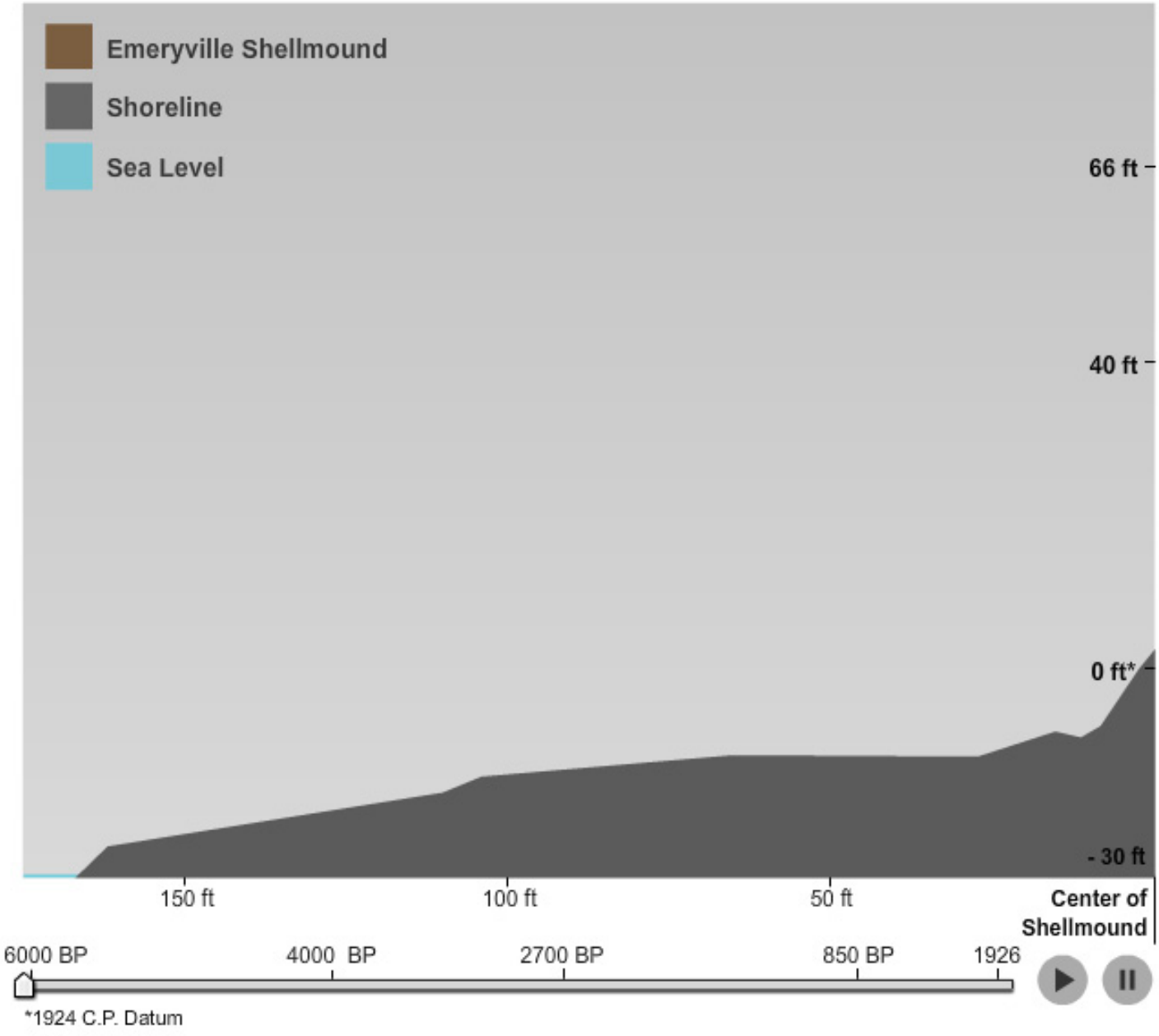
The Emeryville Shellmound, 6000 BP to Present



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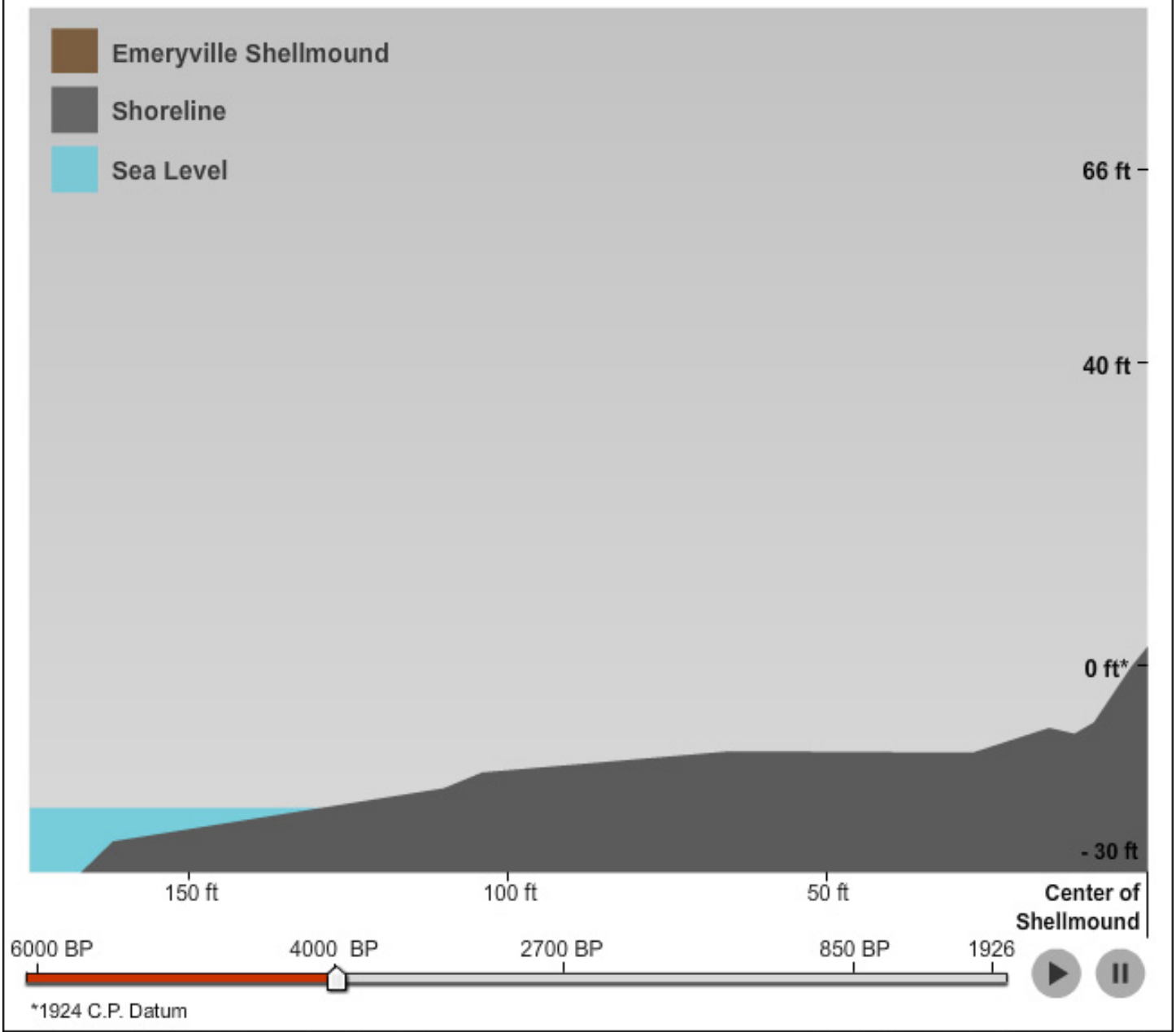

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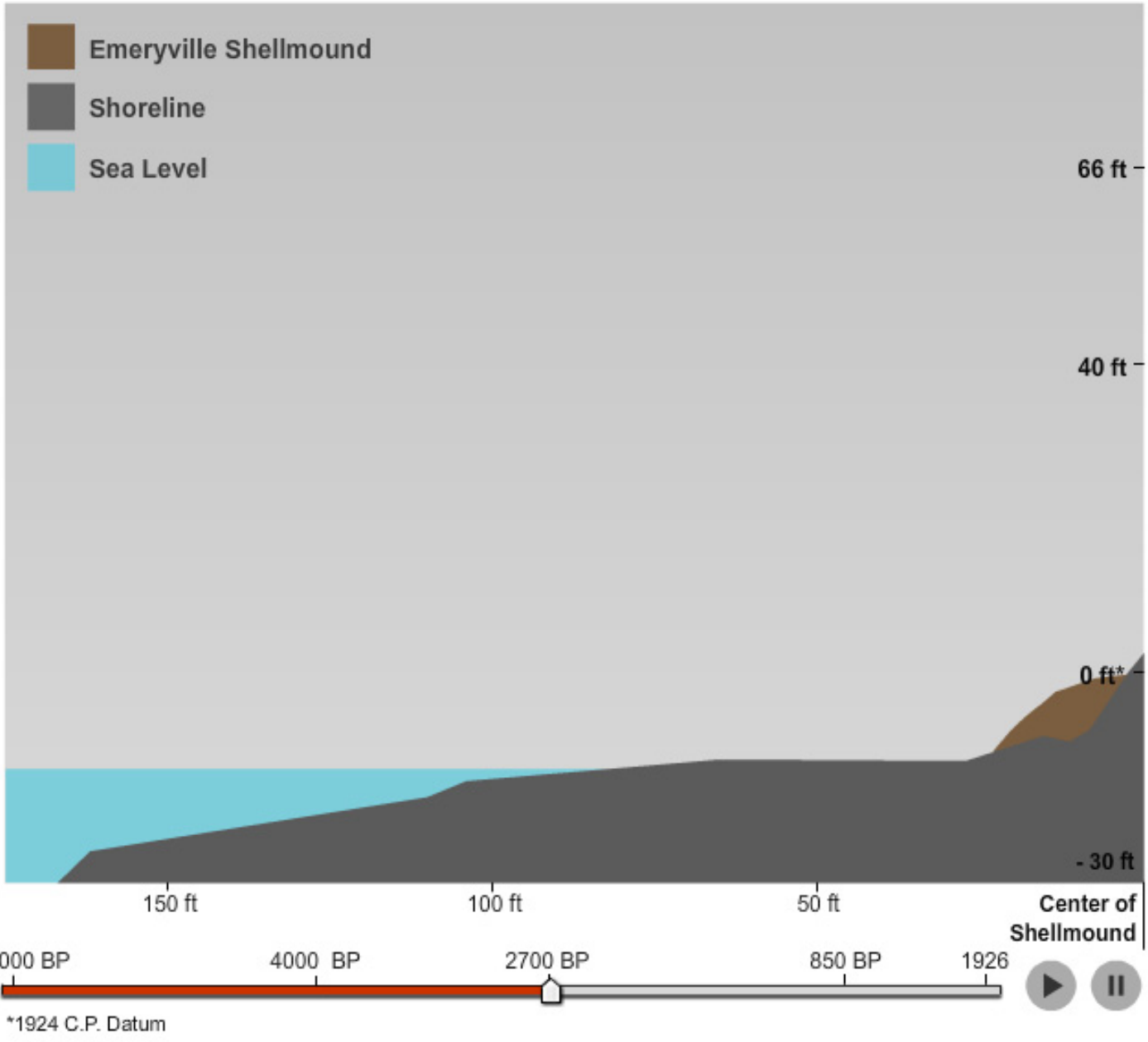

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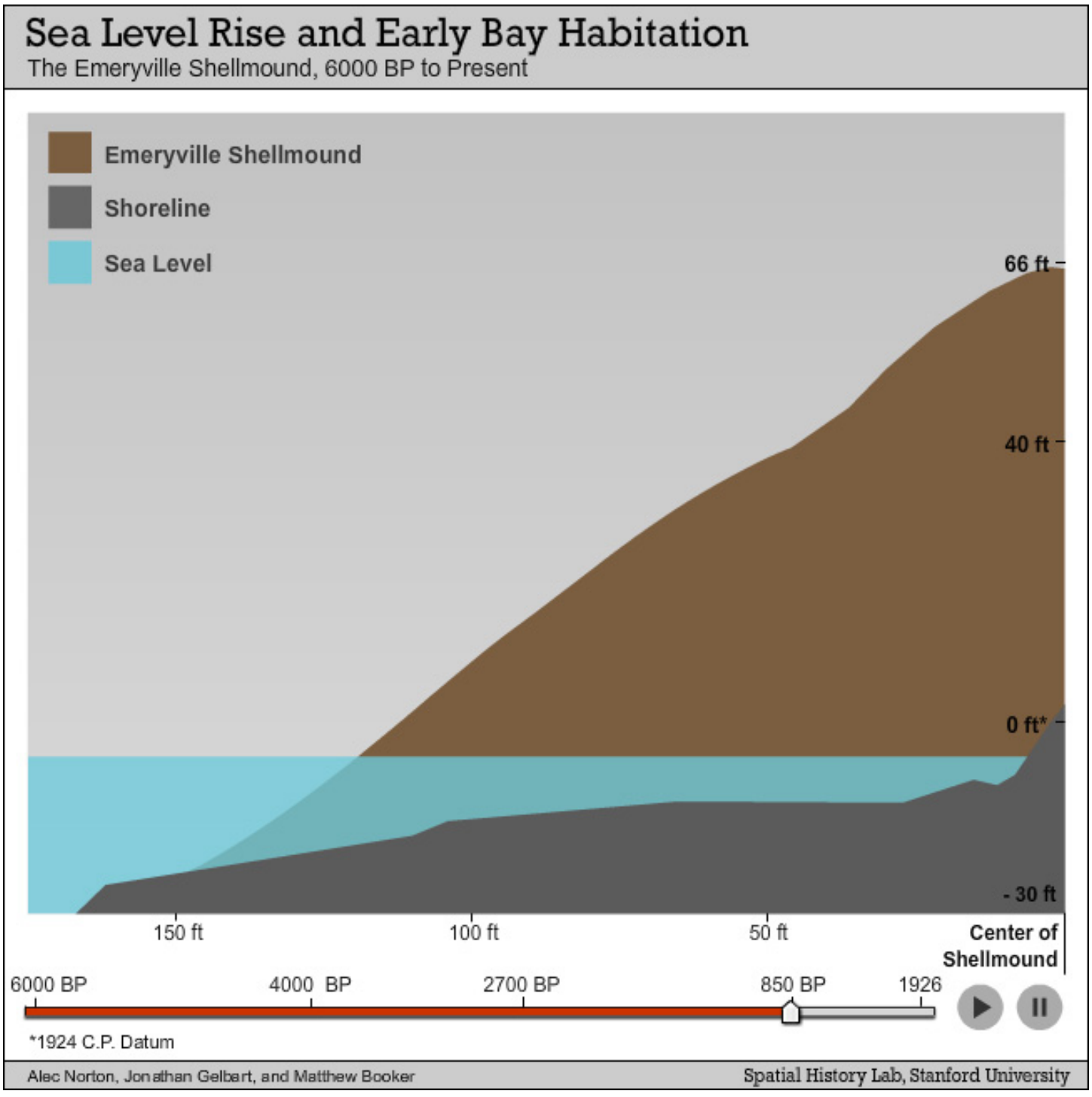

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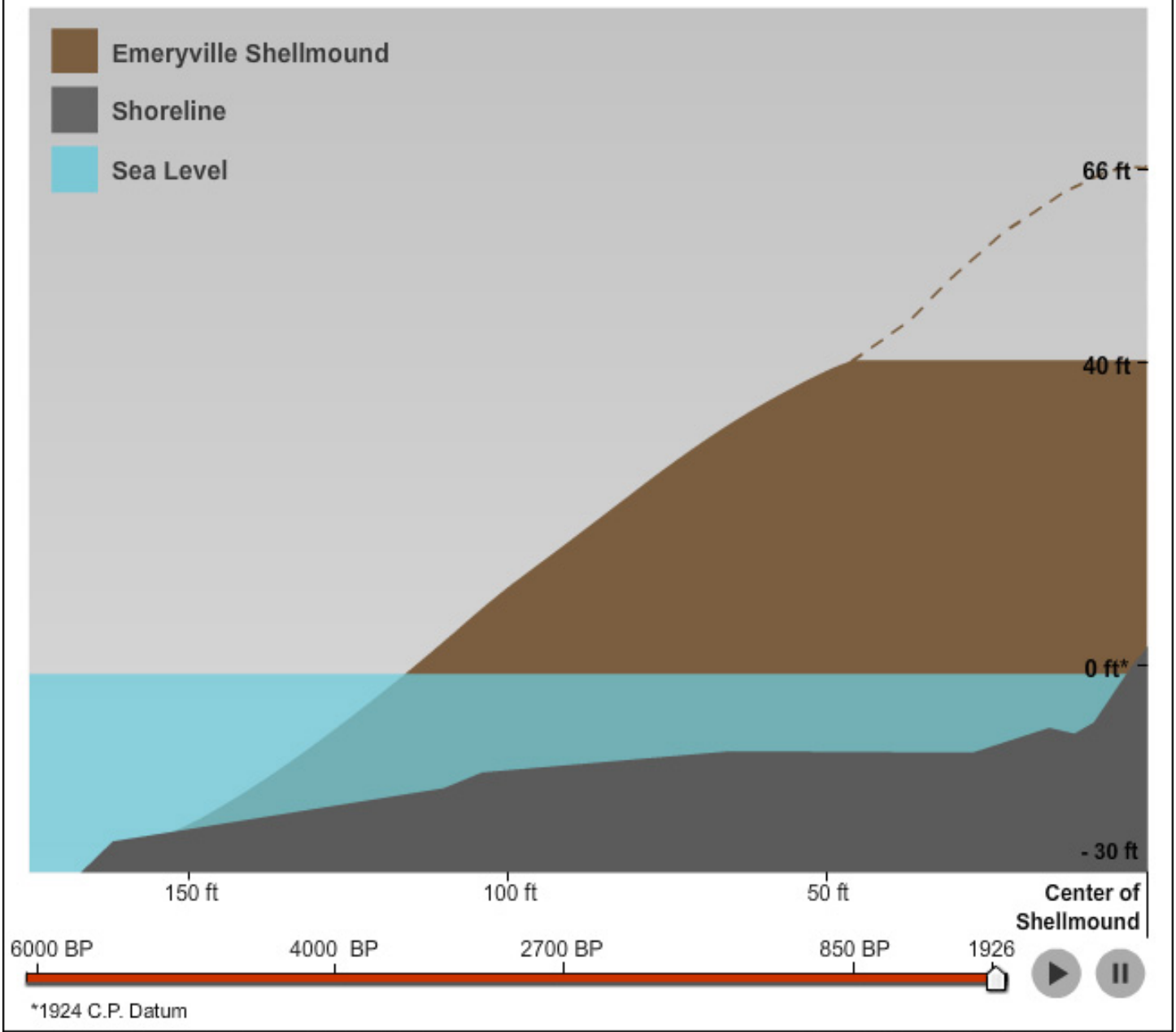

*1924 C.P. Datum

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