Science Forward—Geology

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Summer Ash: Have you ever looked at a city skyline and wondered why it looks the way it does? Why buildings of a certain size, or shape, or height are built where they are? New York City's famous skyline may have been predetermined well before humans ever arrived on the scene.

Karin Block: With respect to studying geology in the city, it is important to understand what is the foundation of New York. Even though much of the bedrock is covered in New York City, you can still see portions of it in Central Park, and Inwood Park, and that it is extremely relevant to the infrastructure of New York.

You will notice that where the clusters of skyscrapers are located in New York is directly related to where the bedrock is closest to the surface. Those rocks happen to be extremely hard and ancient rocks that can actually support very, very tall buildings.

Summer Ash: Then there's a lack of it below Midtown, and in the Financial District? Is there more bedrock than down there?

Karin Block: Between Midtown and the Financial District, the same rocks exist, but they exist a little bit deeper. They are not as close to the surface, so there's a bit more of a sediment cover, which makes a little bit more challenging to build tall buildings in those areas.

Summer Ash: Geologists study the past in order to better understand the present and the future of our planet. In this video, we'll talk to geologists who work in the field and in the lab to answer big questions like, "How did this rock get here? What can it tell us about the history of where it's found? And how can we uncover the geologic history of our planet from right here in New York City?"

But first, let's go over some basics. Rocks can be divided into three different categories, based on how they formed; igneous, sedimentary and metamorphic. We can find all three types of rocks right here in New York City.

Alan Benimoff: Well, you've got almost every rock type. You have igneous rocks, which come from the melt. You have sedimentary rocks, which are products of the erosion of other rocks, and you have metamorphic rocks, which would change from some other rocks.

You also have effects of the ice when it was here. Remember, ice was here about 22,000 years ago, and when it went through the area, rocks in the ice scratched the bedrock and so forth, and so we have evidence of that. So, we have a great deal here.

For Staten Island, we have almost every rock type here. It's a small island, 13 miles by 7 miles, and we have igneous rocks, we have metamorphic rocks, and we have sediments, we have beach deposits…

Summer Ash: We have all these great rocks to study, but how can they tell us about what the city was like millions of years ago? Geologists have formulated a series of guiding laws based on what we can observe today. When we talk about scientific laws, we are talking about statements that describe phenomena based on repeated observations or experimental results. They are reliable descriptions of the world, given specific conditions.

Karin Block: Geology has, in fact, a set of guiding laws. The first and foremost is the concept of uniformitarianism, which is the idea that the physics and chemistry that operate right now have always operated, that that has never changed. It was first vocalized about 1,000 years ago by a Persian philosopher and natural scientist named Ibn Sina, popularized by James Hutton.

What he said was, as he observed the processes that were involved in forming geology, or making geologic formations, that there was no vestige of a beginning, and no prospect of an end. That's where the concept of Deep Time was really formulated.

The other pivotal figure in geology is Nicholas Steno. Steno's laws are still used to interpret the structures that we see in the field, and they involve the law of horizontality; if sediment or particles are deposited in a lake or in the ocean, they will lie flat, and that's the original way in which they were deposited.

The idea of superposition, meaning that if you have a series of rocks or layers of sediment that are being deposited, the layer that is at the bottom is the oldest. The law of lateral continuity, which is the idea that rocks will remain of a particular time until there is a change in environment that will then curtail the formation of that particular rock.

And the law of cross-cutting relationships, which indicates that if you have a series of rocks that are cut across or faulted, the fault or the rock body that is cutting across has to be younger than the rocks that already existed.

Summer Ash:We can use these laws to make sense of the patterns we see in rocks around New York City. In geology, the present is the key to the past. What can we observe now? What does that tell us about how the city's bedrock was formed, and how it changed over time?

Today we're standing in Central Park, in New York City, and we're surrounded by these really cool rocks. What's so special about them?

(Merry) Yue Cai: Well, the first thing is they are called Manhattan Schist. They used to be sediments on the seafloor between America and Europe at the time. When plate tectonics carried an island called Avalon that collided into Manhattan, the sediment got squeezed and uplifted.

They were part of a mountain the size of the Himalayas that was called the Taconic Mountain. This mountain forming event, or like geologists like to call it, “orogeny,” this is what we see today.

The entire mountain has been eroded down to what's behind us, but we can still see the folding, the violent colliding action that happened back 400, 500 million years ago. But we're here today, specifically because this piece of rock called the Umpire Rock preserves one of the best features, one of the best examples of the glaciation that happened recently, about 10 to 20 thousand years ago.

Summer Ash: That's recent for geologists.

(Merry) Yue Cai: Recent for geologists, exactly. The glacier shaped the rock, made the rock really smooth, created these beautiful undulations, the wavy features on top of the rock.

Summer Ash: How does ice actually do that?

Karin Block: Well for one, the ice was really thick. If you look around, the ice was probably as tall as that building there. Imagine that much ice, and it basically spreads because it's so heavy. As it spreading, it's freezing up any little piece of rock underneath, and carrying these little loose rocks with it. These rocks are very effective in sending down the basement underneath.

When you carry a rock on top of that rock, you make these glacier grooves and glacier striations. You see, they all go in one direction, and they don't care about the bending of the rock underneath.

In geology, we often look at this cross-cutting relationship. If Line B cross-cuts Line A, the event that generated Line B must have happened later. In this case, the glacier striae cuts everything, so this must have been the most recent geologic event.

Summer Ash: All of this great geologic history is exposed all over the city. How do scientists examine it in detail?

Woman 4: The way I study those rocks entails mostly going out into the field and sampling rocks at a regular interval, or at least as regular as the outcrop will allow.

I bring them back to the lab, where the rocks are then sub-sampled in many different ways, by crushing the rocks, separating the rocks into the mineral components, slicing the rocks into thin sections that are 30 micrometers thin, so that then we can study the optical properties under a microscope or do electron microscopy.

I love to break rocks. When you look at a rock intersection under plain polarized light, or cross polarized light, the information that you get is an easier way of identifying the minerals involving the range of colors that you see. Sometimes, when you spin the stage, you get a different set of colors that show up.

All of those features are inherent to the mineral crystals, so it's a little bit of a process of elimination, but the actual combinations of minerals that exist in that thin section give you the specific pressure and temperature conditions at which those minerals must be stable, in conjunction with the others.

Summer Ash: Even in this urban and human-altered landscape, geologists can use the tools they have to decipher our planet's past. In fact, sometimes those landscape-altering activities give us better access to the underlying rock formations. Think about this the next time you're on the subway, or driving by a road cut.

Karin Block: Many geoscientists practice geology along roadcuts, because that's where the rocks are very visible, and where you have artificial outcrops that give us a lot of information. We do a lot of roadside geology.

Summer Ash: Almost, the highways of America are laboratories of geologists.

Karin Block: Exactly. The highways of America are indeed a natural laboratory.

Summer Ash: What do you find most exciting about your research?

Karin Block: The thing that excites me the most about my field, and about science in general, is that to me, everything is interesting. Understanding how the world works involves a lot of the minutia, and the details, and the observations that science has equipped me to do.

The fact that I have the ability to have a better understanding of the world around us is an incredible privilege, and for me, there's just no shortage of the things that I want to study; just a shortage of time, really.

Summer Ash: For someone who works on billion year timescales, that's saying something.

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