Podcast Interview: 2016 Cozzarelli Prize Winner Russell Graham

PNAS: Welcome to Science Sessions. I’m Leigh Cooper. St. Paul Island sits off the western coast of Alaska. But, St. Paul wasn’t always an island. In fact, it was part of the Bering Land Bridge between Alaska and Russia until it was isolated by rising oceans approximately 14,000 years ago. This separation from the mainland is thought to have trapped resident woolly mammoths on the island. Russell Graham, a professor of Geosciences and Director of the Earth and Mineral Sciences Museum at Pennsylvania State University, wanted to pinpoint when the St. Paul mammoths went extinct, especially since they are thought to have outlived mainland mammoths by approximately 4,000 years. I talked with Graham about his recent PNAS paper concerning the St. Paul mammoths, for which the group was awarded the 2016 Cozzarelli Prize in Applied Biological, Agricultural, and Environmental Sciences.

Graham: I visited a cave there with some anthropologists from the University of Alaska at Anchorage, and we conducted some excavations and we found teeth in the cave. And we had radiocarbon dated those specimens, and they were about 6,000 years old so we knew that the mammoths had survived that long. The question was, could they have survived longer? And it turns out there’s a lake about a quarter mile from the cave.

PNAS: Lake Hill is one of two remaining lakes on St. Paul, and a researcher named Paul Colinvaux had taken a sediment core from the lake in the 1960s. The sediments contained pollen that documented the ecological history of the island from at least 4,000 years before the mammoths went extinct through modern times. This meant that the sediments might contain information about the timing of the mammoth extinction.

Graham: We re-cored the lake. Methods have changed since the times of Colinvaux. And also we were looking for things that he hadn’t considered. One was the spores of fungi that grow on the dung of large mammals, and there were three different genera that we used. A fungal known as Sporormiella has been used in the continental United States to determine when large megafauna was present and when they went extinct. It had been controversial and so we used two other taxa. And then we also developed techniques for extracting ancient DNA from the lake sediments for mammoths. And so we could use these sources to determine when the mammoths went extinct. Fortunately, they all came up at the same time, which is always surprising in science.

PNAS: Five independent indicators of extinction, including the spores and the mammoth DNA, indicated that the St. Paul mammoths went extinct 5,600 years ago plus or minus 100 years. All that was left was to determine why the mammoths died out. And here the researchers hit a wall. They had thought that the island’s constricting size, caused by rising sea levels, may have driven the mammoths to extinction. They also
hypothesized that a shift in plant communities may have eliminated the mammoths’ food source. But neither of these theories fit the data.

Graham: So we were sort of like throwing up our hands going, what could it be? And one of our colleagues, Matt Wooller, who is at the University of Alaska at Fairbanks, had involved two other postdocs on the project, and they were looking at diatoms and cladocerans.

PNAS: Both diatoms, which are algae, and cladocerans, a type of invertebrate, have body parts that are preserved in lake sediments. At the time of the mammoths’ extinction, the species of diatoms and cladocerans found in the lake shifted from those found in fresh water to those found in slightly saltier waters and from species that usually live in open water to species that live near the shore or bottom of the lake.

Graham: This is an indication that the lake is getting shallower. And modern elephants, they require about 70 to 200 liters of water every day for cooling their bodies. And this was even more of a complication for the woolly mammoths, because they were adapted to surviving in cold climates so they had special fur, which would have retarded cooling. And so they were drinking probably even more water. And the water levels probably just became so low that there wasn’t enough fresh water for the animals.

PNAS: Graham pointed to two reasons for the disappearing freshwater. First, the climate became warmer and drier, leading to more evaporation. And, second, as sea levels rose, seawater seeped farther inland. The salt water took up storage space under the island, which was previously filled by fresh groundwater. This infiltration of salt water reduced the freshwater storage capacity of the island, decreasing freshwater availability.

Graham: And then the mammoths themselves may have contributed to their own demise. What happens with African elephants is, when you have a drought, the elephants will congregate around a water source. They actually destroy the vegetation around the lake and so what happens is erosion increases. And we see that in our record. Their activity was causing more erosion and infilling of sediments into the lake, which again is shallowing the waters.

PNAS: On islands like Hawaii and New Zealand, the arrival of humans has been tied to extinctions, but this was not the case on St. Paul.

Graham: The island was discovered in the 1780s by Russian whalers. The Russians wanted to exploit the seals and what they did was then go down and capture Aleut natives in the Aleutian Islands and brought them up there to help with the sealing. And then they were left there, and formed the community that is still there today. To the best
of our knowledge anyway, people were not involved in this extinction, so it made it a relatively simple—we could focus on the environmental factors.

PNAS: I asked Graham how it felt learning that their paper received the Cozzarelli Prize.

Graham: Very exciting. I think for all of us but particularly me. I was very excited to be honored this way.

PNAS: Graham attributed the success of their study to having a large team of interdisciplinary scientists, each bringing their own expertise to the project, without which, he says, they would not have been able to piece together the story of the St. Paul mammoths. Thank you for listening. You can find more Science Sessions podcasts at PNAS.org.

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