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2009 : July 2009 - Author Commentaries : George Luther III

## AUTHOR COMMENTARIES - 2009

### July 2009



#### George Luther III

Featured Scientist Interview

*In May of this year, Dr. George Luther III had the highest percent **increase** in total citations in the field of Geosciences in **Essential Science Indicators**<sup>SM</sup> from **Thomson Reuters** for the period of January 1, 1998 to December 31, 2008. Dr. Luther's current record in the overall database includes 77 papers cited a total of 1,694 times.*

*Dr. Luther is the Maxwell P. and Mildred H. Harrington Professor of Marine Studies in the College of Marine and Earth Studies at the University of Delaware in Lewes. He is also the Editor-in-Chief of Aquatic Geochemistry.*

*In this interview, ScienceWatch.com correspondent Gary Taubes talks with Dr. Luther about his highly cited work.*

#### **SW: Your highly cited papers are on the subject of chemical interactions with metal-oxides and sulfides in sediments. How did you get into this line of research?**

I was trained as a physical and inorganic chemist. I actually started out working with high-energy rocket fuels that spontaneously explode in air. After my graduate education, I got a chemistry position at a small school, and the chairman of another department, which happened to be the earth and planetary environment department, said to me, "You're an inorganic chemist, so you must know something about metals. We have a problem in Newark Bay, New Jersey." Newark Bay was well known to have a high concentration of metals in the sediments, and he asked me if I would be interested in doing work in the local salt marshes and the water column of Newark Bay.

This was the late 1970s, and everything kind of blossomed over the next 10 years. I went from this small college in New Jersey to the University of Delaware and I was doing more and more of this work in earnest. I made the switch from pure chemistry to pure and applied environmental chemistry.

#### **SW: What prompted the project described in your 1999 *Geochimica et Cosmochimica Acta* paper with John Morse ("Chemical influences on trace metal-sulfide interactions in anoxic sediments," 63 [19-20]: 3373-8, October 1999)?**

I had been doing a lot of work with metal sulfides—not necessarily with John, but we had chatted a lot over the years. John had developed a method with one of his students to measure trace metals in pyrite, which is an iron sulfide, as well as in other sulfur phases. He found what he thought was some very strange chemistry. It wasn't following what we would think is a normal thermodynamics pattern. John asked me what I thought the reason for this was, and I told him that kinetics actually affects rate processes and the thermodynamic pattern he expected.

What most inorganic chemists know is the rate of water exchange for

an ion in solution. We were comparing everything with pyrite, iron in the plus two oxidation state, because pyrite is a major phase in sediments. He was looking at the sediments at the time and he noticed that instead of having this really nice straight thermodynamic line with all the metals, three elements fell off of the line. I said that's because of the kinetics for the rate of water exchange. So we decided to write a paper showing that thermodynamics and kinetics both control the amount of trace metals that could be found in pyrite. It turns out these three metals didn't have to go into the pyrite phase, because the rate of water exchange for them was so fast compared to iron plus two. Those were lead, cadmium, and zinc. They could form their own sulfide phase before going into pyrite. So that's how this paper got going.

**SW: Why do you think this paper has been cited so frequently?**

People want to understand how metals are bound and tied up in sediments. Sulfide phases are particularly important. For the most part these are solid phases. In this case, if metals wind up in pyrite, then the question is, are the metals going to be remobilized in some oxic condition, which means conditions in which oxygen gets into the sediment? If the metals are in a pyrite phase, then you have to understand how the pyrite can redissolve.

For lead, zinc, and cadmium, since they're not in a pyrite phase, you have to understand how they redissolve as their own sulfide phases. So we have all these different metals, and we now provided a thermodynamic and kinetic rubric by which people could understand how these metals will be tied up and may be remobilized in sediments. That's why we think this paper is important.

A number of people are looking at metal contamination, and if they do that, they have to know what form the metal is in. As a chemist, you're always interested in understanding the actual species or compound that a particular element is in. Eventually what happens is that this dictates to some extent how biology will respond to that element. If the element is tied up in a very strong binding phase, then the metal is not going to come back out of solution unless you redissolve it under some other condition. When you're looking at sediments, you're looking at the possibility of reoxidation of these sulfide species.

Eventually people who are interested in it are not just people who understand how something is tied up, but how biology can deal with that metal if it needs the metal to do enzyme chemistry. I think that's why the paper has gotten such a large number of citations. It's valuable for a lot of different people in several different fields—not just geochemistry but bio-geochemistry, even microbiology.

**SW: Did you see this paper being influential when you wrote it?**

I always thought this would do reasonably well. I thought it had a good flavor of physical chemistry; it explained metal behavior and did it in such a way that people could easily understand it. That's something John and I spent a good deal of time working on. I think we always do that, but sometimes it comes out better than others. And this one hit a niche—a number of people are looking at metal chemistry and still are. This is a good benchmark paper.

**SW: Is this research only relevant to polluted environments, or is there a bigger context?**

The context is not just polluted environments. Even pristine environments can have important levels of these metals, too. Most people doing marine science have to understand how different materials get into the environment, what phases they get into, and these sulfides are often involved.

You may not have known this but we've developed sensors to measure oxygen and other ions in sediments. If you're in the near-shore environment, the oxygen basically only gets in about two to four

[+] enlarge



*Dr. George Luther and his chemistry team put the final touches on an instrument before it goes on the JASON ROV basket for deployment.*

[+] enlarge



*Alviniconcha hessleri snails distribute themselves in an obvious pattern around a vent site.*

[+] enlarge



*Dr. George Luther holds the E-chem sensor that will measure vent chemicals on the seafloor.*

millimeters into the sediment. Below that you're going to have processes going on other than oxidative ones, including those where hydrogen sulfide becomes important. So if you're studying sediments, the major phases for these metals are going to be metal sulfides, rather than metal oxides or even soluble ions.

**SW: How has your research evolved in the last decade since that paper was published?**

We've been doing metal sulfide chemistry for quite some time. And we've lately been investigating several related subjects. In the same issue as this paper on metal-sulfides, we had another paper with David Rickard looking at zinc sulfide in particular (Luther GW, *et al.*, "Evidence for aqueous clusters as intermediates during zinc sulfide formation," 3159-69, October 1999). We were looking at how it forms, and at the fact that instead of forming only a bulk solid, which you can see as a precipitate at the bottom of a test tube, you could get zinc sulfide nanoparticles or molecular clusters forming first.

We've been doing a lot of work on that system since then. We've had a number of papers—one in *Nature*, for instance—actually looking at these multi-nuclear sulfide species for iron, copper, and zinc (Rozañ TF, *et al.*, "Evidence for iron, copper and zinc complexation as multinuclear sulphide clusters in oxic rivers," 406[6798]: 879-82, 24 August 2000). We had another paper using our *in situ* sensors showing iron sulfide nanoparticles forming at hydrothermal vents. We were able to show that some organisms live only where the iron sulfide was found. That paper was called "Chemical speciation drives hydrothermal vent ecology," (Luther GW, *et al.*, *Nature* 410[6830]: 813-6, 12 April 2001).

**SW: Why do these organisms live only where there's hydrogen sulfide?**

We looked at metals and how they're taken up by different organisms. So, for example, plants do photosynthesis, but at hydrothermal vents, where we've been doing research lately, organisms do chemosynthesis, and to do that, they need hydrogen sulfide that is not complexed to metals. What we found was that in some environments hydrogen sulfide was free and in others it was bound to metals, particularly iron. So the organisms that do chemosynthesis were found only in those areas where the hydrogen sulfide was without iron. And other organisms, the ones that don't do chemosynthesis, were found only where the iron and sulfide are bound together. We can measure that and, by doing so, we've shown that some organisms can live off hydrogen sulfide, and others can't.

**SW: What do you consider the most challenging aspect of your research?**

*"...plants do photosynthesis, but at hydrothermal vents, where we've been doing research lately, organisms do chemosynthesis, and to do that, they need hydrogen sulfide that is not complexed to metals."*

Well, it's interesting. When you're doing work at the bottom of the ocean, the most challenging thing is to be able to get the samples and do the analysis. One of the things we've done over the years is develop these *in situ* sensors—real-time sensors that allow us to measure oxygen, hydrogen sulfide, iron and other species, as well. We have one sensor that measures all three—oxygen, hydrogen sulfide, and iron. It makes it very interesting for us, since iron is typically a key element in all this. Those sensors have made our life considerably easier and that kind of *in situ* chemical analysis has been really unique.

**SW: Are you surprised at how your research has evolved over the years?**

I'd say that having moved from pure chemistry originally into something that's both applied and pure, I'd have never dreamed that I'd ever go down to the bottom of the ocean in a deep-sea submersible. What else can I say? A few weeks ago I gave a talk to some Navy submarine vets. I showed them some of the things we'd done and how we go down a couple of miles to do it. They just couldn't believe we do this. They said they'd never go that deep. But they enjoyed seeing the video we brought back.

**SW: If you lived in an ideal world, in which funding was not an issue, what experiment would you like to do?**

Okay, I'm going to give you a twist on that question. I'm at a marine campus, not on the main campus, so for me, there's some work I can only get done by going to the main campus. It makes it very inconvenient. So if I had the financial wherewithal, it's not an experiment I would do, but I would love to have a lot of the equipment at the main campus—the electron microscopes, the x-ray diffraction devices, the inductively coupled plasma mass spectrometer, some other analytical tools—down here at this marine campus. That way I wouldn't spend so much time running back and forth on the highways.

On the other hand, whenever I go the main campus I get to interact directly with my colleagues, which is a great thing. So there's a trade-off. If I had all the money in the world and had all the equipment I needed down here, I wouldn't be interacting with as many high-quality people. And my students often go

with me to the main campus. We have many of our group meetings in the car. Time is not wasted. So, now that I think about it, I guess I'll take life as it is! 🍷

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**George Luther III's current most-cited paper in *Essential Science Indicators*, with 186 cites:**

Hutchins DA, *et al.*, "Competition among marine phytoplankton for different chelated iron species," *Nature* 400 (6747): 858-61, 26 August 1999. Source: *Essential Science Indicators* from Thomson Reuters.

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