People in Astronomy

BETHANY EHLMANN

Bethany Ehlmann is a Professor of Planetary Science at the California Institute of Technology and a Research Scientist at NASA's Jet Propulsion Laboratory. She got an International Baccalaureate degree during high school in Tallahassee, Florida. She received her A.B. summa cum laude from Washington University in St. Louis, two master's degrees at Oxford (in environmental change & management and physical geography), where she went as a Rhodes Scholar, and a master's and Ph.D. from Brown University in planetary geology. Following a year as a European Union Marie Curie Fellow at the Institut d'Astrophysique Spatiale in Orsay, near Paris, France, she has been at Caltech and JPL since 2011

She studies Mars, the asteroid Ceres, other planetary bodies, and rocks from Earth.

The interview was conducted and edited in May/June 2019.

Are you an astronomer?

I'm a geologist, a planetary geologist. I've always been interested in space. I've been interested since I was a little kid from both documentaries from PBS and awesome science-fiction series like Star Trek.

As a geologist, do you still concern yourself with rocks you can handle, or are these rocks just around other stars?

That's a reason I did planetary geology instead of astronomy: I liked the tangibility of geology as well as the sophistication of the historical record, because it is really geology. Geology lets us ask historical questions about the Solar System. Geology lets us see what happened.

Are you a backer of uniformitarianism? (Ed. note: uniformitarianism is the idea that the present processes resemble those of the past.)

The physics and chemistry of the universe were the same at the past as at present, but depending where you are in a planet's time, different processes dominated. I spend most of my time studying Mars, and Mars is the ultimate example of a lack of uniformitarianism.

How did you start on studying Mars?

As an undergraduate, at Wash U (St. Louis), the summer after my freshman year, I started working in a remote sensing laboratory—which I had known about before I came to Wash U. There was a set of clustered courses with both field work and classes in environmental students. The director was Prof. Ray Arvidson and he both the curriculum and the lab. I started working on data from the Mars Pathfinder mission.

Is there a fundamental difference between astronomy and geology?

Yes, there is a fundamental difference in approach. One way it manifests itself is that geology is more qualitative and astronomy and physics have more of a quantitative bent, which is not to say that geologists don't use quantitative tools. In geology, you certainly use quantitative measurements but oftentimes there is a deeply qualitative part of what you are doing. For example, you are looking at textures—which came first, this rock or that rock? How and why are they located next to each other?

The best planetary geologists are cross-trained enough in astronomy that they are able to perfectly well follow the methods of astronomers when needed. Both approaches are mutually beneficial.

Caltech has both planetary science and astrophysics departments, which are separate. I advise students who go through the geology track as well as the planetary sciences track of the Ph.D.

What path did you take path to teach at Caltech?

After my undergrad at Wash U, I actually did a master's degree in environmental policy before deciding to come back to the US in planetary geology at Brown. Then I had a postdoc in France at the Institut d'Astrophysique Spatiale in Orsay.

What was and is some of your work?

Much of my work is being involved with cutting-edge data analyses from Mars, understanding water on Mars and data coming back from the Mars Exploration

Rovers (MERs) and the Mars Reconnaissance Orbiter's CRISM (Compact Reconnaissance Imaging Spectrometer for Mars), a hyperspectral imager. It was an exciting data set, as I hoped it would be. For the first time we were studying the composition of the oldest rocks on Mars and discovering that they were different, just as we look through time when we look at the Grand Canyon. Just as we use infrared spectroscopy to study minerals and GIS (Geographic Information System) mapping on Earth, we use both tools on Mars for building environmental histories to trace out environmental change. I was fortunate to be part of the identification of minerals that had never been found on Mars that indicate hydrothermal environments or lakes that were respectively alkaline or acidic. Mars, during the first 1 to 1.5 billion years of the planet, was pretty wet and you would have recognized some earth-like environments. Mars then became arid and colder and water-related processes shut off 3.0-3.5 billion years ago. [Ed.: See pp. 169-180 in The Cosmos, 5th ed., for discussion of Mars's surface and the rovers roaming around on it.]

I still use some of the same data sets, working with my students. I get to work on the Curiosity rover operations and science, this time as a professor with students of my own. Being faculty has allowed me to have the students and the time to expand to other planetary bodies.

So, most recently, I have been working a lot on Ceres with the Dawn mission team, trying to explain the history of this dwarf planet in the asteroid belt. [Ed.: See pp. 252-253 of The Cosmos, 5th edition, for discussion and images of NASA's Dawn spacecraft and its observations of Ceres.] Ceres is so compositionally weird. It has these ammoniated clays that are not common to other asteroids in the asteroid belt or in the carbonaceous chondrite meteorites. Ceres also has some bright spots that are not ice—they are weird salts of sodium carbonate.

I am still working on papers from the last set of Dawn data with its final close-in orbits, the best imaging and compositional data. The other thing that I'm working in right now is serving as part of a team proposing a Discovery mission [Ed.: a NASA category of relatively inexpensive spacecraft] to send a lander to Ceres to get the composition of the dark material and the salts on Ceres, the true bulk chemistry of the major and minor trace elements, and measure isotopes. With C, N, O, and H, we should be able to figure out where Ceres came from in the solar system—was it indigenous to the asteroid belt or did it come from the trans-Neptunian region? Ceres is organic rich, so the third big piece we'd be able to get in situ is whether the organics were synthesized on Ceres and/or delivered to it. And to compare Ceres to the carbonaceous chondrites. Ceres is several factors more C-rich than carbonaceous chondrite meteorites. The question is whether its organic chemistry is different? Ceres is important for understanding the early mixing of materials as well as organic synthesis in the early Solar System.

I still love all the questions about Mars and I love to explore them. We answered the questions: did Mars have habitable environments?: yes. Mars had Earth-like environments 3.5 billion years ago. What controlled the evolution of the environments over time and were they inhabited? Those are the big questions now. Mars is special because it was the case of a terrestrial planet that was intermittently habitable and it has a rich geologic record to decipher to understand the changes. Even now Mars is right on the edge of habitability because of its big changes in its axial tilt from 10 to 60 degrees—the polar volatiles switch around. This extreme climate change is nothing the Earth experienced. Our carbon-dioxide changes pale next to the axial tilts of Mars. Mars is being tugged around by Jupiter's gravity and, unlike Earth, it doesn't have a moon to stabilize it.

WHAT ABOUT NASA'S MARS 2020 MISSION?

The Mars 2020 rover is going to an ancient lake, a lake probably from the later part of the habitable period, about 3 billion years ago. Jezero crater hosts a beautiful, ancient delta with clay and carbonate sediments in it. So Mars 2020 will collect samples and look for evidence of environmental change and biosignatures in those rocks. I am personally very hopeful—and I will work to try to make it happen—that Mars 2020 will be able to leave the lake-bottom sediments and also explore outside of the crater, where there are even more-ancient rocks that record groundwater and hydrothermal systems, which I think represent a really key environment to look for biosignatures on Mars and trace its habitats. The surface environment may not have been stable but the subsurface would have been stable. So I hope that Mars 2020 will be able to travel far enough to study lake sediments and even more ancient groundwater enrichments.

AT CALTECH, WHAT DO YOU TEACH?

I teach planetary surfaces and remote sensing. Both are beginning graduate and advanced undergraduate level courses.

I try to emphasize two things:

· Good understanding of the physical principles of the various problems, both conceptually and mathematically; really rigorously conceptually of the phenomena.

· Analyzing real data—my assignments in labs are real-world planetary or earth data problems that I have been presented with at some time in my career. I try to organize the exercises about these things that we have to calculate.