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Commentaries

Climate Change in the Wild West Fifty Million Years Ago

—Tristan Amaral (Editor: Avery Normandin)

Approximately 55 million years ago, the Earth experienced a massive, abrupt climate warming. A huge amount of gaseous carbon was released into the atmosphere, an amount approximately equal to what would be released if humans burned all the Earth's known fossil fuel reserves. This event, named the Paleocene Eocene Thermal Maximum (PETM), raised global temperatures by up to nine degrees Celsius over a period of less than ten thousand years. Sea level rose, crocodiles lived in the Arctic, and there were palm trees in Wyoming (McInerney and Wing, 2011). The effect of the PETM on climate and living creatures is a topic of active research by scientists all over the world. In many ways, the PETM is analogous to the current climate warming we are experiencing, so studying the PETM may help us better understand how the current warming will affect the Earth. One scientist at the University of New Hampshire, paleontologist Dr. William Clyde of the Department of Earth Sciences, has studied the PETM for over twenty years and travels to Wyoming almost every summer to conduct field research. During the summer of 2012 I spent ten weeks in an apprenticeship program with Dr. Clyde, supported by a Research Experience Apprenticeship Program (REAP) grant from UNH's Hamel Center for Undergraduate Research.

As a freshman geology student, I did not have any idea what area of Earth science I intended to pursue. The REAP summer program seemed like the perfect way to get involved with research and to find out what area of research I may want to study in the future. I had taken only three Earth science courses and knew very little about the PETM or the science behind the research Dr. Clyde conducted. Nonetheless, Dr. Clyde willingly brought me up to speed without overwhelming me and took the time to see that I learned all the techniques and skills I would need in my part of the PETM research.

Warming up to Field Research

The projects I completed were related to the Bighorn Basin Coring Project (BBCP), which is led by Dr. Clyde and seeks to increase scientific understanding of the PETM and Earth's climate in the time surrounding the PETM through evidence preserved in the Bighorn Basin of Wyoming. The Bighorn Basin is located in northwest Wyoming, about sixty miles east of Yellowstone National Park. It preserves a very complete record of the PETM and the time before and after the warming, which makes it an ideal location to collect fossils and conduct field research. The BBCP is funded by a grant from the National Science Foundation, and many scientists from Europe and the United States are involved. Two summers ago, six cores, most of which are over a hundred meters deep, were drilled in the Bighorn Basin, exposing hundreds of rock layers that date back more than 55 million years. These sediment cores provide scientists with a detailed geological record of the PETM.

Before travelling to the Bighorn Basin, I learned a significant amount of background information pertaining to the PETM and the BBCP as well as engaged in several multi-week projects. The first project involved creating a lithographic log for each of the six sediment cores. The term *lithographic* comes from the roots *litho*, meaning stone, and *graph*, meaning picture; and a lithographic log is a computer-generated, visual representation of the core, which



UNH undergraduates in the Bighorn Basin: The author (left), Jean-Francois Benoit (center) and Greg Welter (right).

shows each individual rock layer. Creating the six logs required sifting through the enormous core data set and then formatting it for insertion into a computer program. It took five weeks to produce logs of publishable quality. The finished lithographic logs are important because they are a useful reference tool and visual aid for scientists involved with the BBCP.

The next project I engaged in prior to field work in the Bighorn was working with paleomagnetic data. The word *paleomagnetism* gets its origin from the root *paleo*, meaning old, which is combined with *magnetism* to mean "old magnetism." Essentially, paleomagnetism involves measuring the magnetization of rock samples to determine the intensity and direction of the Earth's magnetic field when the sample was formed. For two weeks I organized the paleomagnetic data Dr. Clyde had collected from research sites all over the world and entered it into an online paleomagnetic database so that all scientists could have access to the data.

The Bighorn Basin up Close

After spending seven weeks learning about the BBCP and constructing the lithographic logs of the six cores, I flew out to the Bighorn Basin in Wyoming to help with field work. Arriving in the Basin after seven weeks of learning about it was a memorable moment. The Bighorn Basin is composed of rusty red, eroding badlands and is barren of all vegetation, save for some scraggly sage brush scattered about. I met some of the other groups of scientists doing research there, including a group from the Netherlands.

During the heat of the day it was well over one hundred degrees in the Basin, and there was little protection from the searing sun. Regardless, accompanied by two other UNH undergraduates, two UNH graduate students and Dr. Clyde, I collected fossils almost every day for two weeks. The fossils of interest were small horse teeth from miniature horses called *Hyracatherium* that existed in Wyoming approximately 55 million years ago (15 million years after the dinosaurs went extinct). It was exhausting and mind-numbing at times, staring at the ground for hours on end, but it was always exhilarating to find even the smallest *Hyracatherium* tooth fossil. It was also exciting just to be involved with field work in the Bighorn Basin.

After returning to UNH, I spent the remaining part of the summer applying the techniques and information I had learned to a small-scale paleomagnetism project. I looked at paleomagnetic data from another research site in Wyoming, Continental Peak, and attempted to solve an apparent age-relation problem between rock layers using paleomagnetic data. I used the techniques I learned in the first five weeks of the summer to create a lithographic log of the rock sections but unfortunately was unable to solve the age-relation problem.

Problems, Solutions and Impressions

Over the course of the ten-week REAP experience, I encountered numerous obstacles and problems in the projects I was working on. For example, three weeks into constructing the lithographic logs, Dr. Clyde and I realized that the data was not being formatted correctly, and I had to start over. As demoralizing as this was, I then completed in one week what had previously taken me three. The other obstacles I ran into were all relatively small compared to that first one, and only halted progress for a short time until I figured out how to solve them. In fact, solving the small problems that arose with each project was often the most interesting and informative part of the project. Finding a solution to a problem often altered my approach to the project and sometimes turned the project in a different direction.

The projects I completed were important not only for me as a student but also for the scientific community and the entire world. In the big picture, the BBCP is important to society as well as to the fields of climatology and paleontology. It strives to increase knowledge about the causes and effects of previous climate change events in



The Bighorn Basin at dusk with our rental cars. Bands of color in the landscape show the different rock layers.



Hyracatherium teeth on display (Courtesy A. D'Ambrosia).

hopes of better predicting and understanding the effects of the present climate warming. And although my contributions were small, every person who is involved with the BBCP will help it grow and accomplish its goal of scientific understanding

My REAP summer research experiences were highly beneficial to my educational and professional goals as well. I was exposed to many techniques and skills that I will need in my future earth science classes. Importantly, my REAP experience changed my educational and professional aspirations for the better. It shed a new light on the importance of my undergraduate classes and spurred my interest in being involved with scientific research. Overall, the REAP summer was an incredible experience, and I would highly recommend the REAP program or other forms of undergraduate research to all who have the opportunity.

Without the help and support of many people, my REAP experience would not have been the same. I would first like to acknowledge the Hamel Center and the work they do to make undergraduate research accessible for UNH students, and then to thank the generous donors who make Hamel Center research grants possible. I would also like to thank Abby D'Ambrosia, Jean Francois and Greg Welter for making field work in Wyoming such a memorable and fun experience; and, of course, Dr. William Clyde for putting up with me for ten weeks as my mentor and for giving me an incredible REAP experience.

References

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Author and Mentor Bios

Tristan Amaral, a sophomore University Honors Program student from Warner, New Hampshire, is pursuing a bachelor of science in geology at the University of New Hampshire. For the summer of 2012, he was awarded a Research Experience and Apprenticeship Program (REAP) grant to conduct research under the tutelage of Dr. William Clyde. In doing so, Tristan was able to gain background in historic climate change events, in which he is interested. Tristan is grateful for the wealth of experience that participating in REAP offered; he gained technical skills and knowledge of the research process in general. "I learned you must be patient. Rarely is the quick way to get an answer the correct way, and it is much better to conduct research in a measured and comprehensive manner," Tristan said. "Mistakes and dead-ends are common but should never discourage you." He chose to contribute to *Inquiry* because he wanted to share what conducting research was like as an undergraduate at UNH.

Dr. **William Clyde** is an associate professor of geology in the Department of Earth Sciences and has been teaching at the University of New Hampshire for fourteen years. Specializing in paleontology and geology, Dr. Clyde's research is focused on how climate change and other geological forces affect mammalian evolution and the terrestrial sedimentary record. He has conducted fieldwork for over twenty years in the Bighorn Basin of Wyoming, which holds fossil records of mammals from approximately 55 million years ago. Through studying the site, Dr. Clyde, as well as other researchers worldwide, hope to compile in-depth records of environmental and biotic change from a period of Earth's history when climates were much warmer than today. While Dr. Clyde has enjoyed working with many undergraduate students, it is his first time as a Research Experience and Apprenticeship Program (REAP) mentor. He is a strong supporter of *Inquiry* and its mission and said, "As we try to keep the public abreast of the latest scientific discoveries and their importance to society, it is critical to be able to successfully communicate those ideas to a wide constituency."

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