Ancient flooding formed, left behind boulders in Wildcat Ridge

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The University of Nebraska–Lincoln's Jesse Korus, Matt Joeckel and Shane Tucker have worked to document and describe, via drone footage and computer modeling, the Haystack Mountain conglomerate in the Wildcat Ridge in Western Nebraska. Credit: Jesse Korus | Conservation and Survey Division

One year ago, a historic flood struck Nebraska, topping levees; taking out bridges, dams and houses; covering thousands of acres in water; and reminding Nebraskans of the power of a raging river.

But destructive floods in Nebraska's ancient past have also shaped the state's geology, forming bouldery rocks in the rim of the Wildcat Ridge of western Nebraska, finds a recent study by University of Nebraska–Lincoln researchers.

The boulders—some the size of a smart car and formed about 23 million years ago—were first documented in 1903 by geologist Nelson Horatio Darton. But they were difficult to study due to their location about 300 feet up extreme terrain, said Jesse Korus, geologist with the Conservation and Survey Division at Nebraska. That changed when Korus got his drone license in 2017, making it possible for the survey division to conduct an in-depth, detailed study of the rocks for the first time.

Over the course of a year, the team of researchers took more than 3,000 drone photographs of the geologic formation known as the Haystack Mountain conglomerate. From the photographs, they constructed 3-D representations of the cliffs, or digital outcrop models.

"We also used ground-penetrating radar, which allowed us to see under the ground behind the cliffs, further enhancing our 3-D reconstruction of the rock structures," Korus said.

Armed with this data, the researchers were able to build models they could use to analyze and interpret what happened to the land millions of years ago to leave the boulders behind.

The Haystack Mountain conglomerate is a bed of sloping layers made of sandstone formed under water at least 80 feet deep. But before that, it was an ancient landscape in a narrow river valley, a riverbed of loose sand and hard sandstone concretions that the river cut into over time. As the river eroded the bed and valley walls, the loose sand washed away, leaving the hard cobbles and boulders.

And then, the researchers think, powerful, deep floods moved through, pushing the boulder material downstream in giant bars.

"These bars may have resembled the fields of ice boulders we saw last spring after the floods of 2019, except the boulder deposits didn't melt like the ice did," Korus said. "Instead, they became consolidated into conglomerate rocks and were eventually uplifted, forming cliffs that are now part of the modern landscape of the Wildcat Hills."

Though the researchers don't know what factors ultimately drove the evolution of the Haystack Mountain conglomerates, they may have included tectonic uplift, climate change, ecosystem change from forest to grassland biome, or even the erosion of stream headwaters into a neighboring watershed, resulting in an instantaneous river-system change.

Future studies using drone work and 3-D models of similar river deposits nearby, or at different locations and geologic ages across the Great Plains, could answer those questions and will be pursued.

"We want to understand the long-term evolution of river systems on the Great Plains as context for understanding modern large floods, river deposits and potential impacts of climate change on river hydrology and sedimentology," Korus said.

Other researchers on the project included Matt Joeckel, director of the Conservation and Survey Division in the School of Natural Resources, and Shane Tucker, highway salvage paleontologist with the University of Nebraska State Museum.

"It is difficult to relate just how noteworthy the Haystack Mountain conglomerate is," Joeckel said. "Its characteristics truly stand out relative to the sedimentary strata above, below and around it in the southern

Panhandle and adjacent parts of Colorado and Wyoming. It has intrigued a succession of capable geologists for some 120 years.

"Our paper, though, is the first published comprehensive study of the deposit, and it would never have happened without Jesse's mastery of modern techniques."

More information: Jesse T. Korus et al. Genesis of giant, bouldery bars in a Miocene gravel-bed river: Insights from outcrop sedimentology, UAS-SfM photogrammetry, and GPR, *Journal of Sedimentary Research* (2020). DOI: 10.2110/jsr.2020.3

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