CATHY WURZER: Glad you're listening to *Minnesota Now* here on MPR News. I'm Cathy Wurzer. When you think of World War II, I'm betting geology does not leap to mind.

But consider this. During World War II, northern Minnesota produced, by some estimates, 75% of the iron ore used in the war effort. That ore was made into steel that went to the factories that produced planes, tanks, ships, ammunitions. Where did that iron ore come from? And why did Minnesota have so much of it?

Jim Cotter is a professor of geology at the University of Minnesota Morris. And every month on *Minnesota Now,* the professor tells the story of our state through geology. Welcome back.

JIM COTTER: Thanks, Cathy. It's nice to be back.

CATHY WURZER: Now, a lot of us know, of course, we've got the ore deposits on the range, the Iron Range. And they're called banded iron formations. What are those?

JIM COTTER: That's exactly right. It's called banded iron formation. It's actually a really good name for the rock. It consists of sediments that collected and formed in layers, bands of gray or silver iron-rich minerals, which alternate with bands of red-colored silica-rich minerals. It's actually a really interesting rock to look at and to study geologically.

CATHY WURZER: Is this where Minnesota's iron ore comes from?

JIM COTTER: It does. There's a little iron produced in Minnesota in southeastern Minnesota for a while. But, overwhelmingly, the rock that produces Minnesota's iron is banded iron formation. And it is a global impact, as you mentioned about the war effort.

Today, Minnesota is still the top iron-producing state in the country. And it produces 85% of the US domestic iron. It's really an amazing resource.

CATHY WURZER: Now just to be clear here, when we talk about taconite, that's something a little different. Is that right?

JIM COTTER: Yeah, what happens is through time, the mining process got the good stuff first and then left the lesser quality ores. Taconite is a hard iron ore that has to be processed into taconite pellets. And those taconite pellets are the things people think of when they think of iron ore.

CATHY WURZER: Right. Exactly. So getting back to the banded iron formations then, what makes that an interesting rock to study?

JIM COTTER: Like all interesting things in geology, it's hard to figure out. This is another one of these great ancient rocks we have in Minnesota that formed under just completely different conditions than now.

CATHY WURZER: Right. So I'm thinking probably that these banded iron formations, in my head, I feel that it sounds like it's various layers. So that must have been over some period of time that they formed.

JIM COTTER: Yeah. In fact, there are three different episodes of banded iron formation. The first one is really, really old and very, very hard to parse out in terms of how it formed because, of course, it occurred at a time that there was very, very little oxygen on the planet. And it may have been a time when ocean crust was different than today's ocean crust. There also seems to be a lot of volcanism associated with this older accumulation of banded iron.

Then late in the program, as far as ancient rocks are concerned, 600 million years ago, there's an episode that's really, really unique of iron deposition that seems to be caused by a global glaciation. In other words, ice-covered oceans somehow triggered the deposition of it. But, overwhelmingly, the world's banded iron formation began to form about 2.2 billion years ago.

And there are banded iron formations in Australia and South America and Africa. And that middle phase is really the source of most of the world's iron.

CATHY WURZER: So we talked about heat and fluids. What role does oxygen play in the history of this banded iron formation?

JIM COTTER: That's right. We're thinking about a time on Earth when there's no oxygen. And because there's no oxygen, a lot of the minerals that are commonly found today just couldn't crystallize out. There is no oxygen to bond with in the ocean.

And so the production of this big phase of banded iron formation about 2.2 billion years ago seems to coincide with an increase in both ocean and atmospheric oxygen. Oxygen comes about as a waste product that's produced by cyanobacteria. In other words, they take in carbon and then produce oxygen through the breathing process that they use.

And when that oxygen is produced, it goes into the ocean that's absolutely starved for oxygen. And so things like iron and silica are super-saturated. And the oxygen bonds with, at the different times, iron and, other times, silica. And you start to get these layers upon layers of both-- the iron minerals are hematite and magnetite. The silicates are this beautiful red chert or jasper.

CATHY WURZER: So let me ask you this question. Because we're talking about layers, do we know how those layers-- I'm presuming these are bands of alternating layers, right? Do we know how that happens?

JIM COTTER: That's actually the million dollar question when it comes to the science part. We actually don't make a million dollars. [LAUGHS] A fundamental rule in geology is if a sediment changes, if you see a line or a band and it changes to something else, the conditions under which that sediment formed have changed. And so you're looking at changing environments.

And so when you're thinking about repeated changes, iron then silica, iron then silica, you start thinking about cycles that the planet goes through. So it could be tides. It could be winter layers and summer layers, something associated with seasonal or daily or monthly changes. Other scientists think it could be repeated volcanic events. All kinds of models exist.

And, again, it forms so long ago. And under such different conditions, it's really a challenge to study. That period of time, by the way, is called, by different people, either the Great Oxidation Event or the Oxygen Catastrophe because if you're in favor of oxygen, you call it the Great Oxidation Event, because the atmosphere is filling up with oxygen.

But those cyanobacteria that produce it as a waste product eventually caused their own extinction by producing that waste. And so depending on your point of view, it's either the Oxygen Catastrophe or the Great Oxidation Event. It's a really interesting time in Earth's history.

CATHY WURZER: Oh my gosh, I was just going to say what an interesting time and what an interesting conversation. You're just the best. Thank you for doing this with us.

JIM COTTER: You're welcome, Cathy.

CATHY WURZER: Jim Cotter is a professor of geology at the University of Minnesota Morris.