Cozzarelli Prize Podcast Interview: Seth Burgess

PNAS: Welcome to Science Sessions. I’m Paul Gabrielsen. At the end of the Permian period, around 252 million years ago, approximately 70% of life on land and 90% of species in the oceans went extinct. Determining the cause of this extinction, which was the most severe in Earth’s history, requires a high-quality timeline of precisely when the extinction began and how quickly it progressed. In a recent PNAS paper, geochronologist Seth Burgess and colleagues put together just such a timeline, finding that the extinction may have occurred relatively quickly, over at most 60,000 years. According to Burgess, of the United States Geological Survey in Menlo Park, California, a high-precision timeline aids in evaluating the plausibility of various extinction triggers, and offers clues to the capacity of life to withstand dramatic environmental change. Burgess’ work was awarded the 2014 Cozzarelli Prize for Physical and Mathematical Sciences. I spoke with him at USGS headquarters in Reston, Virginia.

PNAS: Many people might be familiar with the mass extinction at the end of the Cretaceous period that killed off the dinosaurs. Fewer might be familiar with the extinction at the end of the Permian. Please tell me a little more about this event.

Burgess: The end-Permian was 252 million years ago. It was more severe than was that extinction that killed the dinosaurs, and had great effect as far as biodiversity loss in both the marine and terrestrial realms. So, not just things on land died, but both things on land and in the ocean died at the same time. And those things that build their shells out of calcium carbonate, like most of the shelly organisms in the ocean do today, those organisms suffered preferentially to everything else in the ocean. So if you made your shell out of silica, you survived at a much higher rate than if you made your shell out of calcium carbonate.

PNAS: So, you determined the approximate start and end dates of the extinction using uranium-lead zircon dating. And you also looked at the carbon isotope record before, during, and after the extinction. So, what did you learn from the carbon isotope record?

Burgess: By looking at the carbon isotope record, we’re able to view a snapshot of what was happening with the carbon cycle at the time of the extinction. And that’s important because the carbon cycle is a good proxy, in effect, for environmental health. At the end of the Permian, just prior to the mass extinction, as far as we can tell maybe 10,000 years prior, there’s evidence for a humongous input of what we call light carbon into the marine system. And people think that this light carbon comes from a volcanic eruption called the Siberian traps, which was emplaced and erupted at roughly the same time. And here’s how the cause and effect scenario that many propose, actually works.

We have an enormous volume of magma. That magma contains volatiles, just like when you open a Coke can and all that stuff comes fizzing out – that stuff is CO₂. Under
pressure, magma has CO₂ in it as well. And so as it’s erupted, those gases come out. But you also have lavas that are intruded into a large basin in Siberia, and that basin is full of rocks that contain hydrocarbons and lots of, let’s say, CO₂-fertile rocks. So if you cook those rocks by putting hot magma in contact with them, you can liberate a significant amount of volatiles. The carbon isotopic composition of those volatiles is more negative than carbon that comes from the mantle. So if you pool all of these relatively isotopically negative carbon pools together and put that material into the atmosphere very rapidly, the atmosphere equilibrates with the ocean and you end up seeing, in the fossil record, evidence for this rapid addition of carbon into the ocean system, and that’s exactly what’s seen at the end of the Permian and one of the reasons why people suggest that massive volcanism is responsible for the biotic crisis at the end of the Permian.

**PNAS:** So now, with the refined timeline that you’ve developed, what can we do now with that information?

**Burgess:** We’re able to assess the plausibility of different trigger mechanisms in one case. So if something takes 500,000 years to really do damage, but the extinction happened in 5,000 years, then those two things don’t seem entirely compatible. The large disparity in tempo is problematic. The other thing that having a precise chronology for extinction allows us to do is understand the resilience of the biosphere to these catastrophic events and the timescale over which the biosphere responds following such an event. And that allows us to better understand our current situation and informs our hypotheses about the cause and effect scenario, let’s say, of CO₂ increase in the atmosphere by some concentration over some amount of time. If we can better understand it in the past, when there was a catastrophic result from such a thing – we’ll be better able to understand what’s potentially facing us in the future.

**PNAS:** How do you feel about being awarded the Cozzarelli Prize?

**Burgess:** I feel honored and surprised and grateful. It’s a really neat, neat thing, and I’m extremely lucky to have gotten to work on the project that led to this paper.

**PNAS:** Thank you for listening. The Cozzarelli Prize is awarded annually by PNAS to acknowledge recently published papers that reflect scientific excellence and originality. Look for Science Sessions podcast interviews with all of the 2014 Cozzarelli Prize winners at PNAS.org/multimedia.