

Interviews of the Margaret MacVicar Memorial AMITA Oral History Project, MC 356
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Carle Pieters – classes of 1971, 1972 and 1977

Interviewed by Emma Bernstein, class of 2020
April 6, 2019

Margaret MacVicar Memorial AMITA Oral History Project

Carle Pieters (SB '71, SM '72 and PhD '77) was interviewed by Emma Bernstein (SB Computer Science and Molecular Biology 2020) in Providence, Rhode Island on April 6, 2019.

Dr. Pieters – whose affinities for mathematics and astronomy were apparent early on – is Professor Emerita of Earth, Environmental, and Planetary Sciences at Brown University, and has been a faculty member since 1980. She previously worked at the Johnson Space Center in Houston and as a Peace Corps volunteer in Sarawak, a Malaysian state on Borneo. Most generally, her research efforts include planetary exploration and evolution of planetary surfaces, with an emphasis on remote compositional analyses.

Dr. Pieters – who earned a BA in Math Education at Antioch College before earning her SB, SM and PhD degrees and MIT – was the founder and initial Science Manager of the NASA Reflectance Experiment Laboratory (RELAB), a NASA-supported multi-user spectroscopy facility at Brown. She has been Principal Investigator for NASA's Moon Mineralogy Mapper (M3) experiment launched to the Moon in 2008 onboard India's Chandrayaan-1 spacecraft, and is Co-Investigator on Dawn, a mission to explore the large asteroids Vesta and Ceres.

BERNSTEIN: Could you please tell me a little bit about your childhood – where you grew up and what your interests were?

PIETERS: OK. I'm an army brat. That's what shaped my childhood. What that meant was that we moved every couple of years and all over the country, all over the world. That was a big influence on me, in that I still love to travel and that it took me a while to feel settled in any one place.

I was born in Oklahoma and went from place to place to place. My dad was stationed in Iran when I was in grade school. Then we went to Texas and then to Nevada. In Nevada, I spent junior high school and started high school. That was really important in my life because where we lived was in Carson City, which is right at the edge of where sort of the rolling desert meets the mountains. It's high altitude, dry, but you've got mountains and skiing and pines right next door, a beautiful country. That environment just seeped into me. I loved it.

I guess it was my freshman year in high school when my dad got assigned to a major activity where it required both him and my mother to spend two years in various schools learning languages and political stuff – and they would be moving every six months.

My older brother and sister had just gone off to college, so they were OK. My younger sister went to live with my grandmother in California. I stayed with friends in Nevada, and they sort of took me in. I was able to stay with my friends in local high school and, during summers, would go to wherever my parents were at the time. We'd have family activities, so that turned out really well.

My last year in high school was spent in Heidelberg, Germany, which was the last place my dad was stationed. Then he retired and went into high school math teaching as a retired officer.

But from my high school in Germany, I was applying to colleges and didn't really have a clue. So it was, "Oh, Stanford. I've heard of Stanford." So I applied to Stanford and a couple other schools.

My sister was spending a junior year abroad and was at the University of Tubingen in Germany. And she says, "Well, Carle, there are some students here who are from a small school in Ohio called Antioch and it sounds like a really interesting program." So I looked into it.

They had a work/study program where you spend time on campus and then you go out on a job for a term. Then you come back to campus, and then you go out on another job. It takes five years instead of four years to get a typical undergraduate degree, but you have all this wonderful work experience. I said, "That sounds cool."

I applied there. I didn't get into Stanford, but I wasn't too surprised. I did go to Antioch, the small school in Ohio. And my dad thought, "Oh, this is great. She can earn her way through college." Little did anybody know it was one of the most liberal schools in the country at the time. Off I went, and really enjoyed it. I got this note from my parents saying, "Don't join this. Don't join that." I said, "Oh, OK." But it was a good time. It was a small liberal arts school, and because it was small, it encouraged a lot of initiative by individual students.

At that time, I knew I was good at math. I took a lot of math courses and figured I'd do something using math. I kept asking people, "What can I use math for?" And they said, "Well, you can be an accountant. You can be an actuary." None of those sounded very interesting to me.

I kept taking 'what's your aptitude' exams. It depended on whether I'd been listening to music before the exam or philosophy. So I ended up thinking, "Oh, I want to be a conductor." It didn't help at all!

I did have all these jobs, and that was good. That gave me perspective and different experience in different places. I thought some psychology combination, so I did a lot of educational kinds of things. But again, they didn't quite click.

I thought, "Well, I better have something before I leave school so I can get a job, so I took the requirements for getting a teaching certificate so I could teach high school math. And that worked out fine. So I graduated, had a teaching certificate, and got a job teaching math in Somerville [Massachusetts], a big school, a city school. Pretty tough kids there – at least at that time they were.

I love teaching but was a failure at being a disciplinarian. Here's this young lady who loves what she's doing but is not a disciplinarian. I would have some of the noisiest classrooms in the school. I liked the kids, but I realized I didn't have that talent. I had serious questions about whether I wanted to or whether I should be a high school math teacher, just because I didn't seem to have some of the qualifications.

About that time, the person I was married to at the time and I – he was just finishing his undergraduate class, and we decided to go into the Peace Corps. So we both applied and were accepted.

Of course, that was the middle of the Vietnam issue, so everything was tense. That was one of the reasons why we wanted to get out, because the draft was still going, and for males, that was a big, big challenge. So we ended up going to Malaysia. In particular, we ended up being assigned to Sarawak, which is on the island of Borneo, in a school, to teach. It was a junior high school level, and I loved that. The students were eager. They were very committed to learning.

It turned out that, instead of teaching math, the science teacher at the school we were at had left. They didn't have anybody to teach science, and of the handful of teachers they had, one person said, "Well, I can teach math. But [you] can teach science." So I ended up teaching science, and I loved that.

Here I was in a different situation teaching, but a much more positive experience, working with a diverse group of kids. Malaysia at that time – and still is – a very multicultural environment. Major cultures: Chinese, Indian and Malay. And on Borneo, we didn't have many Indians, but we had local hill people who did a lot of agriculture way upriver.

Each of them had their own completely different cultures and were all together in the school. And the school – in hindsight, a large fraction; I can't say whether it was a third or half – were students that came and boarded there because they lived upriver. People lived out far away from where cities or villages were.

These junior high students were away from home and were in essentially boarding schools and did fine. It wasn't traumatic for them. They did really well. In fact, I learned a lot from them.

Sorry, this is a little diversion, but I wanted to have a chicken, and the shopkeeper in town says, "Oh, I can get you a chicken. OK, yeah. I'll get you a chicken." And so this chicken showed up at my door. It was a full chicken, with

feathers and everything. And I said, "What am I going to do with this?" I had no idea of what to do. But my students knew. "Of course, well, I know how to kill a chicken. I know how to de-feather a chicken." So I said, "Oh, please take it. I'll give you part of the chicken." So that problem was solved, and I was very appreciative.

BERNSTEIN: What about when you came back to the United States?

PIETERS: Before we went into the Peace Corps, when I was teaching high school in Somerville, I realized I'm going to want to go back to school, because teaching high school math is probably not the best thing for my long-term career. I want to go back to school.

I've always loved or was interested in astronomy, and I thought, "Well, I'll look for schools around and see what kind of arrangement I can have so when I come back from the Peace Corps, I can start school." So I started going around to all of the universities in the area. I went to Harvard and Brandeis and MIT, and maybe Tufts. All of them were, well, "Fill out this form. Get these references, blah, blah, blah." And I said, "OK." And I walked into MIT.

I had a letter from the physics professor I had at Antioch, and had a great time with him. He gave me a tutorial and really turned me on to physics. He wrote me a nice letter, and I could take it around. So I walked into admissions at MIT and the admissions officer was a kindly sort of grandfather-like gentleman, a really nice person. I told him what I want to do. I was going to the Peace Corps, and I wanted to come back to school and study science, perhaps starting with astronomy. I said, "Here's the letter from my physics professor. What do I have to do to arrange this?" He said, "No problem. We can easily arrange a special student [status] for you. And when you come back, just come. We'll be happy, and we'll take it from there." And I said, "OK." So we set something up and kept in contact while I was in the Peace Corps of 'this is what my timeline is. I'll be coming back, blah, blah, blah.' So when my time in Peace Corps was over, I came back.

While I was in the Peace Corps is when they landed on the moon. We didn't have, of course, television or anything, but we had radio. The students thought that was so awesome because [Neil] Armstrong-- To them, English is a foreign language. "Armstrong." They know "Armstrong." You have to have strong arms to work in the fields. So "Armstrong" was just perfect for them. They were very excited, as was I.

Apollo had just started. I came back and I said, "OK. I want to do something, maybe, in astronomy, but I need a job. I need to earn some money as well." So they gave me a list of professors to go around to. I walked into Course 12, which is the science department. I can't remember if it was the first person or the second person, but I said, "Well, yeah. I'm interested in astronomy, and the moon is part of it." And he says, "Well, what can you do?" And I said, "Well, I can do math, but I don't have any other skills." And he says, "Well, I've got all

this data that they're sending us, these images, and I need somebody to get it organized. Why don't you come in, and we'll put you to work to doing that?" I said, "That sounds good." So I started working, and everything went from there.

With my math skills, I started helping out with some of the computing. I'd get the cards punched and organized and what have you and was pretty soon helping to process some of the data. It was a planetary astronomy group, so they at that time did a lot of astronomy for different planets, including the Moon.

I ended up processing a lot of the lunar data, and as I was putting away all these photographs from Apollo, they just were awesome – I'd never seen anything like this before. When you put thousands of photographs away and look at them, you get a feeling for what this foreign land is. And you see, "Well, this is a crater. This is a basalt area." You start recognizing features. And then you start recognizing, "Well, this is a weird feature, that I've never seen that in this." And I'd take it around to people who were much wiser than I was, I thought. "What is this? This is really an odd feature." And we'd bat it around.

I remember very distinctly going to one of the senior graduate students (who, of course, know everything) and showing him this picture that I couldn't understand. We went back and forth, and he says, "Well, Carle, I don't know. Your guess is as good as mine." And I thought, "Oh, really?" And that sort of sunk in. It's the whole progression, with my getting more involved with processing data, became more involved with the data, with obviously taking classes at the time, and pretty much got hooked completely.

I haven't turned back from that at all. That's how I got into planetary science.

BERNSTEIN: Do you remember the professor you worked with?

PIETERS: Oh, yes. He ended up being my advisor for all the way through: Tom McCord. [Professor Tom McCord developed MIT's Planetary Astronomy Lab and the Wallace Astrophysical Observatory.] In fact, we just had a 50th anniversary of the group that he founded there [PAL], and it was wonderful.

All of the people who were around got together and reminisced and stories and some of whom I hadn't seen in 40 years. But you recognize people. Even after 40 years, even though you met them on the street, after you start talking, you recognize all the idiosyncrasies that you recognized and learned so well back when you were working closely together. It was a delight to sort of have that reminiscence.

I was very, very pleased that I, without really knowing it, ended up in a place that really was perfect for me. Or at least, it seemed that way. It really has been a major fortunate linchpin in my career.

BERNSTEIN: I'd like to know a bit about your time at MIT. When you were taking courses in the planetary science department, were there a lot of other women in your class?

PIETERS: No, although I'm sort of oblivious to a lot of that. Because it's so much a discussion now, I look back and realize I was pretty oblivious most of my life in terms of what was appropriate and what was inappropriate.

My name, "Carle" – at least the way it's spelled, you can't tell whether I'm a male or female. It never occurred to me that I was anything else, of course, but I would often get letters addressed to "Mr. Carle." And one time, in high school, I was assigned to a boys' dormitory!

But reading books, science fiction books, et cetera, where all the heroes were in fact males, it didn't register on me. It was OK. I was just oblivious to it.

At MIT, I don't think there were any female faculty. I have to think back on it – it's not that I perceived it at the time.

I do remember, as I was working on my thesis, there was one really delightful lady. I think she was a post-doc or a research scientist. I don't think she was faculty, but she was elegant. Just a student, I was sort of sloppy and always in jeans, but she was just so elegant, and she was always very encouraging to me. I noticed that, but not because it was unusual: it just was a nice thing. In hindsight, that does stand out because people are thinking about it now. But at the time, it was just a nice person who I really liked and was glad to interact with.

BERNSTEIN: Do you remember who it was?

PIETERS: She was in magnetics-- "Becher" or "Blecher" maybe; it starts with a "B." One of my weaknesses is spelling and details. And that's permeated everything. So I've learned to compensate for that, but it's still an ongoing weakness. And thank goodness for spell checkers!

BERNSTEIN: Did your time at MIT influence your going to work at NASA? Or did you just decide, "NASA's just where I want to be"?

PIETERS: No, it was a personal reason. Working for NASA was in the NASA Space Center in Houston. Throughout my time pursuing my PhD, since the Apollo program, there was an annual meeting in Houston, and sometimes a lot of smaller meetings. I would go regularly to Houston. Have you been to Houston?

BERNSTEIN: I have.

PIETERS: So you know it can be hot and sticky, and completely different from New England. Near the end of my PhD, I had written a lot and published things that

were of interest across the community. Some of the people in Houston during conferences would say, "Well, Carle, why don't you come to Houston when you're done? That'd be a great place, all these wonderful things happening." I said, "I don't want to come to Houston. It's just not my kind of environment." I sort of pooh-poohed it.

Well, during my last year, my first marriage got restructured and, halfway through my studies at MIT, went away. But during my last year, I fell in love with a geoscientist who was working at Los Alamos and I ended up going out to New Mexico a lot, working on my thesis and taking all my books out there. He [the man who became my second husband] was running a lab there and wanted a remote sensing person, which is my specialty.

So that's what I thought I was going to do: I was going to go out and join that laboratory when I finished my PhD. It was a nice small group, so it seemed ideal. But it turned out that another place in Houston really wanted my husband to move there. They did everything to attract him to their job. So he said, "Yeah." And I said, "Oh, dear." So I had to call up these friends or colleagues in Houston who had previously invited me and say, "Well, maybe I do want to come to Houston. And they said, "Oh, great." It was a completely separate place than from where my husband was.

I think only one or two people knew that my husband was going to one place, and that might be why I wanted to come, as well. But they really did work hard to get the position arranged, and it turned out fine. So I was in the NASA side, and my husband was in an institute that was not far away.

Instead of going somewhere else, that's why I landed in Houston, which turned out to be a really very exciting place to work. NASA at the time was-- Even though the landings on the Moon were over, the analysis continued. And it was still a vigorous program, although constantly in jeopardy of being cut back, because it was past the peak of Apollo. Things were decreasing, but it was still a very exciting time.

I had a lot of ideas and things to do that I enjoyed working on and really good people down there. So that's how I ended up in Houston and enjoyed the time there and the friends that I made and the work that I did.

After a couple of years, my husband got cancer. He had children in New England area and wanted to be closer to them. He knew he was going to have a battle, so we arranged to come to New England. And for my position, what we arranged was a research position here at Brown.

I had a really wonderful program manager at NASA who said, "I can arrange to take your grants and contracts and send them here to Brown, and we can work things out." So people were really wonderfully helpful.

At the time, my brain was all in other things, namely worrying about my husband, et cetera., but the transition worked fine. So I ended up here rather than in Houston and have been here ever since.

That's evolved, both what's happening at NASA, my position itself-- The various activities that I've been involved in have really evolved a lot, principally while I've been here at Brown. That's five stories right there!

BERNSTEIN: I was wondering if we could talk a little bit about some of the work you've done with NASA, whether it be in Houston or while you've been working here.

PIETERS: OK. Well, let's see.

Going back to my thesis work at MIT, it started as astronomy but used spectroscopy on telescopes looking at the Moon, which is what I ended up doing my thesis on. But it also also involved studying asteroids and a little bit of study of Mars. Remote sensing instruments, spectroscopy, was the foundation of what I was able to do.

Through the years, that has evolved a lot – in instrumentation, how instruments have evolved, and in how spacecraft has evolved. I continued to be an astronomer into the '80s, because that was the best way to get data and using instruments on telescopes and lots of different observatories. Those are a wonderful part of my life. But somewhere around the '80s, there is a transition where the things you can do with instruments on telescope, especially for the Moon, there are more efficient ways – by sending spacecraft with instruments on spacecraft – that you can do it a lot better. That transition occurred sort of mid-career for me.

Although I don't build instruments, I know enough about instruments to know what the challenges are and what questions and what issues to address, but I also know the science that needs to be done.

Having my primary academic foundation in geosciences, it's how planets evolve that really drives my interest in science. And then the tools are the instruments and the kind of analysis that you can work with. That has evolved a lot over 40 years and is still evolving in very exciting ways.

I would say the first half of that was more challenging. Every young scientist has, "I've got to get a proposal in. I've got to get it accepted. Oh, what am I going to do? I didn't get this." There's a lot of angst. People have asked me, "Well, how did you get through all that?" And now, in hindsight, I guess I just did. But the process was full of angst.

What I learned also was that even the worst times, when you have a proposal you sent in and you get it back saying, "No, this isn't funded." And you'll get comments on the reviews that you completely disagree with. And you think,

“Grrr.” But you do it again, and you do it again. Some are accepted; some are not. But gradually, you get some things that you're really pretty proud of that you accomplished.

I think that, in the space program in general but also in specific, you always need a backup plan. You always need sort of a fallback position. For me, this is relative to what I said before. My fallback was “Well, if everything falls apart, I can always dust off my teaching certificate and go back and teach in high school.” I knew if I had to, I could do that, but I wanted to keep working on the planets. That was my real joy.

But it is a federally funded program, so you're at the mercy of how federal funding evolves. The best you can hope for is that you'll have some good ideas that other people think are good ideas and that you can get a little hook here and there.

Sort of a corollary to that is to not have one idea but to have multiple that you think are really pretty cool and hope that one, at least, catches. That sort of turned out for me, that several did not. I always had something that I was able to do and enjoyed doing.

Who knows whether any of the ones I didn't get to do would have bloomed? But you can't tell about the road not taken. All you know is the road you did take and whether it turned out OK or not. And I think it turned out OK.

BERNSTEIN: Which projects stand out as highlights?

PIETERS: Well, there are a couple that I was lucky or fortunate to have the opportunity and took the opportunity. This, I would say, really started mid-career and on, that once I had enough experience under my belt, so to speak, that I sort of knew how things worked and how to formulate some of the important questions to explore, that I felt more confident in proposing larger things.

There are a couple of things that in the second part of my "second half" – the latter part of my career, which I'm still in – that made a big difference, in terms of incremental experience that I'm very happy with. They have to do with missions that I had worked peripherally on various missions, but not as a leader.

NASA has opportunities on a regular basis for small missions. Every couple of years, they have a call for small missions. I think it was at some conference I was at. I was talking to one of the laboratory heads, and he said, “Carle, we've got this mission idea that we need somebody to really take over. Would you be interested in it?” And I said, “Well, tell me a little about it.” It turned out it was a delightful opportunity to go to the Mars area and to look at the—There are two little moons of Mars, and to look at their spectra and to map their overall character.

I had already started working with lunar samples at that point. The intriguing part was that the objective was to toss down a little what we call "mobilizer," kick up some dirt, and to catch the dirt and put it into a little carpet and roll it up and bring it back and analyze it on Earth. So it was going to be a sample return of this dirt from both of these little moons.

It was really important to do because these two satellites of Mars are completely different from our Moon. First of all, they're small, and they look like asteroids. Were they captured by Mars, or were they left over after Mars was formed? We couldn't tell.

But it had major implications in terms of how planets evolve and how their relationship to the moons evolves. And it required spectroscopy. So I said yes, and we got a team together.

The nice thing about putting teams together is you get to choose who you want to work on things. By that time, I knew key people in the community and I could bring in some really good people. I worked with the engineering team, which taught me a lot about the engineering side of the management. We were tutoring each other a lot in this, and we put a good proposal together. Much to my surprise, it was selected as a finalist. I think there were five selected as finalists. I said, "Wow. OK."

That meant we had to work even harder, so they gave us a little money to really develop this and present it. I thought we did a good job – not perfect, but good, but we weren't selected. But we had a great team. We had a good idea. One of the weaknesses was that the management, which was me and the engineering counterpart, didn't have a lot of experience in managing missions. So we said, "OK."

The next time, a couple years later, we got an even stronger team together, worked out even more of the details, because we knew all the weaknesses that had been identified, and again were selected as a finalist, but were not selected. And this time, we were really good and everyone fully expected us to be selected. But for a variety of reasons which were more programmatic and political, we really could not have been. And that part of it, it didn't even cross my mind. It's, again, one of these oblivious things that I didn't even think that was a consideration. In hindsight, I understand it now, but it was devastating.

What it gave me was a real interest in leading exciting missions and knowing that when you can get a good team together, that's one of the most satisfying and enjoyable things – to know you can create something that can do great science and carry it forward. That gave me enough confidence that I could do something like that, even though, ultimately, I hadn't been successful.

The next opportunity came when India was going to fly a mission to the Moon, and they invited proposals for foreign instruments [to be included in the

mission]. I had some colleagues at JPL [the Jet Propulsion Laboratory in Pasadena, CA] at the time who I'd worked with on an imaging spectrometer instrument and knew they had been improving this instrument.

We talked and said, "Yeah. Why don't we use the best capabilities now and propose to this opportunity?" We got a good team together, put a proposal together, and this was a little more complicated because it not only had to be approved by India. It had to be selected at NASA. NASA requires peer review, and India has its own way, so we did a lot of that back and forth. India accepted our initial, as long as it would be accepted by NASA. NASA had to support it. So we proposed to NASA in a program which was the same program that I had previously been proposing and failed.

That year, there were many missions that were being proposed, and ours was called-- We were just an instrument [project], but it was a mission of opportunity because it still had to be funded. That year, we were the only ones selected. And all the other teams were just furious. But that's water under the bridge.

That started the teaming with India, which was a really marvelous experience. It turned out to be successful, although not completely. There were hiccups along the road. But the team that we worked with, both our team and our counterparts in India, had a wonderful relationship. That kind of person-to-person – both scientific as well as the personal – interactions, was one of really the most enriching experiences in my professional career I've had. I really value that.

Our mission is the Moon Mineralogy Mapper. It's a spectrometer, going from the visible all the way to the infrared, where you can't see it anymore. It maps the minerals of the Moon.

The objective of this mission was to map the minerals of the Moon using spectroscopy. There are signatures that minerals have that you can use to identify what and where. And at that time, we knew from a separate instrument that the poles of the Moon seemed to have increased concentrations of hydrogen. The thought was, "Well, maybe this is an accumulation of frosts in the shadowed areas." But it was hypothesis. So we said, "Well, let's extend the range of our spectrometer so that if we go over the poles, which are going to go over the poles every orbit, maybe we can add up things and see if there's any signal there, because there's a prominent hydration feature at three microns."

We said, "Well, maybe we'll get lucky and peer into these shattered areas and get scattered light. Maybe we can see something." So we had a little bit of this part of the spectrum that might be able to do that.

Well, the data came back, and the first coverage the first couple of months, we started seeing this feature there that wasn't at the poles. It was just all at high

latitudes. And we said, "Well, no, that can't be right. That's wrong. We've got calibration, and it must be something in our calibration that we haven't gotten rid of. That's just impossible. It's wrong." So we worked and we worked and we worked to try to get rid of this, and we couldn't. We could improve it some, but we couldn't get rid of it.

Two of our team members – one was on a mission that had launched to Saturn, the Cassini mission, and it had a spectrometer on it. To get to Saturn, the spacecraft had come by the Earth's moon to get a gravity assist. And they'd turn on the spectrometers. And he said, "Well, I'll analyze that data to see if they see the same thing there. So he went away and analyzed it the same way he analyzed the data we had. He was an MIT graduate: Roger Clark [PhD '80, Earth, Atmospheric and Planetary Sciences; expertise involves the surface composition of solid surfaces in the solar system]. He was working at USGS [U.S. Geological Survey] at the time.

He went away and worked on the Cassini data. Another person on our team – one of my students here who was working at the University of Maryland, I believe – was on another mission that had gone to an asteroid and shot a projectile at the asteroid to look at the debris. They shot a projectile at a comet to see what comes out of a comet. Their spectrometers were well-prepared to look for water at this part of the spectrum, and they had come by the Moon, I think, after the mission and did some analyses.

Well, I'll go and analyze those data. So Jessica was off analyzing one data. Roger was off analyzing another. We were arguing whether this is real or not: "It's crazy. It can't be real!" Roger came back and says, "Yeah, I see it." And we said, "Well, it's the same way you process our data. Are you sure?" And he said, "Yeah, I'm sure." I said, "Well, let's wait and see what Jessica finds." And Jessica came back. She said, "Well, I see it, too." So we had three completely independent measurements of what we thought was absolutely crazy but was real, and we learned a lot from that.

What it is is that where it's hot on the Moon, hydration can't survive. But where it's cool, towards the higher latitudes, it's more stable. It's not so much water as it is-- Rocky bodies are made of what's called silicates, which are minerals made with the silicate SiO_2 and then other elements, but a lot of oxygen, so SiO_2 . There are oxygen bonds on all of these, so every silicate on the Moon has a lot of oxygen in it. And the sun puts out what's called the "solar wind," which is a lot of protons and electrons, always awash on the planets. And we'd have no magnetic field here to divert them. So you've got protons: hydrogen and oxygen get together.

What we're seeing is hydrated from a completely different source that we didn't even conceive of, but it's there. I guess it's been about a decade now, that discovery. That opened up a whole area of research that's ongoing now is understanding the physics and how does this work? Once you make oxygen and hydrogen get together, do they combine and then go up and settle in these

permanently shadowed areas? Are there other chemistry facts that we haven't thought about? It's a very area of active research that's brand new.

That was absolutely delightful to be part of initiating. So it was a good or a very instructive sequence where yeah, sometimes, there are things you just don't expect and you think are wrong. And often, they are. It's an artifact. I'm sure in every science, there are artifacts that you have to make sure are not believed. But sometimes, they're real data.

We were very fortunate to have a way of checking with independent data, or we would still be arguing about this now!

So if you're ask me for highlights in career, that ["The Moon as Cornerstone to the Terrestrial Planets: The Formative Years," which focused on studying the surface, interior and evolution of the moon and for which Professor Pieters was Principal Investigator] was an important one – and it took a real team effort to come about. It was a lot of people working and bringing things together in a way that really made it work. We all feel good about it now.

BERNSTEIN: That's awesome.

I know you have an asteroid named after you.

PIETERS: Yes.

BERNSTEIN: Can you tell me the story behind it?

PIETERS: Well, actually, there it is up there. There's the spectrum of the asteroid, Pieters, that actually-- Rick Bense at MIT took that spectrum and gave it to me. That's a real treasure of mine. I didn't do anything to get that. But astronomers like Rick keep finding asteroids, and they do like to name as many of them as they can. There are a lot of them. A lot of them are not named, but a lot of them are, and I feel honored that someone put one in my name. My name was put in and was selected, so that asteroid has my name. You can tell from the spectrum what kind of asteroid it is: it's what's called an "S-type asteroid," which is a silicate. We know that. It's probably like an ordinary chondrite, in terms of the body itself.

BERNSTEIN: An ordinary chondrite?

PIETERS: Well, it's a kind of meteorite. There are meteorites that fall on the Earth all the time. And there's a whole classification of these meteorites that fall to Earth. The first-order classification are sort of the stony ones, and then there are the ones that have a lot of metal—so, the iron meteorites.

The stony ones fall into two classes, one that has a lot of hydrated minerals in them, so they're very primitive; and the other, which has very few hydrated

minerals but have some early components that we still don't understand called chondrules. That's the "chondrite" part.

So when I say "ordinary chondrite," it's because of all the meteorites that fall, about 70%, 75% are ordinary chondrites. It's the largest class. We have a lot of those kinds of meteorites and then different abundances of the others that come down. We have a lot of metal ones in our collection, but that's because they don't deteriorate. A lot of them are found in a field because a farmer came across them and said, "We've got to get this heavy rock out of here."

BERNSTEIN: That's awesome.

I feel like we've made kind of a large trajectory. Is there anything else that you'd like to include?

PIETERS: Well, I haven't talked much about MIT. But MIT has been a very important part in my life and obviously in my career, and that's both on the personal side, as well as the opportunities I had while there and that have continued on forever. Even though I didn't go to undergraduate school there, I'm very glad where I went. That was an important part of my career, in terms of what I learned in self-reliance. MIT was very important, in terms of the opportunities that I sort of stumbled into and then was able to work with, and also the long-term friends.

The class reunion we had last summer was really a delight, because it makes me recognize – and I think everyone who participated – recognize that bonds we formed 40, 50 years ago are constant. They're strong and meaningful, even though each one of us have gone into different directions.

A few of us have stayed in planetary science. But listening to the stories of my colleagues and all the different things they're doing was quite diverse, even though we all sort of started in the same place, the same group – and that's very indicative of what happens at MIT. People don't always stay in their one track because they're very inventive and can go into many different directions and use their talents in many different ways. I feel really good to be part of that family.

BERNSTEIN: That's great. Thank you so much.

PIETERS: Thank you. I hope this is helpful.