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International, cooperative research in the Apuseni Mountains of western Romania

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In May of 2006, nine American scientists and cavers from the Karst Research Group at the University of South Florida traveled to western Romania to attend and present at an international conference on records of climate change in caves in the historic Roman town of Baile Hurculane. The conference, co-sponsored by the “Emil Racoviță” Speleological Institute of Romania and the Karst Waters Institute, drew more than 100 experts in the field of climate change and karst, and was a wonderful time spent alongside the thermal springs and Austro-Hungarian bathhouses nestled within the massive limestone canyon of the Cerna River.

Following the conference and post-conference field trips in early June of 2006, six members of the American team joined with several Romanian colleagues to conduct paleoclimate research in the caves of the Apuseni Mountains of Transylvania. A follow-up trip in July of 2007 by a smaller research team completed the projects started the previous year. The NSS provided partial funding for the work in both 2006 and 2007 though an International Participation Grant. The Romanian Science Foundation and the Romanian Ministry of Education and Research provided much of the remaining funds.

Introduction

The Parcul Natural Apuseni, established in 2001, administers 76,064 ha of spectacular landscape and more than 6,500 caves within the Apuseni Mountains in western Romania. The complex Munții Apuseni reach altitudes of more than 1,800 m and comprise the far western flanks of the Carpathian Range along with other mountain ranges to the south, such as the Munții Sureanu. Together, these mountains stand guard along the eastern margin of the Pannonian Basin and Danube River Valley of south-central Europe. The Apuseni contain the longest caves in Romania: Peştera Ventului (42 km) and Sistemul Humpleu (34 km). A number of the well-known caves in the Western Carpathians, such as Peşteras Ursilor, Cioclovina, and Onceasa, host important skeletal remains of the massive Pleistocene age cave bear, *Ursus spelaeus*. Furthermore, western Romania is well known for caves filled with perennial glacier ice, such as the Ghetarul de la Scărişoara. The research conducted under this collaborative study aimed at advancing our scientific understanding of the possible links between the extinction of cave bears and evolution of glacier caves in Eastern Europe.

Paleoclimates and cave bears.

Scientific understanding of when and why *Ursus spelaeus* vanished is not clear. Like similar late-Pleistocene large mammals, *Ursus spelaeus* disappeared around the end of the last ice age. The morphology of the cave bear is similar to the modern brown bear (*Ursus Arctos*) – the main distinction being larger size, a domed forehead, and a convex border of the lower jaw. Blunt cusps of the molars and the absence of premolars suggest a largely vegetarian diet. Climate change certainly played a role in the bear’s extinction. Retreating glaciers and rising temperatures at the end of the Pleistocene clearly resulted in changes in plant life, which would stress the vegetarian bear. However, this does not directly explain why several sites in Romania, including Peşteras Ursilor, Cioclovina, and Onceasa house the remains for several-thousand individual bears. Perhaps entrance collapses at these caves during the hibernation period caused the bears to starve. This appears to be one plausible explanation for Peştera Ursilor – the show cave had no modern natural entrance until quarrying in 1975. But this does not appear to be the case for Peşteras Cioclovina or Onceasa.

Other scientists suggest that hunting by early humans contributed to the extinction, although only limited evidence exists. Ongoing research at Peştera Cioclovina provides some insight. The cave is world renowned for its enormous deposits of phosphate-rich sediments that almost entirely filled some 450 m of cave passage. By 1941, locals mined as much as 30,000 m^3 of these sediments as well as thousands of milled bear bones for use as fertilizer. Within the uppermost layers of the phosphate deposits, scientists have discovered ceramics as well as Human and *Ursus spelaeus* skulls. The excavations for fertilizer provide good exposures of the phosphate sediment sequence that allow for detailed paleontological, archaeological, and mineralogical work.

During our fieldwork in 2006, a team comprised of Lee J. Florea and Bogdan P. Onac from the University of South Florida (USF) along with students Limaris R. Soto, Kali Pace-Graczyk, Aurel Persoiu, and Spencer Fleury joined Romanian colleagues from the Univerisity of Cluj and the Parcul Natural Apuseni. Samples of cave bear remains were documented and collected for a variety of paleoclimate analyses and the team offered management strategies (including monitoring and gating) to the Romanian colleagues. Of particular interest were samples of cave bears skulls that are covered by speleothems and samples of cave bear teeth. Isotopes of Uranium and Thorium help date the speleothems sample while isotopes of Oxygen, Hydrogen, and Carbon within layers of the speleothem help describe the outside environment when the cave bears died in the cave. Isotopes of Carbon and Nitrogen in the carbonate hydroxylapatite from teeth samples can help establish the diet of the bear.

Ground Penetrating Radar in Scărişoara Ice Cave.

Perennial ice exists in a significant number of limestone caves in central Europe and elsewhere in the world. Many of these ice-caves are exploited as tourist attractions with guided tours through a spectacular landscape of ice speleothems. Studies of past climates from within caves have traditionally focused on analysis of calcite speleothems and on different types of sediments trapped within the cave, but little attention has been paid to the ice blocks themselves.

Ghetarul de la Scărişoara is situated in the Apuseni Mountains at an elevation of 1,196 m. The annually-layered ice block is situated at the bottom of the 48 m vertical entrance shaft. The total volume of the clearly stratified ice block is estimated to be 100,000 m^3. The top surface area of the ice covers approximately 3000 m^2. A 23.5 m ice core was recovered from Scărişoara Ice Cave for paleoclimate studies in February 2003, but has not yet been analyzed. Recent data suggests that the ice block may be melting.

During July 4 to 10, 2007, a team from USF composed of Bogdan P. Onac, Sheree Greer, Jonathan Gillespie, and Aurel Persoiu returned to the Apuseni to continue the fieldwork of the previous year. The aim of this trip was to visualize the laminated architecture/structure of the glacial ice in Scărişoara and to map the bottom of this ice block using ground penetrating radar (GPR). The GPR data was colleted using a Subsurface Interface Radar System 2000 (SIR-2000). Profiles were collected in the main chamber of the cave on the surface of the ice block using an established north-south and east-west grid. Data were collected using both a 200 and 400 MHz antenna. Transects were typically spaced about 1 to 3 meters apart. One transect was also collected along the base of the ice block in the Small Reserve. The raw data shows an undulating subsurface reflective interface, which is inferred to represent the bottom of the ice block/top of the limestone. At times, the ice appears to exceed 25 meters in depth – assuming a two way travel time of about 13 ns/m. Additionally, a preliminary review of the profiles indicates that the ice block is thinner at the mouth of the cave and becoming progressively thicker westward from the cave entrance.

Mapping the ice block in Scărişoara serves a dual role. First, it will result in an isopach map of the ice, which will help us better understand the volume of the glacier. This information will enhance our scientific understanding of the origin of the ice cave and will help local cave-managers calculate the percent gain or loss of ice to the cave each year. Second, layers of impurities (organics or sediments) can be mapped within the ice block. The layers from the GPR survey will be correlated to the visible layers from the ice core. The organics from these layers can be dated using ^{14}C methods. These age data, combined with information from the GPR, will help scientists determine historic accumulation rates of ice in the cave.

Summary

The research initiated during the 2006 and 2007 fieldwork seasons was a unique opportunity for us to team up and share information and technology with Romanian scientists and cavers. The long term linkage established through this work will likely result in a considerable international exchange of both students and information that will enhance our understanding of cave and karst resources in both countries.

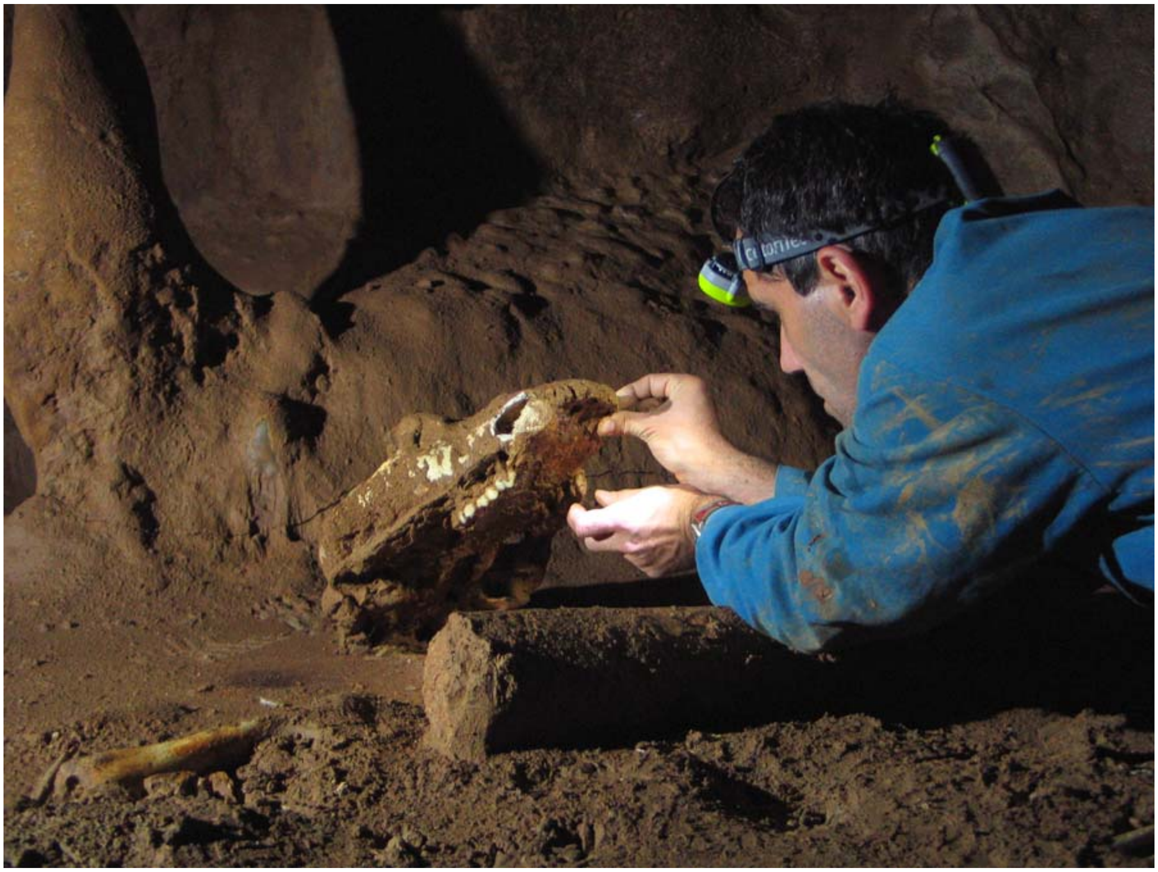
This fieldwork has supported a number of student research projects. For example a study of human impacts and karst policy in Romania comprises a chapter of a PhD dissertation by a student at the University of South Florida. Likewise, our GPR and climate work in Scărişoara Ice Cave will supplement an ongoing PhD dissertation by a second USF student. The cave bear and sediment samples from Peştera Cioclovina are a part of a student thesis from the University of Cluj. Finally, the work with the cave bear and speleothems samples will serve as a pilot project to a much larger study of the paleobiology and paleoecology of the Apuseni Mountain region.

Baile Hurculane – Lee Florea.

Speleo hut at Ic Ponor in the Apuseni Mountains – Lee Florea.

Kali Pace-Graczyk at the entrance to Peştera Onceasa – Lee Florea.

Stalagmite growing on top of an *Ursus spelaeus* skull in Peştera Ursilor – Lee Florea.



Bogdan Onac performing dentistry on an *Ursus spelaeus* skull in Peştera Ursilor – Lee Florea.