MELISSA: You know, one of my favorite words is spelunking. It's a great word, and it just means exploring caves. And it turns out that Minnesota is a great place to go spelunking. You've got the Wabasha Street Caves in Saint Paul, Niagara Cave in Harmony, Stillwater Caves, and the Mystery Cave in Forestville State Park.

Jim Cotter is a professor of geology at the University of Minnesota Morris, and he's no stranger to these underground wonders. Every month on Minnesota Now, Professor Cotter tells the story of our state through geology, and today, he's got the dirt on caves. Hi, Professor Cotter. Welcome back to Minnesota Now.

PROFESSOR COTTER: Oh, thanks, Melissa. It's nice to be here.

MELISSA: Nice to be-- nice to have you. Nice to be here too.

PROFESSOR COTTER: Yeah.

MELISSA: So I just listed a number of caves in Minnesota. How do we compare to other states in terms of the number of caves we've got here?

PROFESSOR COTTER: It turns out almost every state in the country has caves, but Minnesota is a little bit unique in that most caves are in places, where they have relatively high elevation. It's one of the frequent requirements of cave formation, but Minnesota was able to work around that geologically.

MELISSA: Interesting. Why are there so many here if we don't actually have the geology to support it necessarily?

PROFESSOR COTTER: Well, we have a couple of the preliminary steps to cave formation that work out, and then the big thing is we're intimately tied to the history of the Mississippi River. So instead of lifting up the land, the Mississippi cuts down the land, and that creates the proper situation for a cave.

MELISSA: Oh, that's interesting.

PROFESSOR COTTER: Yeah.

MELISSA: So I've heard in my research for this conversation, the word karst landscape. I have no idea what that is. Do you to explain?

PROFESSOR COTTER: It's the right word to describe. Karst is a landscape that develops in rocks that are able to dissolve. In the state of Minnesota, those rocks are carbonates, limestones, and dolomites. But other places have rocks that dissolve. Gypsum is a great example of a rock that dissolves in water.

So the Minnesota rocks are limestones, and what happens is, as water works its way through a limestone, there's a carbonate ion in carbonates. Hence the name, and the carbonate ion is carbon dioxide and oxygen, and that dissociates. So what happens is the rock goes into solution, so literally, rocks are dissolving through geologic time. Maybe you've seen either statues or carvings on stone that are no longer legible because of the same exact process. If they're made of limestone or marble, they'll dissolve over time.

MELISSA: So that's how the caves are coming into existence in Minnesota.

PROFESSOR COTTER: That's exactly right.

MELISSA: Interesting. Are there different types of caves here?

PROFESSOR COTTER: There are. So cave is defined as a naturally occurring hollow space in the ground, so that includes things, like lava tubes in Hawaii and ocean waves on, say, the California coast. But Minnesota has two very distinctive types of solution caves. One is associated with sinkholes, which are a typical karst feature, and they kind of form off the drainages of sinkholes. And those are called branch caves. The other type of cave in Minnesota is forms along fractures or cracks in rocks, and as the groundwater moves through those, it enlarges them at an incredibly slow rate. But nonetheless, I think it takes about an inch to widen a fracture in 2,000 years.

MELISSA: What? Wow.

PROFESSOR COTTER: Yeah, it's a slow process.

MELISSA: Gosh, yeah, so when you take, like, Mystery Cave in Forestville State Park, how long did it take for that cave to form?

PROFESSOR COTTER: Yeah, that's a great question, and there are several phases. One is you've got to deposit the rock. So those limestones down in South Eastern Minnesota were deposited 450 million years ago, so a long, long time ago, and they take a long time to form. And then the second phase is to uplift them out of the ocean, so that the cave process can begin to form. And exactly when that happens is hard to tell in Minnesota, but most people think that the Eastern part of Minnesota was high and dry by about 100 million years ago.

There's one interesting part, and that's the development of the fractures. When did the rocks in Minnesota break? And if you've ever driven along a road through a rock cut in either the Twin Cities or further South, you can see that there's all kinds of natural partings in those rocks. Exactly when that happened is hard to tell. It could have been when the rocks were first uplifted, or it could be 45 million years ago, an event that occurred later on in history. But once the fractures form and the landscape is above the sea level, then groundwater starts filling all those cracks, and dissolving it, and wearing it away through time.

MELISSA: Wow, and these living questions, the things we don't know the answers to, are geologists still trying to figure that out, or is it kind of an accepted mystery?

PROFESSOR COTTER: No, it's a constant process. One of the things that you run into with scientists who study caves is that not only do they study the science part of it, but they love exploring them too. They're just fully invested in cave studies. So it's a kind of natural extension of what they enjoy to study them. So as long as they're still enjoying caves, they're studying them, so the process goes on and on.

One of the things that people are really interested in is cave formations, stalagmites, and stalactites, and the glow stones, and things that are in caves. A lot of scientists think, in Minnesota, those formations are the-- rapidity of those processes. So you have groundwater moving through the rock, and then it hits a cave opening, and then, literally, drop by drop, you deposit a piece of travertine, which is another carbonate-- most scientists believe that they're influenced by climate. So when there's a glaciation in Minnesota, there's very little vegetation on the landscape, so you don't have many organic acids dissolving the limestone in the rock above. So cave stone formation slows down. But then when it warms up, vegetation comes in, lots of organic acids dissolving limestone, and stalactites and stalagmites kick into overdrive. So it's a really, really interesting thing to study cave formation and the implications for the world as a whole.

MELISSA: Indeed, so I have about 30 seconds left. Maybe we've turned some people on to exploring caves around Minnesota. Do you have just a piece of advice for how to do that safely?

PROFESSOR COTTER: I do. Never go into a cave without a guide, all right? They're just too dangerous. There's too many things that go wrong, but luckily, as you pointed out, we have great caves. They're called show caves or commercial caves in Minnesota and nearby Wisconsin, and as you mentioned, Mystery Cave, that's the longest cave in Minnesota. It's really two caves, and the people that tours in caves, they are really interesting to talk to about cave formation, about their perception of caves.

They're really fun. The other one you mentioned, Niagara Cave, there's a huge waterfall in it. It's so cool. Yeah, so go to a commercial cave, first, and then, as you mentioned, spelunking is an option. There are spelunking clubs in Minnesota.

MELISSA: Fun. Jim, thanks so much. I really appreciate your time.

PROFESSOR COTTER: You're welcome, Melissa. It's nice to be here.

MELISSA: Nice to have you. Jim Cotter is professor of geology at the University of Minnesota Morris. We call him Minnesota Now's rock star.