Dan Cordier: Geologist

Interview by Allan McCollum

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AM: I know you were previously interviewed about our fulgurite project – I read one brief interview in the Tampa Tribune, and I read some comments from you about the project in Explorer Magazine. I want to know a little more about your background and your areas of interest and expertise, because when I worked with you on the fulgurite project last summer at the Lightning Research Facility I got the sense that you knew quite a lot about so many different things, and I was I never able to complete a mental picture of your interests as a whole. So I'm just wondering. I know you studied geology and specialized in paleontology or sedimentology?

DC: Both.

AM: I also know from your wife Tia that you've spent some time auditing law classes. How would you describe the way you accrue information?

DC: My overall interests are in earth sciences, which, of course, blankets a variety of disciplines. But at the core of that is the desire to understand the essence of the earth sciences – the materials of the earth. These include such things as minerals, rocks, and sands which are vital contributions to the development of our civilization. One could approach any sub-discipline of our civilization from that aspect, and I've tried to probe as many of them as possible with the aptitudes I possess.

AM: I didn't quite understand; you mean you generally studied earth sciences, but your interest is in how the study of earth sciences contributes to.....

DC: Not the study of earth sciences, but discovery of the physical aspects of actual materials that result from studying earth sciences. I have a very strong aptitude in mechanics, but, like anybody else that grows up in America, you don't necessarily do what you are best suited to do. You follow your instincts because we have that freedom. I should have become a mechanical engineer, but I didn't do that.

AM: Really? Well, I'd like to understand the sequence of these things. You did study geology, you studied paleontology, you studied mythology, and now some computer engineering. What sequence do you recollect learning about these things?

DC: Mechanics is real easy for me, so working on projects like this, where you have to come up with a solution to a problem with physical constraints, is not as much a challenge as it is something that comes naturally for me. Life led me away from my aptitudes due to interest in other things. I was originally


photograph by Jade Dellinger

Dan Cordier

interested in oceanography; the dolphins and whales and the higher order of animals of the ocean.

AM: Did you study those?

DC: I did a lot of reading about them, and pursued it from the best angle I could. I have been a certified research scuba diver, and have done extensive research in river systems. We are going to have a dive on the Santa Fe River next week, where we are pulling up extinct terrestrial fossils. Ironically, I really don't like water, so doing research in it poses a never ending conflict with me. I almost drowned twice in my life. When I get around water, weird things happen inside me, and when I get out on the ocean, I get totally seasick. These are really undesirable attributes for someone who is going to go into oceanography.

AM: So, you'd rather study where the water used to be!

DC: There you go. The possibilities that present themselves with geology allow one to study all the history of the earth's oceans without getting seasick. I am very interested in the physical aspects of life. Electronics and computers are fascinating to me. I like to use computers as tools, but I don't like to be ball-and-chained to a desk for 8-10 hours. I am an outdoor kind of person. I attained certification in computer electronics and repair, and found employment with a computer networking company in Orlando where I managed the design and installation of computer network systems. Becoming Vice President of that company was a completely successful venture for me because it paralleled my tangential aptitudes.

AM: Tangential, what do you mean?

DC: The computer and electronic industries are very closely related to engineering, and if you look at hardware components, the only thing that separates a mechanical device from the way a computer works is that it all depends on electric flow through devices to make something work. So, it's very logical as to how they work, especially since computers simply operate on the use of combinations of 1s and 0s.

AM: Let me stop you because I wanted to understand the sequence of these things. You did study geology, you studied paleontology, you studied mythology, and now some computer engineering. What sequence do you recollect learning about these things?

DC: It started with the museum in Gainesville in 1975 when I started my college career.

AM: The University's Florida Museum of Natural History?

DC: Yes, I started working with Dr. David Webb, a vertebrate paleontologist. I worked there until I moved to Athens, Georgia in late 1976 and took up landscaping.

AM: That's like earth science.

DC: Right. In early 1979, I moved back to Gainesville and became associated once again with the paleontology projects at the museum. This led to a collaboration with Dr. Charles Woods, a mammalogist who was building up this big grant project on the Island of Hispaniola. The project involved the paleontological and geological reconnaissance of vertebrate fossils to be collected from sinkholes in the mountainous regions of Haiti. We put our heads together and developed a research proposal which was ultimately funded by the National Science Foundation.

AM: Were you a student at this time?

DC: Yes, undergrad student and working person. Tia and I then moved to Haiti for about two years (1983-84) where we fulfilled the terms of this project. For us it was an unbelievable once-in-a-lifetime experience. This marked the beginning of my devotion to doing research full time in sink holes and karst zones and studying sediments.

AM: Karst zones?

DC: Karst is the geomorphological expression of dissolved limestone. In Florida you see sinkholes and incised rivers in the limestone terrain – that's karst.

AM: What's karst then, a material?

DC: It's a geomorphological expression.

AM: Oh, okay. How would you use it in a sentence.

DC: Something is karstic.

AM: As in "full of karst?" [Laughter] No, okay, I get it. You mean a morphological expression, just like you said! Okay, you started out studying geology in college, and had these jobs related to...

DC: Geology, paleontology and geology.

AM: So in a way you sort of like entered into the field by taking jobs before you started studying it academically.

DC: Exactly, I think that's a good way to put it.

AM: Your interest was there, but you hadn't decided if you wanted to make it an academic career.

DC: Right.

AM: Well that brings me to a silly question, but did you really like to dig as a child? Is this something that you did as a hobby, or for pleasure?

DC: I don't think so, because I was raised in what was basically a small part of the Milwaukee/Chicago complex, you know, a city boy.

AM: I didn't suspect that!

DC: I was a bookworm, and spent a lot of time reading.

AM: I know that you collect fossils occasionally, last summer you showed me a trace fossil that you recently collected in Colorado; A shrimp burrow that extended through a number of different sedimentary layers of different ages?

DC: The fossilized Ophiomorpha burrow.

AM: Is this interest in trace fossils something that also preceded your becoming involved in being a geologist? That you liked to find trace fossils and study them?

DC: Well, I guess that might have something to do with it. Normally, on the lake shoreline of Lake Michigan, I found a lot of crionoid fossils on the beach. I always liked the beach there – it was a fascinating place.

AM: So you found them in sand!

DC: The shape of crinoids would make me very curious. Crinoids are broken up into little washer-like flakes. And as a kid who had no concept of what was going on, I would ask myself "what is it?" "It's a fossil of a crinoid." "Oh wow!" It made me want to learn more.

AM: So you went to formal training you first majored in geology, took classes in geology.

DC: First I majored in zoology.

AM: Zoology, you told me that.

DC: I knew the world only from books. There wasn't much wildlife where I lived, so I studied what was available. When I was young, I used to track animals using box traps. I would NOT kill them. On the contrary, I just liked to see them up close and study their behavior. The birds weren't safe from me either. I would band all kinds of birds to see how many would return. The crow was (and still is) my favorite, which I extensively studied for years. There was a good fossil record of crows, which related me back to the paleontological aspect of zoology. I attained my first degree in zoology.

AM: You got a degree in zoology!

DC: Yes, and a degree in geology after that. Paleontology is a sort of subdiscipline of zoology and geology of combined.

AM: Right, right, they are related, how did law get in there?

DC: When I moved to Georgia in 1976 I became involved in learning and playing Frisbee golf. By the time I moved back to Gainesville in 1979, I had dropped out of school, and mostly played Frisbee golf pretty intensively for about a year and a half to two years. While I was out of school, I hung around with a good friend of mine who was a law student. Since he was committed to his career and I wasn't committed to mine, I decided to sit in some of the classes.

AM: But it wasn't like you were pursuing some angle on earth science.

DC: Oh no. [Laughter] It's just the way things were happening at the time.

AM: So, you say that during your childhood you were a bookworm, and you lived in the city, so does this mean somehow that you didn't always feel that you were connected with nature? Did you pursue this interest in geology as a way of getting in touch with physical matter or something?

DC: The more scientists like something, the more they tend to bite that hook and never let go. Then you realize there's a lot more to learn. That's where geology really opens up because where you are looking at all the physical aspects of the world, you are also looking at time. So you go into the dimension of time and most people can't even comprehend the vastness of time. Once you get a reasonable appreciation for time then you stop looking at just the ocean. You look at the moon and earth and the galaxy and the universe....

AM: It sounds almost spiritual. When I imagine a geologist's mind, I imagine a sort of heightened and illuminated view, be-

cause the geologist has to know so much about so many different things – chemistry, biology, mechanics, physics, climatology – and even art, because you have to spend so much time drawing things – and this area of knowledge becomes so expansive and all – inclusive that you could almost use geology as a substitute for religion. You use it as a way of getting in touch with the history of all things, all time, all life, it seems. Many people think that being a geologist is also really romantic – is it?

Dan Cordier discussing screenwashing techniques with field crew members Annette Cannon, and Suzanne Jaffell, both from Orlando, during a highly successful dig at the famous middle Miocene (18 million-year-old) Thomas Farm site in Gilchrest County, Florida.

DC: Certain parts of it are really romantic, but you have to have a mind for tedious thoughts and meticulous attention to detail, and that can be very laborious.

AM: It doesn't come naturally to you?

DC: No, it's just very disciplined – very, very disciplined.

AM: Do you have trouble with that?

DC: No, I've allowed myself to exercise my facilities of discipline so that I am able to participate in exploration.

AM: But it's not your primary goal then, it's just a tool. In other words, you like the process of discovery and you sort of learned the discipline so you could have more opportunities to join into the activity of discovery.

DC: Certainly.

AM: Okay, interesting. I guess we should talk about your interest in fulgurites. What were you doing when you were first called by Russell McCarty? As it was told to me, Russ was asked by Dr. Uman to give him some advice and help in excavating a fulgurite a couple of years ago, and Russ didn't have time, so he called you because he knew of your interests and expertise. Did you know him from working at the museum?

DC: Yes.

AM: You were working in the paleontology department? There's not a separate geology department, or is there?

DC: There's a separate geology department that is included in the College of Liberal Arts and Sciences. The paleontology division of the Department of Natural Sciences which is located at the Florida Museum of Natural History. Although they are separate entities, they are closely interrelated. It's a unique situation.

AM: You weren't studying there in any way, you were an employee? What was your job?

DC: At the time I was working with Roger Portell who worked with Dr. Douglas S. Jones, doing museum preparations for him.

AM: You said paleontology?

DC: Yes, invertebrate paleontology. I was a preparations specialist for him working with invertebrate fossils and casts of fossils.

AM: So you were doing that, and you knew Russ because he was also there studying but he didn't do invertebrate preparation, why did he think to call you? Did you have an interest in fulgurites already, or not at all?

DC: Well, he called me because he knew I was into geology and might be a little bit more knowledgeable about the materials involved. Dr. Uman also needed somebody who was an expert at excavation. My credentials fit the bill.

AM: Let me ask you some facts about fulgurites. There's a high occurrence of lightning in Central Florida. Does that mean there are excessive numbers of fulgurites here or in other places?

DC: I think because of the situation in Florida where you have loose sand at the surface there's a high probability that there are a great percentage of these lightning strikes which hit sand and actually form fulgurites. I know from having talked to archeologists and construction workers who are aware of fulgurites. People in the power industry, like Florida Power and Light, know that fulgurites form from their powerlines going down and burning sand, and that they are all over the place. They all say they know what a fulgurite is. The people that don't know are the ones that have no connection with digging in Florida. Others have reported seeing them sticking up out of the sand from the panhandle to the Sahara desert. They call them by the old term, fuselites.

JD: Where did the term "petrified lightning" come from, and why is it talked about in that way?*

DC: I think because it's frozen in time or mineralized or however you want to look at it. The first thing that comes to mind when people say petrified is petrified wood, petrified logs. That is recrystallization of an organic material to a silicate. So you have a rock which is the replacement of a former organic life form. Petrified in a sense that lightning is really an energy and you can't capture energy as a fossil, but it will leave petrification of the system by the path that's melted and left behind. That's why I prefer to call it a trace.

JD: So, describing a petrified anything isn't a time base issue? We think about petrification of wood as taking eons to transform, and yet, lightning "petrifies" almost instantaneously.

* Jade Dellinger

DC: Petrified wood is a replacement of the organic tissues with silicate materials. That's petrified. You lock its previous existence into place because you turn a piece of wood into a piece of rock.

JD: But most of the time wouldn't that take many years?

DC: Well that's variable, that depends...

JD: Are there any other examples of petrification that would be instantaneous?

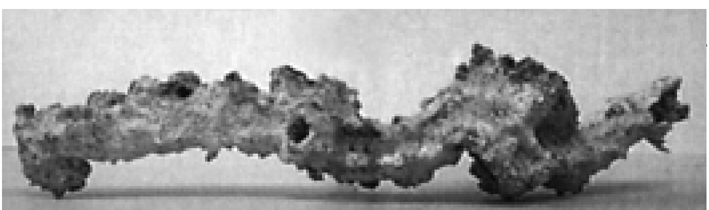
DC: Rapid burial leads to rapid petrification, fossilization, or recrystallization. The circumstances have to be right for fossils to form in the first place. How long that takes just depends on the physical and chemical environment. I think this process probably doesn't happen as fast as lightning. As an analogy, if you consider that a volcano is something that's alive, part of the living earth, given the proper circumstances, this could become buried. You can go out west and find the remnant neck of this volcano – this would be an example of a fossilized volcano.

AM: Does the state of Florida have such a large number of fulgurites because it's more or less all sand?

DC: More or less there's a thin blanket of sand covering the whole state.

AM: You still work for du Pont mining, even now – what do you do for them?

DC: Mineral exploration.



University of Florida Lightning Research Laboratory.

An excavated nine inch section of a natural fulgurite.

AM: So you are specifically involved in seeking out sand mining opportunities? Or do you work with other materials?

DC: The effort of my division of du Pont is to find sands that have titanium bearing minerals.

AM: So they mostly are searching for titanium. I was so happy when you came up with the idea of separating the sands, and I really didn't understand the concept, and when you took us to du Pont and showed us how they separated the titanium from the ilmenite and the silica from the zircon, and so on, the whole subject of sands became so interesting to me. So you are not into researching quarries or oil or other things they might mine when they send you all the way to Brazil, are they still looking for sand?

DC: Yes.

AM: They are looking for sand. And what are their uses for the sand?

DC: Well, the heavy minerals which they extract from the sand have certain commercial values depending on which mineral you are talking about. Du Pont is most interested in the titanium bearing minerals which you find amongst the heavy minerals which constitute about 3-5% of these sands. So, for that purpose, the commercial value of the titanium bearing minerals is to produce titanium dioxide which is the base for white pigment. Other minerals include very clean zircon, which is used as an abrasive for sand blasting, and staurolite, which is used mostly as an inexpensive abrasive. Those are the three big ones. The other ones that aren't titanium are by-products of the process pursuant to attaining those main titanium-bearing minerals to make it commercial to mine. [Laughter]

AM: Are there certain minerals that are often found together?

DC: Well, by the nature of them being classified as heavy minerals, the minerals are eroded out of the mountains from the rivers, arrived at the coast and then concentrated as sand on the beach. So what happens over time is a transgressing sea will take these sands that come out of the rivers and concentrate them, rework them, push them up onto the beach into big dunes, and as the sea transgresses further inland, you end up with these big huge dune complexes. The energetics involved with concentrating those sands removes the fine materials like clays and small sized pieces of sand which are less dense. If you look at those sands that we have at Camp Blanding, 95% of those sands are composed of quartz grains and they are relatively big, twice as big as the heavy minerals that we were looking at and this is because the heavy minerals are twice as dense as the quartz. Heavier. These small pieces of heavy minerals weigh the same as larger pieces of quartz. That's the nature of the concentrating mechanism used to concentrate these sands into a dune. The lighter minerals usually aren't there.

AM: So nature has already done some distillation to make it easier for the miners. Does that especially happen in areas where the sand has been there for millions of years? I guess you would be less likely to find that on the beach where the sand is always being taken away and moving.

DC: It takes millions of years to transport that much sand down to the beach by drifts concentrated along the beach and then sea transgressions to move it up onto the dune complex. It's not something that you would wait a week for it to happen.

AM: But they sort of do that at the mines.

DC: As long as they are there you can separate them, it's getting them into a deposit that takes time.

AM: Have you ever found a fossil fulgurite in any of your explorations? Or do you consider them all fossils? What is the relationship of a fulgurite to a fossil?

DC: If you go by the meaning of the word, a fossil is something dug up, so yes, I've found fossil fulgurites.

AM: How do you define a fulgurite?

DC: A fulgurite is the trace of lightning that's left in the earth as a function of it melting the sands.

AM: But I mean have you ever found a mineralized fulgurite from 100 million years ago?

DC: Okay, that's a different question. Yes, the reason I used the word "trace" is connected to my background in paleontology. Like I was telling you about the Ophiomorpha burrow, they are really trace fossils. It's evidence of the ghost shrimp. That's the common name of the animal which makes the burrow. That is really a trace fossil that represents the past existence of Callianassa which is a ghost shrimp that lived in that environment on the beach. Even though the ocean is gone and we don't have to get wet anymore to find that guy, we can say the fossil beaches here are a function of the Callianassa having been present, it left the trace there. The reason I described fulgurites the way I did is that a fulgurite is really a trace fossil of the lightning having existed in time and space and left its mark in the earth as a fulgurite. This is one of the reasons why I wanted to get involved and I wanted to do the project. Once we were drilling down about 20 or 30 feet which is well below the water table in this particular area, and consequently, as we know now, well below where a fulgurite would have formed. I had this "stuff" coming up in my hand and I said, "that looks like a fulgurite." Pan after pan and we collected enough material of broken bits and pieces to make a tentative identification. I was fairly certain at that point that these were pieces of fulgurites.

AM: So it's not made of glass anymore, it's limestone or something?

DC: No, it is the sand. What happened was...

AM: It's not a mineralized fossil exactly, it's just an old fulgurite?

DC: Yes, it's just an old fulgurite. Which is a fossil because we dug it up. When this fulgurite was formed, the water table was probably lower, and when lightning hit the beach dune at that particular time, it made a fulgurite. Then with transgressing seas this fulgurite was buried and the water table moved up.

AM: How old might it have been?

DC: No older than the beach dune!

AM: So Russ asked you to go talk to Martin, and he's been interested in fulgurites for 20 years or whatever, and you already knew about them at that point, and you were interested in them already?

DC: I had heard about them through other people who had done excavations, and I thought they were fascinating. When I studied mineralogy with Dr. Frank Nelson Blanchard, he knew about them and thought they were fascinating, and I toyed with them in my mind and wondered if it were possible to date these fulgurites, and if you could date these fulgurites, then you certainly could have a record of when lightning hit the earth at certain times.

AM: To tell you something about the atmosphere at that time...

DC: To tell you about the atmosphere in Florida. Being a lightning center, things fluctuate here a lot. Sometimes you have a lot of hurricanes with frequent thunderstorms and a lot of lightning. With these lightning strikes, charcoal is deposited in old lake basins in Florida. Charcoal represented periods of time when you had lots of lightning strikes and a lot of storms. I figured that if you could get a population of fulgurites, you might be able to determine climate cyclicity.

AM: So you had your own erratic agenda going already before Martin even asked you to help him dig up these fulgurites.

DC: The opportunity presented itself at that certain time to pursue one of the many ideas in my brain. [Laughter]

AM: I was told that you have these connections with golf courses, not just the lightning research center, you've tried to find other sites and you have a kind of network of friends to help you locate fulgurites.

DC: I know a lot of people who golf and superintendents that work on golf courses. I know from having worked at a golf course that they can get a lot of lightning, favorable or unfavorable as that is. That's where I found out how do you find a where lightning hits. It burns the grass where it hits. I knew a golf course would be a good place to find fulgurites.

AM: What exactly did you do for Martin, because we heard that you unearthed the world's longest consolidated fulgurite, is that true?

DC: Yes, exactly, it's in the Guinness Book of World Records. We started out by excavating some of the fulgurites that had formed in previous lightning seasons.

AM: Martin started.

DC: That was the purpose, to dig up these fulgurites that he generated by triggering lightning with rockets. In the experiment where EPRI was testing cables underground, they buried cables in a continuous loop around the lightning center and triggered lightning above those loops. They wanted to see what lightning would do to the cable. The cable was buried a meter deep. Where it hit the ground, lightning would travel to the cable and either burn it or damage it or do nothing. It was attracted to that cable because it had current in it. There was a reason for it to seek a course to that cable. Fulgurites formed between where it struck the earth and that cable. Martin wanted to see what the deal was with these fulgurites that formed in the sand. He dug one out by hand that was 9 or 10 inches and then realized that it wasn't going well, so he wanted to find someone to excavate them. That's where we got started.

AM: But the world's largest fulgurite, I remember it wasn't part of an experiment, it was just a natural strike that happened out of the blue.

DC: Yes, there were several natural strikes which they had the opportunity to witness and mark. They occurred on the lightning center. When we started digging up these natural strikes, they weren't quite as impressive as the ones that formed as a result of the cable experiments, but we excavated them anyway because they were interesting. We wanted to see at that point you know. We recorded the depths, the course that they pursued. We followed them as we excavated them.

AM: I remember that the big one had divided into two forks - did you find anything in your excavation that seemed to trigger that division?

DC: It was just one of those things that happens with lightning. We didn't know why.

AM: So you were saying that nobody's ever figured it out?

DC: Why it split? Could be a number of reasons, and Martin proposed a few things, but at this point, I don't think we could ever say concretely what it did.

AM: Did you just pay for your own time to dig it up?

DC: What happened was, one of these natural science filming companies from Italy wanted to come here. They were interested in lightning and triggered rockets and so as part of that scope, I just went out there to dig. It was one of those things.

You yourself, who was a out at the lightning center for a long time in the summer, and you realize now that you can spend a lot of time out there and see the big bright blue Florida sky which isn't the foremost reason why you are there. It was one of those days. It was that kind of year. This is Florida in drought season. The sky was blue and there was not a cloud in the sky and there was no hope of ever getting any lightning shots for the Italians. But they shot up a rocket anyway. But as a function of excavating fulgurites, that's perfect. So I thought, well we can make this thing and they can hit it.

AM: So you did it for the movies?

DC: It added a bit of depth for Martin's operation.

AM: Would you have excavated it anyway?

DC: Well eventually we would have done it anyway, but that was another time and place, so we started that excavation that day. The previous natural strike that we had excavated was 30 inches long. This one looked to be very similar: the diameter of it, the fragility of it at the surface, so that day I started digging, and I got down 2 or 3 feet. I decided to move over and find out if I could get underneath this one because it was going at a pretty steep incline. I knew I would have to expand the pit, so I went over to the other side, and oh, we've got another branch going the opposite way. This is going to be fun. Before I knew it, Mike Stapleton, Keith Rambo, Vladimir Rakov and Martin were coming out there all the time. We had a trench that was 6 or 7 feet deep. The thing just didn't stop, it was getting bigger and bigger. I said to Mike when you are looking at grass roots from the underside, that conditions were not real good. I said, probably what we ought to do is slope the angle of these walls because obviously we are going to have to build an even bigger pit and as much of a bummer as that it’s the thing to do. We had just started sloping the walls. I had traced the thing out and charted it. I got it all prepared and covered because if we were going to slope the walls, sand

University of Florida Lightning Research Laboratory.

Dan Cordier and Mike Stapleton excavating the world's longest fulgurite ever excavated.

was certainly going to be spilled on it. Mike was going to photograph it with the video cam and get still shots. I was just finishing up. I had just finished cleaning out the bottom and Mike had started photographing from the far end. Then, one of the walls collapsed on me and virtually destroyed my knee. Here we were in the middle of a humongous excavation and my knee gets destroyed. So I'm incapacitated. Mike built this huge covering system and covered up the site with the fulgurite and luckily it was during a drought season in the winter time. We didn't get a lot of rain and it didn't get destroyed. I was out for six weeks and a I came back as soon as they released me [Laughter] and then we finished the excavation of the fulgurite. We even had a back hoe involved. The excavation turned out to be huge!

AM: So was it one of those situations like in the movies where you and your wife and everyone's there and you're supposed to stay in bed and you are like, "No I got to get back to the fulgurite." [Laughter]

DC: I ended up excavating it with my leg like this. I was laying down on the job because I couldn't do anything else. I couldn't kneel I couldn't bend. [Laughter]

AM: Well I've seen you dig very energetically when your leg was well, so I can imagine. I mean I've never seen anybody who is such an energetic digger in my life, I mean even the diggers who fix the streets in the city take like 5 or 6 breaks a day. [Laughter]

DC: After that hole I know how much it takes to move that amount of sand.

AM: Did you end up consolidating the entire fulgurite? Did that mean you just pulled it out in one piece?

DC: No, we pulled it out in manageable sections.
AM: Does that mean you put it back together?

DC: No, I haven't because we don't know where it's going to end up.

AM: So you are waiting to see how it's going to be mounted. You are waiting to see where it's going to be displayed to the public somehow. So you were clearly the chosen one to work on my project. You probably knew more about unearthing fulgurites than anybody in the world at that moment... Since we finished making my fulgurite last summer, have you continued experimenting? You were running triggered lightning through PVC pipes and making even finer and finer discriminations between layers of sand, seeing how different sands interact and so forth, as a part of our project - can you describe a little of what you have been doing since?

DC: Well it draws upon the previous wanderings of my mind in terms of fitting fulgurites back into some kind of a systematic scientific evaluation. If we can look at fulgurites under controlled circumstances in other words, determine what happens to one specific mineral a number of times, various amounts of current, a number of different strikes, we can determine what happens to fulgurites. Then you have an understanding of how it works when you step out of that controlled atmosphere. So, if you are to go out and excavate a bunch of fulgurites wherever in the world, you can see what you might do with fulgurites in terms of scientific methodology. For an interpretive process, then you really have to have conducted some sort of experiments on fulgurites, so that's what we are trying to do.

AM: So you are meaning then, it could happen at one time that people could be able to guess what the charge was from what they have already studied of fulgurite formations, it's possible that they could find one they could find out how many years ago it happened, they could guess the charge.

DC: A number of the articles that you read from the early 1900s suggest lots of guesses as to why this one fulgurite looks like it does and acts like it does and has the texture that it does. That was just common sense in evaluating a setting that has physical interactions.

AM: When we started off, you designed this 20' tube and set it up to catch lightning above ground, and you had done some experiments

University of Florida Lightning Research Laboratory.

The world's longest excavated fulgurite, as seen during an early stage of excavation.

towards my project before I even arrived last summer, and I think we had both discussed this before hand and you thought it was smartest to run the lightning through a number of different sand layers, so we could learn 19 things at once instead of just learning one thing. When I got there the first day, you had just triggered a strike, and it did form *like a "chain" of fulgurites within the tube, each one made a different mineral, but what I was most surprised to see was the differences that showed up so clearly. That one certain kind of sand that was thick and grainy formed a different kind of fulgurite from the fulgurites formed and the finest sand, the zircon, with its very regular-sized small grain, which formed a very regularly patterned fulgurite as it was formed! Could you describe those differences to me?*

DC: That particular tube was probably one of the most productive ones that we had, I think because it was a lot of current in that tube. Those were fairly substantial fulgurites, some of the thickest we have made. The conclusions that we made from that tube was that greater current give s you a bigger diameter fulgurite. The finer grain sands give you better bumpy surface textures.

AM: Better aesthetically you mean?

DC: Better in the sense that you can have a number of bumps along the thing instead of just 1 or 2 bumps. With fine grained sand you will see those bumps, not so much with courser grained sand. With those real fine grains and dense sand you will make bladed structures like the black ilmenite fulgurite. The zircon was neat because it had a ropy texture.

AM: I was so surprised to see that. Were you able to come up with any rules-of-thumb? What did we learn from doing those first couple of strikes that you triggered?

DC: Well, the best thing that we learned was that even in that tube, some of the sand got wet. I think the sand in the upper part of the tube got wet where it wasn't closed, and as a result, you had almost a venting, de-gassing episode which happens with volcanoes where you get a lot of steam pressure built up that causes ejecta. This shot the top of the tube right off and formed the umbrella mushroom features. As that medium was shooting and venting, it shot the fulgurite material out and up. When the materials started recrystallizing they actually started migrating downward into the void that was created by venting.

They actually started mushrooming. You probably wouldn't find that in nature.

AM: They have them in the Sahara, they found a lot of them with "collars." So, when I got to the Research Center last summer you actually had done some narrowing down of the possibilities, and I was able to decide on using the zircon sand on aesthetic grounds, basically. So, since we had discovered the texture I wanted, we were able to move on to the more specialized experiments using my trash receptacle. But in the very beginning, after you had designed these experiments using PVC pipe, you seemed unsure if it was better to pack the sand very tightly, or loose, or whether you should glue the caps on the ends or leave them loose, or whether it was better to let the ejecta flow out or not – but at the end of the first couple of experiments you had learned that you need pressure, you need containment which made me figure that the sand needed to be packed more firmly than you would have guessed beforehand. Is this accurate?

DC: Yes, pretty much.

AM: During this setting-up period I remember when you brought up the idea of using the PVC pipe for containment, your wife Tia said, "Dan is the PVC pipe guy, he makes everything out of PVC pipe, the furniture, the children's toys, everything!" She made it sound like you made lamps out of PVC pipes and bathroom appliances and beyond! [Laughter] Is that true?

DC: It's a strong material – you can even make greenhouses out of them!

AM: I was trying to design the experiment myself without even knowing anything, but I was imagining ceramic piping and instantly you had the idea of PVC pipes I really enjoyed watching you designing experiments so quickly and creatively on the run as things would happen. I guess that's something you've learned, had you been designing experiments before?

DC: That goes back to my mechanical aptitude, which, as I stated before, is something that is second nature to me. If one is trying to discover something or explore something with an intriguing aspect, you can't let the mechanics of the solution get in the way. You can easily come up with a solution to something with a mechanical twist. I'm certainly not going to let that stand in my way.

AM: I previously hadn't thought much about what designing an experiment entailed; I knew you've got to have your hypothesis, you've got to record the results and compare them to your hypothesis, you've got to have controls, but I'd never really thought a lot about the design aspect. There are a million ways you can design an experiment, so you have to choose one that based on intuition and elegance and simplicity, whatever, and consider a lot of other rules of science about keeping things objective and quantifiable, so it seems to be very intuitive and you do it on the run and you have to change your mind at the last minute, especially if your precious hypothesis isn't working. I was impressed with all this, and I enjoyed it.

DC: It was fun.

AM: I guess I do that in the studio too. You know, you want an effect of some kind, and you don't know how to get it, and you try and you try to figure out what works and you can't imagine in your head, you have to do it.

DC: With science, it's an exercise that aids you in the understanding of things. I would just as soon explore and learn about things instead of having the obligation of reporting these findings to the world, but when you go through that exercise, it helps you find processes to learn the most you can learn in this pursuit. The process of designing experiments is the more creative aspect of this very rigorous discipline, and allows you some amount of artistic license to enter into the discipline.

AM: Sort of satisfying too. With me, it's the same thing in my studio, when I produce an effect I want it to be really reproducible [Laughter] because I work in this way using hundreds of things and I can only do effects that are reproducible, and I am sure that you must approach it in the same way. You can't just do something and not really measure what you are doing or pay attention to how much of this you use or whatever, you have to know.

DC: That's part of the scientific method. If you can't reproduce your results . . .

AM: It's pointless.

DC: Well not pointless, but it's very difficult to convince somebody else that you have analyzed that situation enough to interpret it properly. As you get away from the capability of reproducing results, you are really out there on your own, you are pioneering, you are a mad scientist, and, if in fact you do witness some phenomenon the one time it may happen, e.g. seeing an asteroid hit the earth and knocking out all of the light in the atmosphere, if you happened to have been there and witnessed that and you can't reproduce the conditions or results which actuate that event you are standing alone, you are just out there, you know? [Laughter] Einstein spent a lot of his life out there, it wasn't that he didn't understand things properly or interpret them properly, it's just that he had to put it into a mathematical perspective that other people could understand. He understood fine, everything made sense to him, but it didn't make sense to us. Once we could understand the mathematics of what Einstein was thinking in his brain, which probably far surpasses what he ever revealed to us, then the scientific community could accept it as fact.

AM: Now I totally understand. [Laughter] I want to know what experiments you've done and what you've learned in doing these new experiments since I've seen you.

DC: We learned that lightning current can be divided.

AM: That happened in the tube?

DC: Yes. As controversial as that is, we did it under controlled circumstances. This is a direct verification of the world's natural fulgurites.

AM: So you did this without running a fine wire through the tube?

DC: No we did it with a wire.

AM: But you didn't divide the wire?

DC: We had two pieces of wire. If you think about it, lightning, because of its magnitude and power, like water, or like anything that has energy or that chases the path of least resistance, even though it's not making a conscious choice, it will take the path of least resistance, this way...

AM: Sure it's not conscious?

DC: Not sure now! [Laughter] If you look at electricity in terms of Ohms Law, current can be divided. For example, the electrical wiring in your house is divided to allow the current to go to two different places yet originating from the same source. So current can be divided. Now what does that mean? I don't know. We should have set up the situation where we had two of those pods in series because in that tube where lightning divided, those fulgurites would have been half the diameter as a fulgurite with one with one wire. Did we really divide the current – some amount of amps divided by two? Or was that amount of current going through each division? See what I'm saying? That would have been a good measure of what was happening to the current.

AM: Have you done any geological experiments, you know putting together two different minerals and mixing them into different amounts and percentages and so forth to see...

DC: Yes, we've been mixing some things. I brought some sand back from Pike's Peak and made a fulgurite out of that.

AM: That's very romantic!

DC: Yeah. [Laughter] I like Pike's Peak. We've got some of those minerals going now. I'm experimenting with the interactions of the physical components of electricity.

AM: You are actually now doing studies of electricity? As separate from geology?

DC: I'm studying electricity through sand, because as you record the effect of the electricity of lightning on your material, it's eventually going to tell a nice story. Since quartz is one of the most common minerals, and one of the most stable on the surface of the earth, that is the material to work with. If I can understand how that mineral reacts to lightning, I think I'll know a lot more.

AM: So, when we started working together, you designed a certain experimental method and so forth, and what pleases me is that all of that work wasn't just wasted for my project, you continued to use these techniques in other investigations. If you hadn't been asked to do this in the first place, you might never have .

DC: I'd still be waiting for the next natural strike hoping my knee doesn't go! [Laughter]

AM: Really? No!

DC: As you know, one of the things I'm infatuated with is PVC tubing. That's why I thought about doing this experiment the way we did. Our first fear was incited by a comment from George regarding our 20 foot tube. He said, "I think it's


photograph by Robbie Land

Dan Cordier working with Allan McCollum excavating a fulgurite from the PVC tube in which it was created.

going to blow up!" So I was convinced that we were going to come out after the storm looking for little pieces of shrapnel fulgurite everywhere on the ground. Actually the distance that separated those threaded rods was probably the maximum distance possible before it arcs out of the tube. I would like to put sensors inside the PVC tube so we can measure pressure and then capture that data at the time of the strike period. Perhaps one could record actual temperature and pressure during the formation of a fulgurite. That's a good way of tying that data into mineralogy.

AM: How quickly can you sample the pressure?

DC: I don't know. We haven't even reached that point yet.

AM: Did you think about how many times per second?

DC: I'm sure that with little or no sensitivity you can record what's going on in there. It's going to be kind of difficult because the lightning comes in at so many milliseconds. I don't know, we'll have to see how that goes. If we can figure out just that one step, we will be able to actually record the particular physical characteristics of what's going on. It may make it blow up, I don't know.

AM: Then the water content would be totally related to this...

DC: Then we'll saturate the sands and see what that does.

JD: Is it possible to remove all moisture particles from sand?

DC: Yes, that's what kiln drying is. There are new things to be done with that.

AM: So I should keep checking back with you and the Research Center!

DC: Don't lose touch, this thing's not over.

AM: I've heard that after we finished working on my project last summer, a local group started up a kind of business, creating fulgurites using our system, and trying to sell them! And they're offering to produce "made-to-order fulgurites!" Are you involved in this?

DC: Yes.

AM: So you are actually thinking about trying to make some money?

DC: Well the pressure-sensor issue is just one method of measuring this kind of pressure or being selective of those kinds of temperatures.

AM: So you hope that selling triggered-lightning fulgurites might help pay for research?

DC: I enjoy studying fulgurites, but that's not something the lightning center is focused on doing. The lightning center is there to study lightning, so it's hard to directly tie the science of geology to the science of lightning. That's going to have to be its own self-generating research.

AM: Since we've been doing this project not only have I been approached by people writing me email wanting to know what kind of wire to use on rockets triggering lightning, [Laughter] Martin has been approached to speak on glass art. [Laughter] Something's happening.

DC: The truth is out there. [Laughter]

AM: It's nice to know it didn't all end with me. I've found texts from the 1700s forward, and maybe one day our work will appear in a science journal's footnotes... [Laughter]

DC: It sure will.

JD: What was the most interesting part about working with an artist?

DC: Well I have a lot of interest in art myself. I inherently try to find the artistic side to the different projects that engage my time. I like to realize the balance between left brain and right brain. If you spend too much time exercising those little gray cells on only one side of your brain, you end up walking through life lopsided. So, you exercise one side of the brain with the other and you can achieve a more balanced approach to life. My pursuit of art is as strong as my pursuit for science.

AM: Do you have artistic hobbies?

DC: I like to do some sculpting.

AM: What material do you like to sculpt with?

DC: I like to sculpt with clay and some epoxies. When I was working in paleontological preparations, part of my work was to reconstruct skeletons...

The Event

Petrified Lightning from Central Florida

a Project by Allan McCollum

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