Oral History Center
The Bancroft Library

University of California
Berkeley, California

Global Mining and Materials Research Oral History Project

Bill Langer:
A Geologist in the US Geological Survey and in Industrial Minerals Research

Interviews conducted by
Paul Burnett
in 2015

Since 1954 the Oral History Center of the Bancroft Library, formerly the Regional Oral History Office, has been interviewing leading participants in or well-placed witnesses to major events in the development of Northern California, the West, and the nation. Oral History is a method of collecting historical information through tape-recorded interviews between a narrator with firsthand knowledge of historically significant events and a well-informed interviewer, with the goal of preserving substantive additions to the historical record. The tape recording is transcribed, lightly edited for continuity and clarity, and reviewed by the interviewee. The corrected manuscript is bound with photographs and illustrative materials and placed in The Bancroft Library at the University of California, Berkeley, and in other research collections for scholarly use. Because it is primary material, oral history is not intended to present the final, verified, or complete narrative of events. It is a spoken account, offered by the interviewee in response to questioning, and as such it is reflective, partisan, deeply involved, and irreplaceable.

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Bill Langer, 2011

Bill Langer is a geologist with over forty years of experience with the US Geological Survey, with the last two decades devoted to research on industrial minerals and aggregates. He holds a master's degree in geology from Boston University after completing a bachelor's in geology at Alfred University. He was the 2015 recipient of the Hal Williams Hardinge Award from the Industrial Minerals &Aggregates Division of the Society for Mining, Metallurgy, and Exploration (SME) for his "extraordinary contribution to the science and sustainable development of industrial minerals and aggregates." He is currently working as a consultant.

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Global Mining and Materials Research Project

For over twenty years, the Regional Oral History Office (ROHO) produced in-depth oral histories of members of the mining community, under a project called "Western Mining in the Twentieth Century," which was overseen by Eleanor and Langan Swent, Doug Fuerstenau and others. http://bancroft.berkeley.edu/ROHO/projects/mining/index.html The 104 interviews in the project covered the history of mining in the American Southwest, Mexico, South America, and Australia from the 1940s until the 1990s.

ROHO has recently changed its name to the Oral History Center of the Bancroft Library, and with that change we proudly announce a new project entitled “Global Mining and Materials Research,” which will focus on key transitions in technology, policy, and geopolitics that have brought mining to its current state worldwide.

Much has changed in mining industries in the years since the Western Mining project was in full production, including the increased globalization of mining operations, the decreasing concentration of mineable minerals in ore, increasingly complicated regulatory environments, new systems of environmental remediation, new technology for exploration, extraction, and processing, and new stories of political conflict and resolution. In addition to collecting interviews about mining engineering, metallurgy, and administration, we also hope to explore the history of information technology and data analysis with respect to mining, as well as the legal, regulatory, and policy history of the industries.

This interview was funded with support from the American Institute of Mining Engineers, Metallurgists, and Petroleum Engineers (AIME), the Society for Mining, Metallurgy, and Exploration (SME), the Association for Iron & Steel Technology (AIST), the Minerals, Metals, & Materials Society (TMS), and the Society of Petroleum Engineers (SPE). We are also collaborating with the IEEE to host these oral histories on the Engineering and Technology History Website, located here: http://ethw.org/Oral-History:List_of_all_Oral_Histories. Thanks also to former Western Mining Project Lead Eleanor Swent, Dr. Douglas Fuerstenau, and Noel Kirschenbaum for their advice and support while the Global Mining Project was being established. Finally, we are most grateful to Bill Langer for taking time out of a busy schedule to speak to us about the evolution of the mining industry over the past forty years.

Paul Burnett, Berkeley, CA, 2015

Interview #1 February 18, 2015
[Audio File 1]

01-00:00:00
Burnett: This is Paul Burnett, interviewing Bill Langer for the Global Mining and Materials Research Project of the business series of the Oral History Center at the Bancroft Library, and it's Wednesday, February 18, 2015, and this is audio file one. So, welcome, Mr. Langer. I want to start at the beginning, here. So can you tell me a little bit about your family background and where you grew up?

01-00:00:31
Langer: Sure. My father was a college professor, chairman of the economics and business department at a small university in western New York. It's Alfred University, and not many people hear of it, but in this business, actually, they do, because it's the country's number one ceramics college. So miners here that are involved in clay, will know about Alfred University. Most other places I go, they scratch their head and wonder where it is. [laughter] My mom was a stay-at-home mom. I have two sisters, both older than I am. The town's population was about 1,000. The two universities there—we had one university and one state college—the students way outnumbered the local residents.

01-00:01:16
Burnett: I bet.

01-00:01:17
Langer: We had one stop light. Very small town. Had to go to a centralized school shared with another town, because it was such a small place we couldn't afford, or couldn't maintain, our own school.

01-00:01:29
Burnett: And where was the next biggest city around there?

01-00:01:33
Langer: Well, the biggest to us was Hornell, which, nobody knows of that either. It was twelve miles away, and it was a major chore, in those days, to take a ride into Hornell. My mom used to go grocery shopping, twenty dollar food budget for the week, and we'd drive into Hornell, and that was our trip to Hornell. Anything else we needed, we'd better get that trip, because we didn't go back for a week. But the next real city was Rochester, and that's—we were at the southern end of New York State, and Rochester was directly north of us. So just drive south from Rochester until you hit the Pennsylvania border. Turn around; go back about fifteen, twenty miles, and you're in Alfred.

01-00:02:14
Burnett: [laughter] All right, that's great. And can you talk a little bit about how you became interested in geology and mining? How did that come about?

01-00:02:26
Langer: Yes. Yes, I can. My dad, as I said, was a professor at Alfred, and that gave him the privilege of having his children attend that school at a reduced or no tuition, depending on which choice he made, and his salary was adjusted accordingly. So for all of us, it was assumed that you went to grade school, junior high, high school, and college. There was no question. It was just part of things. And so when I went to college, I went there without a career in mind. I just went because that's what you're supposed to do. Many of the other students around me all had some career that they were planning on. I didn't. It was just more school. Well, my junior year, at the beginning of my junior year, I had to declare a major. I never really thought about what I'd do with a major, but the class I that had most fun in turned out to be geology. So I said, hey, what the heck? I'll do geology. So that's how I became a geologist at the earliest stage.

01-00:03:31
Burnett: Right. What was fun about it?

01-00:03:34
Langer: Oh, outside. We did outdoors. My dad used to take me hunting, and fishing, and just hiking through the woods. This was like a classroom where you got a grade for doing that. So.

01-00:03:48
Burnett: Right. Right. Did you have in mind that you were going to pursue academic geology, or were you thinking about a career in an industry at that time?

01-00:04:00
Langer: I hadn't even gotten that far. It was what I needed to do to graduate. I was in ROTC [Reserve Officers' Training Corps], and had elected to continue on to join the Army when I finished, so that was my job. Never viewed as a career, but that was my job.

01-00:04:22
Burnett: Right, right. And you're in ROTC at a very pivotal point in American history.

01-00:04:29
Langer: Yes.

01-00:04:30
Burnett: And can you talk a little bit about that?

01-00:04:32
Langer: Yes. It was during the Vietnam War, during the latter part of the Vietnam War. It had become quite unpopular, protests on campus.

01-00:04:42
Burnett: Even at Alfred?

01-00:04:44
Langer: Even at Alfred. And we were quite backwards. We were way behind the times. But it had reached there. It was not a big deal, but— [break in audio recording]

01-00:04:57
Burnett: We're back. So you were speaking about 1969, and Alfred, and there were protests even at a small, remote college town.

01-00:05:12
Langer: Yes there were. The graduation ceremony for the ROTC was disrupted by protestors. Not a big deal. The student population was not that big, and they had a hard time getting enough people together to even mount a halfway-decent protest. But they did have a representative group there that did nothing. But was a time where I pretty much assumed that when I graduated, I would be drafted, and go into the Army, and go to Vietnam. So I might as well do it as an officer.

01-00:05:46
Burnett: Right. Right. How did you feel about the protests at that time?

01-00:05:50
Langer: It bothered me.

01-00:05:51
Burnett: I bet. Yeah. And so you graduated ROTC and you were drafted or you were—

01-00:06:02
Langer: No, I was a volunteer.

01-00:06:03
Burnett: You were a volunteer. You enlisted.

01-00:06:04
Langer: I received a commission. ROTC gave me a commission. And I went right from graduation to my first assignment, which was to a training school where we learned the military aspects of our career and chose a career—I mean, we were given a particular career path.

01-00:06:24
Burnett: Did you take a number of tests for aptitude at very things? Officer level?

01-00:06:28
Langer: No, they relied on your college education. And where they needed people.

01-00:06:34
Burnett: Ah-ha. And so for someone with a training in geology, where did you end up?

01-00:06:39
Langer: I had hoped to end up in the Corps of Engineers, but I ended up in the Ordinance. It had nothing to do with my training; that's where they needed a person.

01-00:06:50
Burnett: And I understand that you're a recipient of the Bronze Star Medal.

01-00:06:55
Langer: Yes, I am.

01-00:06:56
Burnett: Can you talk about that?

01-00:06:58
Langer: Well, I'd prefer not to talk too much about it, but let's say that in Vietnam, there were some difficult times, and I helped resolve some of them. It was not a medal for valor. It was for meritorious service. So it was not like I was carrying wounded soldiers out on my back. It was difficult times that I helped make better.

01-00:07:24
Burnett: It was service.

01-00:07:25
Langer: Yes.

01-00:07:26
Burnett: Yeah. And so you finished your service in 1971, so you were there for two years?

01-00:07:33
Langer: Actually, I finished my service in '70. I went in '68 to '70. Mustered out directly from the Army, and eight days later showed up for graduate school.

01-00:07:49
Burnett: Okay. And so it was clear in your mind that geology was something you wanted to continue in.

01-00:07:58
Langer: No. [laughter]

01-00:07:58
Burnett: No?

01-00:07:59
Langer: Not yet. As I said, my dad taught economics. We communicated a lot during the war, and during my deployment. And he found a college, Northeastern University in Boston, that was offering a degree in CPA [Certified Public Accounting], you would graduate as a certified public account, and it was designed for people who had no experience at all, or no training, in economics or such. And so I figured, hey, this should be great. Geology, and then I could be a CPA for an oil company, a gold company, that'd be a good career path. So I signed up, got to the class. First day in class, professor said, "How many people have had at least one course in economics?" And I and everyone else raised their hands. And, well, that's okay. Next question was, "How many

people had a minor in economics?" Everybody except for me left their hands up. The next question was, "How many people have a major in economics?" And all those that had their hand up left it up. And so the professor said, "Well, we're not going to start out at the beginning now. This is an advanced class." And so I was a beginner in an advanced class. They bought advanced textbooks. I had to buy advanced and introductory textbooks, and I have never worked so hard in my life to get Cs. After one semester, I said, this is not going to work. And that's when I decided, through an odd course of events, to become a geologist. So fate made me a geologist: not love, not planning, not anything else. Just fate.

01-00:09:44
Burnett: That's a common trajectory for people. Fate does intervene in these instances, and oftentimes quite happily. So it's 1972, and you graduate with a master's in geology. Is that correct?

01-00:09:59
Langer: Yes.

01-00:10:00
Burnett: Okay. Can you talk a little bit about your first position that you made use of this training?

01-00:10:08
Langer: Yes. I was fortunate, while in graduate school, to have a professor, Dabney W. Caldwell, son of Erskine Caldwell, who knew people that worked at the United States Geological Survey, USGS, and they had a need for an intern to help prepare some simple maps that translated geology into terms that regular people could understand. Mostly tracing lines on a geologic map, and then putting new labels on their lines, sometimes combining two or three units together as one. And I was given the opportunity, and accepted it, to have that job. So I had a small-paying job as an intern. When I graduated, it turned out that the person I was working with was opening up a new field office in Middletown, Connecticut, and they asked if I would be interested in going along, and I said, "You bet!" I had been sending out applications, and receiving replies that I was not real happy with. Some of them, "Yeah, we'll hire you, but you aren't going to like this job." And this was one that I was already doing. I knew the person, and I liked the work, and so I went. And as I said, it was a job translating complicated geology into simple English.

01-00:11:27
Burnett: So it's not necessarily for the public, but it's for other professional use, perhaps? That would need this maybe for legal or city planning purposes?

01-00:11:43
Langer: Absolutely. This was a time in the country's history when they were starting to realize that nature mattered. Rachel Carson had written her book, *Silent Spring*. Things were going bad. Love Canal was a disaster. And so they said, gee, we cannot live in spite of geology, or in spite of nature. We have to live

in concert with it. And geology is one part of nature, and so this was one of the USGS's first attempts to help provide meaningful data into the land-use planning process. And that's what this was all about. And indeed, the project that I was working on, we worked very closely with some planners and came up with new town plans of growth and development based on geology.

01-00:12:32
Burnett: Can you give an example of how that might work in the planning of a town, and respecting geology?

01-00:12:41
Langer: Sure. The town that we did was in rural Connecticut, and much of the town—in the East, there are townships and there are villages. The villages are little incorporated centers; townships abut one another. There's no unincorporated counties in the East. And so this township was mostly rural. The village had sewer and water; the township had wells and septic. And one of the things you don't want to do, of course, is have your well interfere with the septic or vice versa. And so there are certain geologic materials that are better at communicating away the septic effluent, or that are better for providing wells. And so this kind of information was useful in helping plan where you might—the density of the development. Some soils, you can say, "Well, we can put houses closer together and the septic systems will still function well." But in other parts of the township, you better have acres between each lot.

And so they came up with a development, a density map, based on that. And it included other things, like identifying and protecting wetlands, identifying areas where it was steep slopes, where it might be a danger of rock falls or hazards like that. And even—I was delighted to see—even at the time, places where it was reasonable to develop the resource as aggregate, as sand, or gravel, or crushed stone. They were forward-thinking enough at that time to recognize that we need construction materials, and let's set aside a little place. Now, it wasn't quite that altruistic. There was a big existing quarry, and they realized they better not constrain that quarry so it couldn't do its job. But they did include it.

01-00:14:46
Burnett: Right. So that land-use planning is both respectful of urban development, industrial development, and ecology. You have those three goals as part of the planning.

01-00:14:58
Langer: Yes. Yes.

01-00:14:59
Burnett: Right. Right. And that's—well, we can talk about how those priorities evolve during the time of your career. And so you did that for a number of years, not just in the Northeast? Or was it mostly in the Northeast?

01-00:15:16
Langer: No, I worked for five years in the Northeast, and then moved to the USGS headquarters in Reston, Virginia, which is in northern Virginia, and continued on the same type of project in a totally different geologic terrain. The Northeast is paleoglacial terrain. It's so young, glacially, that you could almost see the ice left in the gravel. [laughter] But in the Virginia area, it was so old, quite the opposite, that nature had plenty of time to weather the rocks into very soft material, quite different from a rock. And so 180 degrees as far as the type of material.

01-00:16:01
Burnett: And does that present different challenges for urban development, and for ecological planning, and industrial development, and so forth?

01-00:16:10
Langer: Yes, it did. Quite different challenges. Similar in that you wanted the same goals, and there were similar engineering conditions, in that you wanted to have well drain material for a septic system, as opposed to a tight clay, and so forth. But different challenges as far as how you interpreted the geology, and also hugely different challenges for me. The first thing I did was recognize, my goodness, how much of this stuff—where is the rock? It was weathered so deeply that you could hardly find the rock.

I remember a fellow named Al [Albert J.] Froelich, one of my first and best mentors—poor fellow smoked himself to death, and left this earth way too early—we were out in the field—he had a passion for geology you wouldn't believe—and we were out in the field, and he has his rock hammer in his hand, and we're going down this ravine, starting at the top, and he's banging on the soil and it's going, thump, thump, thump. And then we get a little farther and it's going thump, thump. And then we get down and there were little pieces of rock, what they call core stones, and you bang on that, and it would kind of go clunk. And you'd go thump, clunk. He's not saying anything. Not saying anything. Just doing this [hammering alternately on two places on the earth]. And then we'd get a little deeper, we'd get down the bottom, he goes bang! And it goes like that, and he said, "It's ringing like the anvil chorus." I still remember him saying that. And what he was showing me is how as you go down through the section, the rock is completely disaggregated, and then there's just little pieces of it floating around, and you get down to the bottom to the solid rock. And that was my introduction, and it just got better from there on.

01-00:17:54
Burnett: Is that a reference to *La Traviata?*

01-00:17:56
Langer: Yes, of course. [laughter]

01-00:17:59
Burnett: You hear opera references as you are doing geology. This is great.

01-00:18:06
Langer: Yeah, well he was a well-balanced man.

01-00:18:09
Burnett: Yeah, yeah. Being well rounded is important.

01-00:18:11
Langer: Yeah. He had other things to say. I loved the guy. He shared my opinion, which was imparted on me by my dad. And that was that for a project's work to be good, it should result in a meaningful, useful product. And in the USGS, as a research geologist, it was very easy to lose that perspective. You could end up in research which may end up on a shelf—doing research that could end up on a shelf and never see the light of day. Or fifteen, twenty years down the road, somebody will reference it, but in another research study. But it never makes it to where it's really used. And that's why I was fortunate to be on a project where the products were being used right away. That's what they were being done for. And Al shared that experience, and one of his critiques of his colleagues was that they used to like to see how many angels could dance on the head of a tourmaline crystal. [laughter]

01-00:19:18
Burnett: Well, it sounds like this is knowledge for use. You want this to be of service to other people, other disciplines. It sounds like it was also a little bit interdisciplinary. Were you working with other experts in other areas to do this work?

01-00:19:37
Langer: Absolutely.

01-00:19:37
Burnett: Or was it exclusively geology?

01-00:19:40
Langer: No. In fact, the USGS had three disciplines at the time: geology, hydrology, and topographic mapping and land use. And these projects were all designed to include all three of those disciplines, and we would work together, hand in hand, on the maps. We wouldn't each go off to our corner and work. And we'd produce a large number of maps that could not have been done if you did them by yourself. When you understand how geology and water interact, you can make a better geologic map, you can make a better water-related map. And then certainly when you knit them together at the planning stage. Now, the next step, of course, involves the planners who include all of the cultural, socio-economic parts. And that makes the waters even muddier. And that's what I found intriguing, because many geologists would like to know how many angels could dance on the head of a tourmaline crystal, and you've got to identify those tourmaline crystals, and you focus narrower, and narrower, and narrower. This was just the opp—but a very complicated, difficult process to learn the crystal structure, and to learn the biology of an angel, or whatever. But we had to go the other way: broader, and broader, and broader. And so as

we're going on, rather than knowing everything about [practically] nothing, we start learning a little bit about everything.

01-00:21:09
Burnett: Is that more satisfying knowledge for you? More satisfying kind of work for you?

01-00:21:13
Langer: For me, it truly was, and continues to be. It's a totally different kind of puzzle.

01-00:21:19
Burnett: Yeah, absolutely. Was there any relationship between this kind of work and the Bureau of Land-Use Planning? It just sounds like it might be. Or does the Bureau of Land-Use Planning have a very different mandate from the work that you were doing with USGS?

01-00:21:35
Langer: Different mandates.

01-00:21:36
Burnett: Yeah. It's much more legal and political?

01-00:21:39
Langer: Yes. Regulatory.

01-00:21:41
Burnett: Regulatory. Got you. Great. So this was an enjoyable few years, that you were taking on these challenges. And that was until the late seventies? Until 1978, I think?

01-00:21:56
Langer: Until 1981, actually.

01-00:21:58
Burnett: Until 1981? Okay.

01-00:21:59
Langer: Well, '78 doing the hardcore fieldwork-related stuff. And I'd like to interject, during that time, I met Steve [Stephen F.] Obermeier, a bona fide engineer, and the USGS did not have many of those. He may have been the only one. And he looked at things quite differently yet; he looked at how you could take soils and squeeze them, and find out how strong they're going to be. And put holes in them and see if the holes are going to close. Pull and stretch on them, do all this kind of engineering stuff. And we worked together on a number of projects where I knew the geology, and I could tell him where these clays of a certain type were, and he could say, "These are bad clays. This—if you put a house on this and start watering the lawn, the house is going to slide down the hill." And there were some very real problems in northern Virginia about that type of ground failure, and Steve was one of the leaders in working with finding ways to deal with it. You don't commonly deal with it by outdoing

nature. You deal with it by working with nature, and together, we put out a very handsome report that included the geology about where you might want to watch out for this kind of stuff, and the engineering side about why you want to watch out for it.

01-00:23:25
Burnett: Right, right. And was this taken up by planners and developers in that area?

01-00:23:29
Langer: Absolutely. Absolutely. And there were very serious land use constraints put on things, where the counties didn't want to get involved with big messy suits where houses were sliding down the hill, and they had permission from the county to put their house there, and so now whose fault is it? And so they didn't like that kind of problem, and this kind of work had direct application.

01-00:23:55
Burnett: And for how long had the USGS been involved in that kind of work? Was this fairly new?

01-00:24:02
Langer: Fairly new. It started in the seventies.

01-00:24:05
Burnett: Wow. Wow. I guess it's part of the general regulatory push in the seventies, towards safety and—health and safety, I guess.

01-00:24:19
Langer: Yes.

01-00:24:20
Burnett: And ecology, and the environmental soundness and health.

01-00:24:25
Langer: Well, and then there were groups that were concerned about how long our resources were going to last, and there were publications: we're going to run out of copper, and gold, and lead in so many years, if you look at the population growth. It was not called sustainability at the time, but, you know, are we going to be able to sustain this lifestyle? And most of their projections—all of their projections were off the mark. I mean, we're still here today, and we wouldn't have been if those had come true.

01-00:24:53
Burnett: Right. Right. That's an interesting period in history. You have the popular books coming out, like *The Population Bomb*, and The Club of Rome's 1972 report, which is just a series of charts showing, you know, for each element, and each natural resource and energy resource, with a graph going straight down towards the future. An inevitable, very, very rapid decline, that, as you say, did not pan out. How did those big—these were popular, part of the popular culture. This is something that affected and influenced the work of the government. This spurred the kind of work that you were doing: we need to

get a handle on resources, and information about resources need to be made available to the public so they can make informed decisions. Is that part of the piece?

01-00:25:54
Langer: Yes it is. The Club of Rome was one of the driving forces. Now, the USGS never got involved in the debate. Our role was to provide data, and to provide reliable—I hate to say honest, truthful data, but unbiased. I'll use that term. Reliable, unbiased data. And that put us in a good position, because we would get calls from engineering groups, engineering associations asking to give papers. We would get calls from groups like Nature Conservancy to give presentations. And they all valued our data and—I was going to say our opinions, but we weren't really allowed to have opinions. But we were allowed to show the data. And the trends that we saw with the data, but we wouldn't project and say, "This is what's going to happen." We would be very willing to say, "This is what happened in the past." And we would be very willing to say, "Here are examples of what happens if you don't shepherd your resources well."

01-00:27:01
Burnett: Right. Right. And so in this period from '78 to '81, you're a Senior Research Geologist for Aggregate Resources at the Office of Land Information and Analysis. So this is this kind of unit that you're talking about that has interdisciplinary research, that applies interdisciplinary research to land use questions, basically.

01-00:27:28
Langer: Yes. What happened was I had been doing the fieldwork, so I was part of a program that was called Regional Geology, or at the time I think their name was a branch of environmental geology, because environment was the key word of the day. And I was thoroughly enjoying the fieldwork, but the USGS needed some help encouraging more of that kind of work, because it was being done in a very small part of the survey. And so I decided—upon encouragement and being recruited by other—to join a more management-related aspect of it, where I would fund programs that did this kind of work. I'd encourage others to do it, and then find means for them to get the money to do it.

And although I agreed completely with their goals and the mission of that group, I found it difficult in the morning to come in and have an in-basket and an out-basket. In the morning, it was here [to my left], and in the night, it was here [to my right], and that was my measure of success for the day. Now, as a geologist, I could say, "I put down fifteen test holes today," or, "I mapped eighty-three miles of contact," or maybe, "I mapped one mile of extremely difficult contact." But I had feedback every single day. And shoveling from one box to another didn't help, and so what I had to do was live vicariously through the results of others. When they got, when their project was finished, I could say, "Hey, I helped fund that. I helped them get the money." That didn't

quite do it for me. I appreciate the opportunity to do that work, and I think I had a positive impact, but it was not the same.

01-00:29:28
Burnett: And as you said, you're interested more in kind of solving puzzles or mysteries.

01-00:29:36
Langer: Right.

01-00:29:37
Burnett: You're kind of describing detective work.

01-00:29:40
Langer: It is. It is.

01-00:29:42
Burnett: So it has that kind of excitement built into it. So this was more of a supervisory position, a research evaluation position. And so you're looking at the work of others, and it's not as satisfying for you.

01-00:29:57
Langer: Correct.

01-00:29:58
Burnett: So how did you cope? What were the next steps, then, for you?

01-00:30:03
Langer: Well, the next step, actually, was a great one. They liked what I was doing, and wanted to now try to encourage the same kind of work in the western USGS offices. And so they set up an office for me, and I was transferred to Denver from Reston, Virginia. That in itself was huge. Didn't have any idea what it would be like. I'd spent my entire life in the East. Showed up in Denver in February: dirty, dull. I mean, blue skies, but the ground is just all bare. No grass, no snow, just—Pam and I look at each other: what have we gotten ourselves into?

01-00:30:51
Burnett: This is your wife, Pam.

01-00:30:52
Langer: My wife Pam, yeah. But wow. And then, no sooner did we get here than the bottom fell out of the environmental work in the USGS. The director at the time said, "This is very important work, but we don't need separate groups doing it. We will roll all of this work back into the divisions." And so here I am one year out here, ready to start up a new thing, and the rug is out from under me. Yeah. So I had a choice of where I would go back: to the geology group type of work that I was doing, or hydrology. Those were my two disciplines, because in graduate school I had a strong background in hydrology. And I decided the hydrology folks looked like they were a little

more on board than the geology ones. It looked like the geology folks wanted to get back to mapping and forget this, and the hydrology folks generally have a very apply-driven effort anyway. They're looking for water, not out of scientific research, but: where is there water? We need water. Now, they do have the research that says, how does that water move through the ground? How difficult is it to get out? And that kind of issue. But one of the bottom lines is: where is it, and can we get it? We need it now. We want it in our sink. And so I chose to go with that group.

01-00:32:31
Burnett: And what year was that in?

01-00:32:34
Langer: Well, let's see. We moved out in '81, so that was probably '82.

01-00:32:37
Burnett: And so you became the research geologist/hydrologist at this division?

01-00:32:46
Langer: Yes.

01-00:32:47
Burnett: And it lists a number of things that you did, along the same lines of what you described before: that this is urban geology, as you described it. Can you talk a little bit about the kinds of work that you were doing in the 1980s?

01-00:33:04
Langer: Yes. Urban geology might be—it's a general approach. It's applied geology. But in the eighties, another issue that the country was trying to cope with was what to do with the radioactive waste that we're generating from nuclear generation facilities. And the country was trying to deal with this in an orderly manner. And so the first goal was, well, let's divide the United States up and find eleven or twelve areas that might be useful. Tremendous different geologic terrains, and different types. Do we want to bury it deep in the ground in a hard crystalline rock, or do we want to want to put it over in some shallower place here in a different kind of rock? Where do we want it to go? And there was a subgroup of that called Task One, and the first task being to find out where this might go. Well, for various reasons, probably politically driven, it soon became obvious that looking throughout the entire US was not going to work. And so Task One was refocused to say, let's look at three potential sites: Hanford, Washington; Yucca Mountain, Nevada; and [Hanford] a place in Texas. And so the effort was, well, we will look in—let me step back.

Before it got quite that pointed, they said, well, let's look through the entire basin and range as Task One, and we will look in other physiographic provinces as time allows. But we'll start out there because it's dry, it would be a good place because there's not going to be water moving it. And so our goal was to find places in the basin and range, a variety of places, using the same

technique that you'd use to find out where's a good place to find a septic system. Entirely different criteria, of course, but using the same general technique: mixing water, hydrology, topography, and so forth. And as we got into that, that's when politics took over and said, well, quit looking for any place here: focus on these three sites. And so we did that, and no sooner did we get well along in that path then politics took over and said, we're just going to look at Yucca Mountain now. Who knows why, but the fact that Nevada had two senators and two congresspeople might have been something to do with it.

01-00:35:42
Burnett: I never knew that about the siting efforts for Yucca Mountain. You know, the story that I had heard was that there was this grand search among expert geologists who scoured the Earth, and the United States specifically, for the ideal sites: they had to be geologically inert—they had all these criteria they had to fit, and there were candidates that were eliminated, and the one that was left was Nevada. And you're saying that it was actually, no, we weren't even consulted as to—

01-00:36:13
Langer: Right. What you were led to believe is not quite right. No, it was for—I was not part of the decision-making process, so it's speculative for me to say it was political. There may have been, perhaps, somebody behind the magic curtain did look, but no. We were involved in trying to find sites, and I'll tell you, we had found a dozen sites in the Basin Range that looked like they would be good, one of which was the Yucca Mountain site. But we never got to the stage of saying, how are we going to narrow the field? And that's where we were just getting. Computers—small desktop computers—were just becoming popular, and they gave us a whole new way to manipulate large amounts of data. And we were just getting set up to use those to try to unravel this mystery. All the sudden, we're told, "No, this is where it's going to go."

01-00:37:20
Burnett: What year were you informed of the project, to begin doing basic research on siting for the nuclear waste disposal?

01-00:37:29
Langer: You mean for the narrow-it-down-to-Yucca-Mountain part, or the whole—

01-00:37:32
Burnett: Just the very beginning of the whole project, as far as you know, and your involvement.

01-00:37:38
Langer: My involvement was started in 1982 when the group I was going to be with was dissolved. They had been already doing this, and were still at the many places throughout the US stage. In fact, I was part of a team that went to a number of meetings discussing what we were doing in the Basin Range versus what other people were doing in other parts of the country. So it was still alive

at that level. But the emphasis ended up being put on the Basin Range, perhaps because we had so much data. There had been a lot of work there before for us to draw upon. Or just perhaps we were doing a good job, or perhaps because that's the type of terrain that someone had decided. But they were talking about deep crystalline rock repositories in the East. I mean, burying them in deep, deep holes underground where water might never make its way. But those disappeared for strange reasons, and we were left with the Basin Range for about five years, and then that one disappeared. And each of these events were overlapped. So while we were looking at the entire US, the Basin Range took on a life of its own. And then while we were looking at the Basin Range, Yucca Mountain started a bigger life on its own. While we were still ostensibly trying to find the best place in the Basin Range, one of those had already taken on a life of its own.

01-00:39:17
Burnett: There are so many parameters that go into calculating, because nuclear waste disposal, you're talking—I don't know what the years that this chamber had to be intact for, but 90,000, or something like that?

01-00:39:32
Langer: Oh, an outrageously long time. It was, we want to bury this and make sure it's safe, essentially, in perpetuity with no recognition that over time, technology would get better. It may be something even worth going back and recovering in the future, or certainly if we found out how to do it better, moving it to a better location in the future, have it as a more temporary place there. It's a very complicated business. I was not involved in any of those decision-making processes. But from my perspective, we could have done a good job with a geologic search and we just never completed that effort.

01-00:40:19
Burnett: Yeah. And then, as you say, the candidate Yucca Mountain was decided upon, and they drilled, I understand, and built access roads, and built the chambers inside the mountain. They got all that stuff ready, and then there was another change that happened. Can you talk about the eventual fate of Yucca Mountain?

01-00:40:41
Langer: I have not been involved in it, but basically, it's no longer a candidate. In defense of my organization, we did not make the decisions about where we would be doing our research. I believe the Department of Energy, perhaps with input from the Nuclear Regulatory Commission, made those kinds of decisions. We just moved our research to where we were told. We were trying to do good scientific reports as part of this process. And we even had some difficulty in doing that, because the Department of Energy wanted information on a timeline that we weren't quite used to. We had a very rigid review and approval process, and then we would generally publish our reports in peer-reviewed literature to stand up to the criticism of others if it was there. And that took a long time, and it did not meet some of the timeline criteria of the

Department of Energy. And so after I left that project—and it had nothing to do with me leaving—but after I left, it evolved to where they were doing mostly administrative reports rather than traditional USGS reports. And when it came time in some of the final evaluation, those administrative reports didn't have the pedigree, and didn't stand up to the criticism, or to the critique. And so they were not as valid—considered not as valid. Now, they were probably done just as carefully. But they did not carry the prestige with them that a traditional USGS report would.

01-00:42:33
Burnett: And in the end, I think the siting was not the big issue. The political football was the trans-shipment. How do you get the nuclear waste from the plants to Yucca Mountain, and states were like, "you're not taking this through our backyard," and that ended up killing it in the end. Or, one of the factors that killed it.

01-00:42:55
Langer: Well, yes. And transportation would be one, but you used, I think, the key phrase: not in this backyard. Not in my backyard, NIMBY, became the rallying cry for many, many things, including opponents to the mining industry.

01-00:43:14
Burnett: Right. And this is a big—I was going to say watershed, but we probably shouldn't use those terms, [laughter] and be that punny. But there's a tremendous environmental regulation that is put in place, starting in the 1970s, but there's an awareness that there needs to be some responsibility on the part of industry to clean up ecosystems that have been damaged by work, even if they didn't do the initial pollution. Whoever owns it ends up being responsible. So I imagine—did that affect some of the work that you were doing, and have an impact on what you were doing?

01-00:43:58
Langer: Absolutely. Cleanup is an issue—we did not get directly involved in cleanup, although there would be cases where the hydrology group that I used to be with would study the extent of damage. They would put out monitoring wells, and they would determine which way the plumes, contaminant plumes, would be travelling, and in that case, they would actually predict, using hydrologic modeling, where those plumes might continue to go, when you might expect them to daylight, or to enter some well field, or something of that type. But what also came about was more opposition to having the things. Kind of an assumption that any land use, now, was going to result in a problem. If you put a landfill anyplace it's going to be a problem. If you put nuclear waste any place, it's going to be a problem. If you put a septic system in any place. If you put a mine in any place, it will create a problem. And part of that was because prior to the seventies, people didn't know any better. People didn't know any better, and so they—they were allowed to do activities, there was no government control.

In Alfred, when I was a kid, my job once a week was to go out back and burn the papers. Open burning. And that was my job. I remember how fun it was to throw a shaving can cream in and watch it explode from a distance. But that was my job, to burn the papers. Well, open burning is no longer an acceptable way to do things. We separated our glass and our trash; we recycled newspapers. So we were ahead of the times there. But the garbage man would come by and our wet garbage, they'd come by with a manure spreader pulled by a tractor—at first a horse, but later on a tractor—and throw the wet garbage in that, and take it up in the field, and spread it out on the field. That was all. We'd go to the dump. We didn't have a landfill; we had a dump. And I said my dad used to take me hunting: we'd go plinking. We'd have a .22 and set up little bottles at the edge of the dump and shoot them. Or shoot the rats. And we'd find good stuff up there that somebody set aside when they went to the dump, and they knew it wasn't trash, so they didn't heave it over the edge. They just set it off to the side, and we'd say, hey, we could use that old chair. And we'd pick it up.

01-00:46:36
Burnett: So that's not burial, it's just an open pit.

01-00:46:39
Langer: No! It's an open pit. And we did just heave things over the edge. All the trash just got pushed over the edge. That was not a sanitary landfill by any means. And nobody knew any better. Well, now, that would be a terrible place—and then it turned out to be a terrible thing. The runoff in that stream, creek, that was down below it, I sure wouldn't want to do anything with that. And we learned better. But the assumption was if you put in a dump in the eighties, it was going to look like the ones that they constructed in the sixties or fifties, when I was a kid. And that was an improper assumption, but it took over. And it became the driving force of a lot of land use decisions.

01-00:47:20
Burnett: Yeah. I mean, it was in the air. There were those television commercials from the seventies featuring the American Indian who's riding his horse through the wild, and then he comes to the top of the hill, and he looks out, and he looks over at the big garbage dump, and there's the tear going down his eye. That kind of environmental consciousness-raising was in full force in the seventies, and by the eighties, Earth Day was a big annual occurrence, and environmental consciousness was being imparted in school curricula, and things like that.

01-00:47:51
Langer: And a good thing. And a good thing. It's not bad. That was a good thing.

01-00:47:55
Burnett: Yeah. And so some of the work that you were doing was around that? To some extent?

01-00:48:05
Langer: Well, it was. Especially prior to the nuclear-waste disposal. It was, okay, we do need resources; we do need to live on the Earth. How can we have our footprint be minimized? How can we tread lightly on the Earth, and look out and not ruin things? The USGS never argued that we didn't need some kinds of regulations, and didn't need to take care of things. In fact, I was one author of many of a watershed document that the USGS produced in the early eighties, called "Nature to be Commanded," and it's part of Francis Bacon's "Nature, to be commanded, must be obeyed." And these were a collection of case examples of how you could use geology, hydrology, and understanding of nature, and could live within the boundaries set by that. But one of the troubles is that when people oppose something nearby, the rules don't count anymore. Even the natural rules. It becomes NIMBY: not in my backyard. And the only way to stop things may not be through a real sound understanding of the conditions, it's through more arm waving, and screaming, and loud protest.

01-00:49:40
Burnett: And the local activism had the effect of just displacing it to areas with less social and economic power, presumably, right?

01-00:49:47
Langer: Yes. Yeah.

01-00:49:48
Burnett: So if people say not in my backyard, then they'll find a backyard where the people are transient, or they have less power. And then there's an equity issue there, I suppose, you know?

01-00:50:00
Langer: Absolutely. The corollary to not in my backyard is: in somebody else's backyard.

01-00:50:03
Burnett: In somebody else's backyard, and it's going to go somewhere.

01-00:50:06
Langer: And that would happen. And somebody else's backyard may not be the best backyard.

01-00:50:09
Burnett: Yeah. Well, that's an interesting reflection. And so there's the decisions that are being made are not—scientifically-informed decisions are also social and politically-informed decisions, in other words. That there's a balance of considerations that take place, and sometimes the best engineering proposition is not accepted because of this kind of political controversy.

01-00:50:39
Langer: Right. Absolutely.

01-00:50:41
Burnett: There's a kind of subset here, getting into the nineties, there's this Missouri River Basin project that you were involved in. Could you talk a little bit about that?

01-00:50:59
Langer: Yes. When the Yucca Mountain effort was winding down, or at least for me, I was able to transfer back to the group that I used to be with that did geology. And so I became, instead of a hydrologist, I became a geologist again. And at that time, once again, they decided what are we going to do that really demonstrates the value of geology? And a large part of the US that had been relatively ignored in recent years by geologists was the Missouri River Basin. And they were begging people to do something there, and I said, hey, I could do something there. And so the first thing I did was to form a coalition of the—I believe there were seven, or a dozen, state geologists along the Missouri River—I could count them, but it's not worth the time—along the Missouri River. And we decided, let's start out and figure what kind of natural issues are there to deal with in the Missouri River Basin? Well, as luck or Mother Nature may have it, the Great Midwestern Flood of 1993 happened. And that opened up and said, well, that's one of the problems. Along with that, there's all the other socio-economic problems that are associated—or, I mean, geologic problems associated with developing areas. Largely rural, largely agricultural area. And so you find the problems of pesticides, herbicides, and problems of waste disposal in areas that aren't sewer, and so on and so forth. And you find little, tiny exploding population centers. And so how do we handle all that? And so amongst all the state geologists, we lined up three areas that looked like they would be good to study: one around Iowa City—no, I'm sorry—yeah, Iowa City.

01-00:53:22
Burnett: Sioux City? No.

01-00:53:24
Langer: Sioux City. Sioux City. [Actually, Omaha, NE, and Council Cluff, IA.] One in St. Joe, and then one on the other side of the river in Leavenworth. These appeared to be areas where the population growth would be becoming heavy, and that we could use good effort. Well, funds never covered all of those, and so we narrowed it down to what we'd take off in St. Joe, and I was fortunate enough to be the geologist that got to work in St. Joe. But as luck would have it, the geologic work got done, which was a hoot, I loved doing geology. And it was yet another completely different area. I was in New England, where the glacial geology was fresh; I was in Virginia, where the rocks were old, and tired, and weathered, and beat up; and in St. Joe, it was largely influenced by glaciers, but the glaciers were half a million or years older, and so there had been plenty of time for nature to rework everything, and it doesn't look like a freshly-glaciated terrain anymore. So yet another geologic challenge, which made it fun. But when that was done, there was really no effort, and unfortunately, no real desire by the town folk in St. Joe to use the data. I came

in with maps that showed in simple terms what they could do, and the planning development guy pointed at the wall and said, “Well, here are the developments we have, and they’re approved. How can you help me now? They’re approved.” And I said, “Well, are you expecting any in the future?” And he said, “Well, I don’t know. But these are what we’re dealing with.” And so although it was fun, it was back to the traditional geologic mapping, which I enjoyed but missed that challenge of how do you bring all this together to something useful.

01-00:55:26
Burnett: Yeah. I mean, that’s so much of the history of US government scientific research, is finding a service angle. Like, the agricultural experts, the extension service: you go out and you demonstrate the value of the work, and then the customer, so to speak, would come to you, the citizen, the farmer would come and ask. They’d know they could go to their state or county extension agent. And I guess there wasn’t—these almost sound like pilot projects for something that doesn’t quite get off the ground. Is that a fair characterization?

01-00:56:00
Langer: Absolutely. In fact, they were called pilot. They were routinely called pilot projects, with no thought of what would happen after the pilot film went out. If you look at a pilot TV program, if it works good, they turn it into a series. This one was, it’s going to be a pilot, and whether it’s good or not, that will be it. It shows what we can do, but let’s go back to doing what we do best.

01-00:56:26
Burnett: Which is unfortunate. I mean, the whole piece of it is you need to demonstrate the use, right, to get—

01-00:56:33
Langer: That was my belief. It still is. And my goal.

01-00:56:38
Burnett: Yeah. And it had worked. You had experienced the joy of being useful, and of service, and that people were able to make use of the work that you’d done, and that’s, of course, satisfying.

01-00:56:52
Langer: Yes. Absolutely.

01-00:56:55
Burnett: The next phase is this Colorado Front Range Infrastructure Resources Project.

01-00:57:03
Langer: Yes.

01-00:57:04
Burnett: Is that another kind of pilot project, or is it something different? You’re the Senior Research Geologist for this, and this is 1996.

01-00:57:12
Langer: Yes.

01-00:57:12
Burnett: Through to the end of the decade.

01-00:57:13
Langer: That was great. What happened: there were budgeting problems, and Congress, or OMB [Office of Management and Budget], or somebody—again, I was never involved at that level—decided that they would yank away $2 million from the minerals program. Just take that money away. And the director [of the USGS] gasped, and said, "Well, how about if we come up with a project to use that money that would really demonstrate the value of the work that we're doing, and not only demonstrate it, but would implement it." And they bought it! And so a call was put out to people to send in applications or proposals for this kind of study. And a group of us—hydrologists, geologists, topographers—put in a proposal for the Front Range urban study. And what that was, was we would look at all of the natural resources along the Front Range, the need for them, where they're coming from, where they're going, including aggregates, water, [oil,] other mineral resources, and how the topography and the land-use growth affects all of that. And they selected our project, and that became, then, that project was a five-year timeframe to implement it and saved the USGS from losing a couple million dollars, and gave us the basis for a good project. A little bit more about the history: when that finished, that same $2 million then came up for grabs and people liked the work that was done so much that it was extended another five years to broaden the study to look at more detail on the other industrial minerals.

01-00:59:19
Burnett: Yeah. Brilliant. Well, it sounds like as far as the government side that interfaces in direct and indirect ways with the mining industry, the mid-nineties are a pretty bad time. I guess '94 is the Contract with America from Congress, and there's this kind of fiscal responsibility orientation. In spite of the fact that it's the boom years in tech and other sectors, there's this cutback climate, I suppose. The US Bureau of Mines is shut down in '95, '96, and there's this trimming here. And there's this adaptation that your group does, the person in charge whose name was—do you remember his name? The person who made that deal saying if we make a project that is profitable right—or, not profitable—

01-01:00:10
Langer: Oh, I believe the director at the time was Gordy [Gordon Pryor] Eaton.

01-01:00:13
Burnett: The director of the USGS over—

01-01:00:15
Langer: Of the USGS.

01-01:00:16
Burnett: And he was able to make that pitch, and they bought it, and bought in again, subsequently.

01-01:00:19
Langer: Yeah. Yeah. Actually, I think the timing of that was either very late nineties or early two thousands. In the mix, or just coming out of the Contract with America and so forth. But before that, something else happened. The Survey was trying to reinvent itself, and they had people come in and train us on, you know, huggy, squeezy, you know, warm, fuzzy kinds of stuff.

01-01:00:57
Burnett: [laughter] Can you be more specific?

01-01:00:58
Langer: Kumbaya kinds of stuff. You know, how to manage people, and better—and one of the things they tried to do was have people empower the people to have more control over the organization itself. Well, a group of us said, they want to play that game, we'll do it. And we started something—I can't even remember the acronym that we had, but basically it was a group of us that got together and said, we believe that multi-disciplinary geology is the way that the USGS should go. And so we followed all these steps that the people told us you should do, and we actually went to the chief hydrologist and chief geologist—we never got to the director, but we had a meeting with those people making a—oh, I know. We called ourselves the E-Team. The Environmental Team. And we went to the chiefs of the division saying, "This is the kinds of stuff that we think we should be doing collaboratively, as an interdivisional group." They kind of bought it. And that, eventually, gave us some of the leg up to why the Front Range project came about. Because many of the people that were part of the E-Team became part of the Front Range project.

01-01:02:34
Burnett: That's great. That's great. So there was something, even though it was huggy and squeezy, interpreted in the correct way, it produced some results.

01-01:02:44
Langer: Yes. Yeah.

01-01:02:45
Burnett: And you were able to run with it. And so just from the records here, it says 1996 to 2001 was the Colorado Front Range infrastructure resources project, so it winds down early two thousands, as you say. And in 2002, you become the Senior Research Geologist for the Geology of Industrial Minerals.

01-01:03:12
Langer: Yes.

01-01:03:12
Burnett: So, can you talk about how—is that a new position? Or are you taking over something that has been going on for a while?

01-01:03:21
Langer: They're more titles than positions. What happened was that the Front Range study of aggregates went over so well they said, "Let's broaden this to look at all the industrial minerals along the Front Range." And as a matter of fact, the Forest Service was one of the people that really wanted us to do that, because there is the idea that Forest Service land is a multi-use land, and there are resources on it, and if done carefully, they can be developed. And so they wanted to know what was on some of those lands. And so I was appointed the—and agreed to be, and pushed for—to be the project chief, and along with that, then, came this glorious title. [laughter] But basically, I was a senior research geologist, and they then add to it by adding that little modifier to it, for industrial minerals.

01-01:04:22
Burnett: But it sounds like it's more in keeping with your identity as a researcher, that you wanted this stuff to be useful.

01-01:04:34
Langer: Absolutely.

01-01:04:35
Burnett: The work that you did to reach people, to reach projects, to produce new knowledge and new work—

01-01:04:41
Langer: Yes. But something else came about at the same time. In the mid-nineties, I was introduced to SME [Society for Mining, Metallurgy, and Exploration]. I'm a relatively new member in SME. I've only been here twenty-some years, and people my age, most people my age, were here thirty or forty. They got in on the ground floor, and I did not. And SME became my compass. It really helped me identify—and the people in it—helped identify where are their needs, and where are they that relate to my needs? My only exposure to mining, the first job I had was mapping where existing aggregate operations were, so I was looking for mines. But as a geologist, the only reason that I looked in the sand or gravel pit was to see the exposures afforded by a hole in the ground, rather than peering down something I dug. Mother Nature didn't provide such nice observation points. I didn't even look at the equipment off of the side. I'd go in, and I'd stop at—a young whippersnapper, still shaved head, and would go up to the scale house and say, "Hey, can I look in there, look in your pit?" And I'd say, "I'm with the US Geological Survey. Can I make it a map?" And they'd say, "Sure. If it's big and yellow, stay out of its way."

01-01:06:07
Burnett: [laughter] Because it's uranium?

01-01:06:08

Langer: No, no, no. Trucks. [laughter] Earth-moving equipment. That was my safety training. No hard hats, no steel-toed boots, no nothing. Not even a—nothing. And they just let me alone. By the time we got to the Front Range, I had to sign papers, I had to have on-site job training. And I don't mind. I never minded, because they would still let me in and look. And I was perfectly willing. But a complete change. But it was also a change for me, to where until the nineties, what's that equipment? At least it was on the floor of the pit so it wasn't in my way. And the only problem was that where they were mining the face, I had to stay, because it was big and yellow, and I had to stay out of the way. But then starting in the mid-nineties, I started spending all this time looking at the equipment, and seeing, what do they have to do to make the sand or gravel something they can sell? I thought they just pulled up a truck, and dug it, and threw it in a big and it went up. That's not the case. I mean, it's a real serious job.

And at that time, I met a fellow named Mike [Michael D.] Sheahan, and he was in the aggregate business, and he was part of the Front Range project too, or at least a resource for them. He taught me everything I know about the aggregate business. Not about geology, but about the business. And the first thing he told me was there are three parts to the aggregate business: there's product, there's marketing, and there's everything else. If you don't have a product, you're out of business. If you can't market it, you're out of business. And he said, "Bill, geology is in everything else. And when things have to go, it's the everything else. But you cannot do away with marketing, and you cannot do away with the product preparation." And it was an eye opener for me, because I thought geology was everything. [laughter] And geology is everything else, and it's expendable. And along those same lines, one of my other friends, short-lived—short-time friend, because we weren't together that long—he told me when I was finishing his pit, "The only reason they hire geologists is so they have somebody to fire during the downturn." Six months later, there was a downturn, and he was gone. How prophetic! So it just really helped me see what. So I'm thinking, what can I do as a geologist? I'm not going to be fired tomorrow. What can I do as a geologist that can help the aggregate industry, that can help the mining of aggregate? And that's where SME came in and provided me with a compass. And then that expansion of my efforts to include industrial minerals provided me with an even better compass to see how geology can really be used to address serious bona fide issues, other than just, oh, geologic curiosity: "gee, that's kind of neat to know." It's more than that. There are real ways that geology enters the game, and I'm grateful to SME for bringing me along.

01-01:09:36

Burnett: Well, the timing is such: it works out with the other information that I've been gathering. The US Bureau of Mines is shut down in '95, and the story is that some of the information services that the US Bureau of Mines used to do got shipped out to the US Geological Survey. So I don't know how that fits into

your story, whether there's an official transfer of resources. According to my sources, there was not really a transfer of personnel so much, but the information-gathering aspect in terms of geological knowledge got transferred to the USGS.

01-01:10:21

Langer: What happened: the Bureau for Mines used to do all kinds of research, and have come up with some very, very good ways of processing minerals. Froth flotation is a perfect example of a technique, now, that's employed all over the world, designed because of Bureau of Mining efforts. Priceless for the mining industry, but, yeah. For some reason, people didn't think the Bureau of Mines was necessary, but there was one part of it. And that was the part that collects statistics on production, and they had been doing so since the late 1800s. I go back to them all the time. History is a lot to me, and I still use those old documents. But they did transfer that function, and the few people—very few people that were doing that. And there were a few other tagalongs that were part of that group that weren't actually doing statistics, they were doing the analysis of the statistics. But most of it was just collecting the statistics. Most of those people ended up in Reston, Virginia, but the ones that were doing the analysis ended up in Denver. And I befriended many of them, because they were doing exactly the kind of thing that I thought was valuable: what can you learn from the history of production to use to predict what might happen in the future? What happens to bumps when you find a downturn? How does a production recover over time? I was only lucky enough to get to work on a paper together with one person from that group, because they had very tight controls over their time, but we put together a paper describing what has happened along the Front Range—they were included in that Front Range study—and historically, you put together a chart showing the construction of, oh, that's Cheyenne Mountain, there was a big blip there. Big blip in the Denver Airport when that was built, and you can see the use of construction materials, how all of these things affected demand for aggregate. And then we looked at how urban growth and transport distances affected the ability to meet the demand and needs for aggregate, collectively.

01-01:12:54

Burnett: Yeah. And road and highway construction, I imagine, which is a bit more of a constant, I guess.

01-01:13:00

Langer: It came in spurts. But it was always there. It was always the background. An upward line, but a wiggly upward line, as opposed to some that just go and stop, never get— Cheyenne Mountain was once; the airport was once.

01-01:13:12

Burnett: Right. Well, it sounds like you're almost venturing into mineral economics territory.

01-01:13:19
Langer: Yes.

01-01:13:20
Burnett: You're thinking about, you know, the trajectories of production, and the boom- and- bust cycles, and those kinds of things. That's something that you're interested in and tracking. But it also sounds like there are services that the US Bureau of Mines used to provide that, even with the transfer are no longer available, and so, I imagine, the kind of work you were doing was welcome. So you learned a lot from SME, but SME was probably grateful that you were there doing that kind of research.

01-01:13:54
Langer: I like to think so. [laughter] Yeah, I hate to brag, but I am the recipient of the Hal Williams Hardinge Award, which is for outstanding contribution to the industrial minerals industry. And that validates my career to me, because that's what I wanted to do, to impact the industry. I didn't want to just have maps sitting on a shelf. And when I found out I was a recipient of that award, it just made my day, and I still, I can't believe the emotional meaning to me. It's wonderful.

01-01:14:33
Burnett: And industrial minerals is not something we typically know a lot about. When there's education about mines, the kind of sexy mine stuff is gold, and the metals, the hard-rock mining. Coal mining is, if it's not sexy, it's notorious. It's the bad boy of the industry. [laughter] In the public mind, perhaps. And so industrial minerals is, as you said, because you didn't know what went into it before you started. You kind of thought it was relatively unproblematic: it's rock. It's bulk.

01-01:15:17
Langer: Right. Right. And I was a geologist. I should have known better! I should have known better. [laughter]

01-01:15:24
Burnett: So can you talk about the learning curve for you in terms of industrial minerals. It's not just one or two. It's not just aggregate; it's not just the stuff that goes in cement. It's many things. Can you talk a little bit about what industrial minerals are useful for, and what's tricky about mining industrial minerals, from your perspective as a geologist?

01-01:15:49
Langer: Okay. I think as far as my learning curve goes, I throw myself into things. And in the Front Range, the Bureau of Mines—or the folks that were left over from the Bureau of Mines—track the production, and they track the location of existing operations. And so it was very easy to see where this is being done. And so the next question that comes about is, well, we know physically where it's being done, what kind of rock is it being done in? And what are the problems that go along with it? That's where it starts to get tricky. And

basically, what I wanted to do is first learn as much as I could about that industrial mineral. And so collectively, with a couple other scientists, primarily Anna [B.] Wilson, we went and put together some papers looking at the history of industrial minerals. I've done the same thing with aggregate. For me to understand a commodity, I have to see how it's changed over time.

And I looked at the very first time when people were using aggregates—I mean, Stone Age, everybody likes to go back to that. But realistically, before we had good roads. And starting with the Good Roads Movement, then the interstate highways, all the way through, to see what happened. Well, I did the same thing with industrial minerals in the Front Range: which counties, where had they been produced in the Front Range? And quickly learned, well, there wasn't enough data just in the Front Range to understand this, so we went through the whole seventeen Western states, and looked at the industrial minerals. And then you start seeing where things were being done: that New Mexico does perlite, and Washington does diatomaceous earth.

And then you say, well, what's driving these markets? I mean, somebody didn't just wake up some morning and say, "I'd like some perlite." What's driving the market? Strangely enough, perlite is an example: wasn't even on anybody's radar until the 1940s. Perlite is something that you buy in a bag. It's white. It looks like puffed wheat, or puffed rice, but it's a rock. In the mid-forties, there's two stories of how it's developed, and I'll go with the one I like. And that was that a geologist was sitting on a beach in an island in Greece, a volcanic island in Greece, Milos, and had a campfire there, and the fire got real hot and started popping the rocks. And he said, "Hey, maybe we can use this." And they decided they would start—you know, what can we use it for? And it became a lightweight aggregate with all kinds of uses.

Well, it quickly caught on, and many Western states have sources of perlite. And so does Greece, where they found it. The problem is it's heavy until you pop it. And then it's bulky. And so how do you get it from Western states, where it exists, to the Eastern states, where we want it? Well, you move it in a railroad car when it's heavy. Because, I mean, you can't afford to ship hundred-ton railroad car with five tons of perlite popped in it. So the popping plants are all where it's needed. And for a while, rail worked. And they tried bringing it from Greece, but they just couldn't maintain a supply. Well, they came up with the idea of just-in-time supply. And so now, they'll bring it from Greece, drop it off at a US popping plant, and pop it, so it's not going from the West. So now, we're importing large amounts of perlite from Greece. Well, some things have happened to that market recently, and the US market is picking up. In fact, we're now exporting to Canada, and Greece is not taking it to Canada and not bringing it here, so it's cut into the market.

Well, those kinds of things—and I use perlite as an example—those are the kinds of things that make industrial minerals interesting, and something that, as a geologist, if you understand those things, then you can worry less about

physically, where it exists, and more like the properties: what does it need to do to pop? I mean, another example would be lightweight aggregate made from heating clay. Well, clay does one of two things when you heat it: it either turns into a brick or it blows up into lightweight aggregate. There are no mineralogical associations between which it does. It's like, how do you know? Experience.

01-01:20:47
Burnett: Really? Really?

01-01:20:48
Langer: Really. And so, some of these things, as a geologist, it makes your life complicated. But you need to understand those things in figuring out how geology can be brought to bear. But the bottom line that you need to understand and convey to the people is that Mother Nature puts it where Mother Nature wanted it, and "not in my backyard." If it's in your backyard, that may be the only place it is, and we have to learn how to deal with that. And that's one of the biggest things that I find about industrial minerals, as far as the mining. I'm sure there's issues that relate to the geologic structure, nicely layered. Simple geology is easier to mine than contorted geology, and that sort of thing. But miners know that. Well, some of them do. But most geologists do. But I try to reach these other niches, where people kind of forget about them, and bring them to the forefront and educate people. And the other part is to just let people know that when they brush their teeth in the morning, they're putting rocks in their mouth. [laughter]

01-01:22:02
Burnett: Right. Well, again, it sounds to me that you've got a bit of an economist in your blood there. [laughter] You're thinking about access to markets, you're thinking about distance, you're thinking about mode of travel, in addition to the geology. The geology becomes the piece of a larger social, political, and economic puzzle.

01-01:22:28
Langer: Absolutely.

01-01:22:28
Burnett: And you like the puzzle solving, but you like your puzzles complex.

01-01:22:33
Langer: Yes. I think you hit on it, yeah. I've kind of really not looked at it that way, but you're right.

01-01:22:37
Burnett: Yeah. It needs to be complex for you to find it satisfying, and you like bringing to bear—one of the goals of this project is thinking downstream to education, and people with accomplished careers, one theme is that you get more mileage in terms of job satisfaction, career satisfaction, and advancement by learning different things and keeping moving. It sounds to me

like you've had a kernel of, you want interdisciplinarity, you want contact with different kinds of disciplines and knowledge, different kinds of people, different kinds of projects. And you like to keep moving. There's fate as part of it, as you said, but you're also active in making choices about becoming part of communities, and part of knowledge communities, and that's something that you've done really well at. And so these industrial minerals are complicated, and I've talked with others about the ways in which they're complicated. They sometimes have unique properties in particular locations, which is why geology is so important. And sometimes they also combine them into compounds that have particular applications that satisfy particular markets. So you finish up that part of your career around 2011. Can you talk a little bit about what happens after that?

01-01:24:14
Langer: Yes. I'd love to. When our grandchildren were born, we spent large amounts—which was, we have a ten- and eleven-year-old, so 2004 and 2005, I believe, if I do the math right. We would take regular trips back and forth to—we lived in Denver and then regular trips between Denver and Phoenix to visit. And when our granddaughter was born—she happened to be born on my birthday—they moved in to a new house. About two years later, they called and said, "Mom, Dad, the house across the street has a lockbox on it, and we want you to buy it." We kind of looked at each other, said, we loved our parents, but I'm not sure we'd want to live in a house across the street from them, so we thought about it said, well, maybe we could. So we went down, put an offer on the house. It was turned down. And so we thought we'd let them stew a bit, and our son-in-law called up a couple weeks later and said, "Don't let that house get away." Our son-in-law! We only have one child, and so it was not favoritism moving there, and so we went down, bought the house, and rented it. Rented it out. And we knew, for five years, that we would be moving down there, getting closer and closer to when I was ready to retire. And the day came when there was no reason not to retire, and we put our house on the market and moved down there. That's what got us out of Denver.

And at that time, we decided that I would dearly love to continue in the business, but clearly not full time. We decided, well, maybe quarter time would be enough to spend. Whatever quarter time is. I don't have a punch clock. How do we keep track? So, whatever—basically, what we meant was if it starts to be where I'm getting too much work, we'll stop. And I was fortunate to pick up a consulting job as an expert witness right away. Right away. And that continued, and I've continued on doing consulting at that level, being a full-time grandfather, father, and husband—

01-01:26:38
Burnett: And neighbor.

01-01:26:38
Langer: —and being a part-time neighbor. [laughter] And being a part-time geologist, and I'm just loving it, and still get to associate with people like this, come

back once a year, and see my old friends, and get together, and share stories about what's going on.

01-01:26:54
Burnett: That's wonderful.

01-01:26:55
Langer: And the best part is people pay me for my work now, which means they want it. I mean, if it wasn't useful, they wouldn't pay me. And so now, my whole goal through my life has been to do useful work. And now they're validated every time I get a paycheck. Which is a double, then. The money is nice, but it's also: "we like what you do." And I have a customer, a client—I guess that's what we call them—that comes back over and over. I'm on the fourth project with them. Which tells me they really like what I do. And what else can you want? I'm having fun doing it. I'm loving life. I have a great time doing geology, and they tell me they like it.

Another thing that I've done is I've been writing articles for a trade journal called *Aggregates Manager* and also one in Australia, called *Quarry Australia*. I've been writing articles there. This month, I wrote my 200th article. I write one a month. It's telling a geologic story to people, to aggregate producers or quarriers, who don't really do that much with geology. But their life is a result of a geology, their livelihood, but they don't understand it. And so I write stories, and I have three goals: one is that they'll read the whole article, because I watch people, and if it's too long, you get about halfway through and then you start skimming, and then you forget the end. So, 600 words max—575, really, max. One page. The second goal is they learn one new thing. And that's what I liked about my job in the past: every day I learned something new. And I want them to learn one new thing. Doesn't have to be earth-shattering. Doesn't have to be great. Just one new thing. And then the third goal is have them to want to read the next one. And so I make them personable, and I include stories about my grandkids, or my dogs, or my wife. I don't get many about my wife, because she edits every one, and grades me. And she doesn't want me talking that much about—And if I don't get an A on it, I won't do it. So. [laughter]

01-01:29:16
Burnett: Right, right. Well, it's good that you have an editor in several senses, then. [laughter] So you have this expertise, and you've done this kind of translation work for the broader aggregates community. I would like to take this opportunity now to ask you about the big shifts in the industrial minerals and aggregates industry in the United States, and perhaps worldwide. What are some of the big sea changes in those industries in the last ten or fifteen years?

01-01:30:00
Langer: Sure. And I'd like to talk mostly about aggregates, because I was mostly involved with that and maybe spin off a little bit about some of the industrial minerals. As I mentioned a while back, when I first went into pits, there was

no control. These were—maybe not mom-and-pop organizations, but they were not big mega-companies. They did a very good job, but there was no reclamation required of pits. When you were done, that was enough, you know? The interstate highway system was still underway. The construction was still underway, although the biggest push was over. But it was still going on, never really finished until the nineties. It's still being—you're still seeing small pieces. So you're going along the roads, and every five or ten miles along the highway, you see a pit, which maybe now holds a motel, or a shopping center, or something. And they were not expected to be reclaimed. Nobody asked them to. And I'm not sure what they would have done to the effort if they had. But it was: "dig it, get a resource out of the ground." The mining techniques were fairly well established. It's like construction, just digging holes. The processing was fairly well established.

But then as time went on in the seventies, the environmentalism came in, and NIMBYism—well, two things came about: NIMBYism, but the other was rampant urban growth. If you go through the literature of the seventies, you will find all kinds of state geological surveys doing reports on what they called sterilizing aggregate resources. You have land, it's nice and flat, it's near a river, it's well drained. Sand and gravel. Perfect place to put a house. Perfect place to put a septic system. And so you build your subdivisions there. Well, now where are you getting your sand and gravel from? Well, I guess under this house. Well, no you're not. And so there were huge efforts put in by the state geological surveys, and a little bit by the USGS, to identify where these resources were being covered up and being sterilized. And the project that I worked on in Connecticut was doing part of that. We were pointing out: some of these are resources. They aren't just good places to live. And that's why I mentioned earlier how pleased I was that they had protection of a quarry on one of their plans of development. I'm not sure that that ever caught on. It might have been one of those things we were worried about that we didn't need to worry about, the Club of Rome kind of concern. Maybe it just wasn't a problem. Because we haven't found successful ways to protect them, and yet we're still getting sand and gravel and crushed stone.

Over time, NIMBYism started required people to be more responsible. Not only with how they mined, but closing the mines. But there were some difficulties in understanding. A lot of times they wanted land restored to the original contour, and when you dig out a hole and use what was in the hole, to restore to the original contour means digging another hole to fill it up. And then it's a shell game. It won't work. And so it took some insight, and we found landscape architects getting involved with geologists and miners to come up with innovative ways to reclaim land. And so you find real estate lakes. I was doing some mapping, and was kind of peaking around between houses from the road—didn't want to get permission to go, so I wasn't going to knock on the door, just peaking around. Woman came out and asked what I was doing. I said, "Well, I'm just looking at the lake out there to get a sense." And she said, "Oh, yeah, we love it." And I said, "Did you know it was an old

gravel pit?" She was incensed. "It was a grav—" "It was not! This is a lake!" Well, it's a beautiful lake, but it was reclaimed in a nice manner. And they do the same with quarries, cement plants in Lake Michigan, the limestone quarries to feed the cement plants have turned to some prime, really, really expensive places. They turn old aggregate operations into pieces of art. I mean—

01-01:35:05
Burnett: Yeah. Recreational scuba diving.

01-01:35:05
Langer: Recreational scuba diving. All kinds of wonderful uses. So people have caught on now, and so the reclamation part is a great change from an open pit that maybe you could throw garbage into—not a landfill, just throw garbage into it—to some really fine after-market second uses. Equipment has gotten better. The methods of processing, the specifications for highways are always increasing. They're always trying to make highways better and better, and they learned that the size of the particles in the highway are important, and the grading of the sizes in the asphalt or concrete are important. And so they're constantly jiggling those, and aggregate operators have to find ways to process it, to make those parts. Because they don't come in, all fractured nice, the same size. And you can't just break it all and sieve it and keep the best size and throw away everything else. You want to make sure that when you break it, you break it into close to the approximate sizes. And that takes new types of crushers, and new ways to feed the crusher: do you choke feed it? Do you feed it where you flood it with aggregate, or do you gently feed? All these things matter.

But geology matters, too. The type of rock that's going in. And if you find an aggregate operator that just treats their pit—or, more likely, quarry—as homogeneous rock, they're going to wake up some day and have problems. And I've had calls from people saying, "What's going on? Our rock is out of spec." Well, if it was like this, this is spec. And this is—you know, and it's real good. And then they mine it, and it's like this, and this, and this, and they're okay, and they're okay, and they're okay. And then all the sudden, oh, we're out of spec! Well, it's been changing all along, but as long as it's in spec, it doesn't matter. The rock was changing all along, and if they had caught that, they wouldn't have been surprised when they got here. And that's something that I've tried to make clear in some of my articles: geology makes a difference. So the methods of processing, the equipment has gotten better for digging, and for reclaiming, the screening.

Operations have become bigger. Bigger and bigger. We have operations that produce 5 million tons of aggregate a year. That was never the case. There are mega, international companies now producing aggregates. A lot of the mom and pops hang in there, but during this last housing bubble, and then predatory lending and collapse of the housing bubble, they had to go out of business. I

mean, the aggregate production went down to one quarter, in some places. One quarter. And most companies can't afford that. Well, the big ones hung in. A lot of the little ones were gone. Some of them had to sell to the big ones, who buy it not for the resource, but to keep the small ones from coming back online when it's over. And it's an extremely competitive business. There's a good profit to be made if you do it right. Because of the volumes, you make a little bit of money on lots of stuff. You sell 5 million tons, you don't need to make a lot of profit on each ton. So the companies have gotten bigger, and international companies.

01-01:38:51
Burnett: Yeah. And export? Or is it too bulky to really export economically?

01-01:38:58
Langer: There's a small amount of export, between US and Canada, across the Great Lakes. And Puget Sound area. There's some between US and Mexico. But where most of the exports take place are in the aggregate-poor parts of the country. Florida is pretty starved for good quality aggregates. It's underlain by limestone, but it's a soft limestone that doesn't stand up. And in particular, it doesn't have good skid-resistant properties. When you build a road, you want something where, when you're driving a car down the road and you come to a corner, it goes around the corner instead of off the corner. That's call skid resistance, and there's a certain kind of rock that works for that, and Florida does not have that. And so they will actually import materials in Florida from Nova Scotia—Porcupine Mountain in Nova Scotia—and from the Yucatan. Well, that's more limestone. But also from parts of South America. And it's because ocean transport is fairly reasonable, and because you don't need huge, huge, huge amounts of the skid-resistant material.

There was a short period of time when they tried exporting aggregate from Sweden over to the US and it lasted for a while, largely because they would backhaul US goods, and so the backhaul was the main product, and they were just keeping an empty ship from going over there, so they put some rock in it. And hey, they did that in colonial times. All those cobblestone streets are ballast, and so we imported aggregate in colonial times so they could haul the colonial products—tobacco and whatever else we were doing—back to England, back to the mother country, right? They do the same in Puget Sound. The airport took such a huge—expansion of the airport took such a huge demand of aggregates that they would haul it down from Canada, from British Columbia, and haul it down just because they couldn't meet the demand. And because local aggregate producers weren't quite willing to spend the capital for a one-shot deal. The same happened with the Denver Airport. They hauled aggregate here from Cheyenne, or past Cheyenne, because nobody wanted to put the money into building new equipment for a three-year project.

01-01:41:42
Burnett: I wanted to just return to your involvement in SME, to sort of close off here. You've been chair of the SME industrial minerals and aggregates division.

01-01:41:52
Langer: Yes.

01-01:41:52
Burnett: Yeah. So that's a fairly high level of involvement, and a tribute to you, because you're a geologist. You wouldn't necessarily expect a geologist to be in that position, so it speaks, I guess, to the esteem in which you are held in the community.

01-01:42:14
Langer: Well, I guess so. Or maybe I gained some of the esteem by doing it. At that time, we had a career ladder. The division had a career ladder. And there were seven rungs on the ladder. You started out as in a technical group, organizing the writing of technical articles. Then you became in charge of that group, and then you worked your way up through various things, seven years. And so you got to learn an awful lot about the division, and about SME. Not only on the ladder, you were also then coerced or volunteered to go on various other committees, including SME. Not just division committees, but SME committees. And I took my job seriously. I figured if Uncle Sam was paying my way here, I owed it to the taxpayers to do a good job when I was here. And so I volunteered for these things, and learned a lot about the group. It was a really wonderful ride up the ladder. But it introduced me to people and gave me insights about the industry that I never would have gotten without being here. I said earlier, SME was a compass for me, and these people were little lodestones that my needle's pointing to.

01-01:43:37
Burnett: Right. Right. Others I've talked to—not in mining, but actually the one that comes to mind is pharmacokinetics—scientists and engineers talk about how much they learn from contacts with industry, for example. So this guy was an academic, and his involvement with industry, he learns research questions. They come from the fact that the industry is puzzled by something, and so by doing this work for SME, you're getting exposed to puzzles that need solving.

01-01:44:13
Langer: Absolutely. Yes. Yes. A good example of that, I guess, would be: we had part of the Front Range project, and I was fully involved in SME when that was going on, there are oil wells around. And I had to learn something about oil wells. And I don't care that much about oil, other than that I put it in my car, and I'm glad the gas price is down. But had to learn something about oil wells, and how you take care of them, and what you do. Because there were oil wells competing with aggregate. Not only were there houses competing with aggregate, and farmers competing with aggregate, there were oil wells. And you can buy up a farm, but what do you do with an oil well? Well, you have to leave a pad around that for work-over rigs, you have to leave a way to get to that pad. There's a pipe transporting the oil out of that rig. You have to leave that in place. So it turns out that if you think you've got a large reserve of aggregate around, you've lost a big hunk of it if it's in the middle of an oil

field. And Denver happened to be in part of the D-J [Denver-Julesburg] Basin, and there were oil wells complicating things all over the place. And so I worked with people from the industry, and people familiar with the oil industry, to prepare maps showing how much aggregate is lost because of oil wells. Because you know oil well is going to win out.

01-01:45:43
Burnett: Yeah. Sure. Sure. I guess it's one of the things that is most striking by these insights that you have, is that it would never have occurred to me that aggregate quarries would be a kind of scarce resource. You're almost talking about it as if it were like wetlands or something. But it's industrial wetlands that need protection. Or, not need protection, but need to be monitored in terms of the other competing land use, right? And that this is something that needs to be monitored, and that the industry needs to be aware of, and that the competing industries need to be aware of as well.

01-01:46:24
Langer: Yes, and probably the industry itself is aware of problems with aggregate, or any industrial mineral. The main people that aren't are the decision makers, the ones that allow the industry to do what they would like to do. There's large parts of the US, in the North, where glaciers covered the land with thick material that does not contain gravel. You can go tens, hundreds of feet—not tens of hundreds. Tens of feet or hundreds of feet—to find good rock. There's no gravel anyplace. And to find good rock. And St. Joe was right at the cusp of that. You'd mine through thirty, forty feet of nasty, ugly ground. It's till. Glacial till. But it's a gray, sticky, nasty clay. You wear boots on it, and you lift up your foot, and boot comes off, it's stuck in it. I mean, it's nasty stuff. And you've got to get rid of all that. And St. Joe is about as far north as you could go to get a hole. And then any farther north, up in Iowa, they couldn't dig deep enough. They could, but the stripping ratio, it was too expensive. It just cost too much to take it off to get what you got when you got there.

And so they were buying aggregate crushed stone in Iowa, they were buying it from quarries in St. Joe. Well, people think, yeah! Not in my backyard. Do it over there. Well, it isn't over there. And that happens with all—industrial minerals are even more defined, because of their geology. It mean, aggregate, everybody thinks it's every place; it's not! There's lots of rock that does not make good aggregate, more that doesn't make good aggregate than does. They seem to think that everything is available wherever they want it. And of course today, the idea is we'll get it from China. And we don't even have to buy it in the US anymore, don't have to destroy anything. But we better be ready to deal with the issues of that.

A little story: used to be with potash. Great story. When the country was first settled, the New Englanders were farmers, and they had to clear their land. Well, it was expensive to clear their land, but when they cut the trees, they burned them, turned them into ash, put that ash into pots, and soaked in water,

and made a chemical called potash, or a material called potash, which was very valuable. And it about paid for the cost of clearing the land. And that was the only cash crop they had to start with. Well, as time went by, a source of naturally-occurring, rock-based pot ash was discovered in Germany. People said hallelujah! You know, we've got all the potash we need now. And we were importing 90 percent of our potash or more from Germany. Well, potash is one of the ingredients in gunpowder. And when World War I came around and Germany was the only source of potash, we got a little concerned. Then the rest of the story is we found a local source, and blah blah blah. But, you put all your eggs in one basket, you may not want them in that basket sometime.

01-01:49:54
Burnett: That's right. And that's been a story that's been repeated, kind of in the background. They make it explicit, as you have, and sometimes it's just in the background, that there is a geostrategic element to mining. For certain military and defense purposes, it had better be in your backyard, because if you're dependent on a single source that might be in hostile territory, you're in an awful lot of trouble.

01-01:50:27
Langer: Perfect example: rare earths another one of those industrial minerals that nobody ever knew about, probably everybody knows now, or has heard the term and thinks they know all about, but they don't. But anyway, the US used to be the world's largest producer of rare earths. And then China came on board and could produce it a whole lot cheaper. We stopped all of our rare earth production, and it wasn't until, I believe, last year, that we resumed rare-earth mining in the US.

01-01:51:01
Burnett: Yeah. In Mountain Pass, yeah. In California.

01-01:51:03
Langer: Same goes with fluorspar, it's a material that's used in all kinds of things, primarily to make hydrofluoric acid, which then is a feed stock in all kinds of chemical industries, but it's also in your toothpaste. And it's used heavily as a flux in steel. Well, the US used to produce all it needed, and then it became—it was hand cobbed, something you'd pick out of the rock by itself. Very expensive to do. So they started bringing it in from Mexico. Next thing you know, they come along and prohibit the use of CFCs, chlorofluorocarbons, which comes from fluorspar. The demand drops down, the US market, we can't make a profit anymore. So eventually, all the US mines close, and we started getting it, again, from China, too. We got into it. Well, China's starting to keep some of the stuff themselves now, and prices are coming back up, and we opened up a fluorspar mine once again in Kentucky, last year. So the wheel goes round and round, but people need to understand this. And if they say, "We don't need fluorspar anymore, let's build over all this stuff, let's never permit another thing," wrong. We don't want to go there.

01-01:52:29
Burnett: Right. Right. So the lesson is, I think, from your career, and from your insights, that interdisciplinarity is the key, and we need to keep our eye on the larger picture in anything. It's not just a particular technology, or not just a narrow research area. You have to understand how it fits into all sorts of other disciplines, and all sorts of other social, and political, and economic areas.

01-01:52:57
Langer: Absolutely. Which piece of the puzzle is it?

01-01:53:00
Burnett: Right. Exactly. As long as you get to work on solving it, you're okay.

01-01:53:03
Langer: As long as I get to solve the puzzle. [laughter]

01-01:53:05
Burnett: Mr. Langer, thank you very much for your time. I appreciate it.

01-01:53:07
Langer: Oh, it's been a pleasure.

[End of Interview]