FUTURE SCIENCE IN BURNSVILLE COVE

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INTRODUCTION

There is a long history of scientific research in the Burnsville Cove caves. Chapter 15 of the Burnsville Cove book summarizes what had been done. This report looks to the future. What research opportunities remain in the Cove? The list that follows is somewhat off-the-wall and certainly not inclusive; others may have additional suggestions.

There are two requirements for conducting research: money to pay necessary costs and an investigator with the necessary skill set to carry out the observations and measurements and to interpret the results. The suggested projects vary from those that could be done by interested cavers with expenses of a few hundred dollars to projects that might cost tens of thousands of dollars and require professional scientists who had specialized in the subject. In the manner of some hotels and restaurants, I've marked these projects with $ for those requiring only modest funding, $$ for those probably requiring grant support, and $$$ for the big ticket projects.

BIOLOGICAL SCIENCES

Biological Inventory of the Chestnut Ridge System, Helictite, and Wishing Well Caves ($)

We actually know very little about the biota in any of the Burnsville Cove caves. John Holsinger reported the available observations on Butler, Breathing, Aqua, and Better Forgotten in the 1982 NSS Bulletin. Concerning the biota of the more recently discovered caves, we know even less. Although this would be a low dollar effort, what is needed is a cave biologist with the caving skills to effectively inventory the organisms that may be living in these caves. It would be interesting to know if the mix of organisms existing in Helictite and Wishing Well caves are the same as in the caves of the Cove proper.

Microbiology: Vermiculations in Wishing Well Cave ($)

The Leopard Rock (Fig. 13.31 in the Burnsville book) is an exceptionally good example of vermiculations which are now thought to be of microbial origin. This display is already under investigation by Jenn Macalady at Penn State as part of her larger investigations of vermiculations. There are other microbial features in Wishing Well.

Microbiology: The Weird Iron Deposit in the Subway Section of Water Sinks Cave ($$)

Figure 11.26 of the Burnsville book shows a bright red deposit of what appears to be hydrated iron oxides. It appears to be, at least in part, of microbial origin but likely with a complex of iron minerals. However, the red colors are not typical; the usual iron oxide hydrates are various shades of brown. Other masses of iron oxide mineral occur throughout the caves. An interpretation of these deposits will likely require both microbiology and also determination of iron mineralogy at the nano-scale. Access to X-ray and SEM equipment would be needed.

GEOLOGY/GEOMORPHOLOGY

Relation of Caves to Impervious Beds and Geologic Structure ($)

The caves of Burnsville Cove are strongly controlled by the very complicated structure of the Cove and by impermeable units (mostly sandstones) within the limestone sequence. There could be a great deal of refinement in cave interpretation is we knew exactly which beds contain the cave passages and where exactly the structure axes are located. Small faults and secondary folds also occur and should be precisely located. This is a good excuse for a geologically inclined caver to spend a lot of time in the caves. Chris Swezey and John Haynes have this one already underway.

A Test of the Schwartz-Doctor Hypothesis ($)

On of the most original ideas concerning the development of the Burnsville Cove caves is the idea put forth by Benjamin Schwartz and Dan Doctor that drainage in the Chestnut Ridge Cave system was originally to the south toward Dry Run and that there was a later drainage reversal perhaps initiated by the deepening of the Bullpasture Gorge. One way to further substantiate the hypothesis would be to construct highly accurate profiles of the main passages in the Chestnut Ridge System. It seems likely that the existing survey data base could be used but would require considerable re-plotting to show both passage floor and ceiling. The idea is to reveal any changes in passage gradient that might correlate with a reversal of flow direction. The implications for the geomorphic development of the Appalachian karst are considerable. This would be a very valuable contribution that does no require exceptional support or exceptional facilities.

Age Dating Speleothems ($$$)

Determining the age of calcite speleothems from the $^{234}U/^{230}Th$ contained within the calcite crystals is a well established technique providing that one has access to a laser ablation mass spectrometer. Most of the very pretty clear stalactites and stalagmites are likely of Holocene age -- formed since the last ice age. But there seem to be multiple periods of deposition. For example, in Ghost Hall in the Blarney Stone section of the Chestnut Ridge System, there is a tall column covered with a brown coating as are many nearby smaller stalagmites. Not far away is the ghost of Ghost Hall, a pure white stalagmite. Obvious guess: The brown column represents an earlier stage of cave development and the ghost a later stage with a flood event in between. The project would be to identify places where hard dates on speleothems would contribute significant understanding about the development of the cave system. The investigator would need to collect samples and establish a collaboration with one of several labs around the world who are set up for U/Th dating. It can be done if one is willing to pay.

Paleoclimate Investigations ($$$)

Oxygen and carbon isotope ratios in precisely dated speleothems (stalagmite microstratigraphy) are some of the best available paleoclimate indicators one the continents. Stalagmites are sliced longitudinally to reveal the stratigraphic layers. These must be dated by U/Th methods to give a growth history for the stalagmite. Then various isotope ratios of $^{18}O/^{16}O$, $^{13}C/^{12}C$, $^{2}H/^{1}H$, $^{87}Sr/^{86}$ or whatever are measured for samples taken at close intervals along the growth axis. Chris Ray's new investigation in Helictite Cave is of this type.

Age Dating Clastic Sediments ($$$$)

From magnetic reversals found in the sediments of Butler and Breathing caves, we know that these caves are old - at least mid-Pleistocene - but probably much older. The upper levels of the Chestnut Ridge System are still older. The question is: how old are the various passages of the cave system? Determining the age of the cave passage is difficult because it is just empty space. However, there is a technique for determining the elapsed time since the clastic sediments in the passage were deposited. When the sand and sandstone fragments were lying on the surface they were being bombarded with high energy particle. These converted a tiny amount of the silicon in quartz into ^{26}Al and a tiny amount of the oxygen in quartz into ^{10}Be, both radioactive isotopes but with different half-lives. On the surface, there is a balance between creation of new isotope and radioactive decay so the ratio of Al/Be is a constant. When the sand and sandstone fragments are swept underground and deposited in a cave passage, the high energy particles are shielded, continued radioactive decay changes the Al/Be ratio and by measuring the ratio, the length of time that the sediments have been underground can be calculated. This is PhD thesis level work and requires an accelerator mass spectrometer of which there are very few. This project is a long shot but would be extremely valuable if we could sweet-talk someone into doing it. The role of BCCS would likely be limited to doing sherpa and grunt work for the investigator.

HYDROLOGY

Storm Response of the Underground Drainage ($)

We might get some insight into the behavior of the underground drainage system if we had more quantitative information on the springs. The project would be to install a V-notch weir on Aqua Spring, install a pressure transducer and data logger, and measure storm discharge hydrograph with close enough data spacing to get the exact shape of the curve. Analysis of particularly the recession curves for a number of storms of different intensity may yield some insight into the feeder system for the spring.

The Mystery of the Emerald Pool ($)

The Bullpasture River springs are fed by deep rise pools the extend a hundred feet or more below river level. It has been assumed that the downstream portions of the cave systems were completely sumped. Then comes the discovery of the Emerald Pool. Is it in fact, the master drain for the Cove? How does it link to Aqua Cave? The project would be to make very careful discharge measurements at the Emerald Pool and at the feeder streams in Butler and Better Forgotten. Does the water budget balance? Obviously all of the discharge measurements should be made at the same time.

Will White, February 2017

Geochemical Inventory of Burnsville Cove Waters ($)

This was an old project identified long ago but never expedited. Specific conductance of carbonate water is a good proxy for dissolved carbonate. Take a portable conductance meter, and tour all around Butler and the other caves measuring the conductance of streams, pools, drips, and any other water than can be found. The inventory should be done several times under different seasons and flow conditions. If it is possible to collect and analyze a few samples spanning the observed range of conductance, a calibration curve can be constructed that will convert conductance into concentration of dissolved carbonate. From the data set, we may be able to deduce something about the flow paths within the system.

MINERALOGY

Mineral Inventory of the Chestnut Ridge, Helictite, and Wishing Well Caves ($$)

The Burnsville Cove book has a chapter on the minerals and speleothems found in the caves but the chapter is heavily biased toward Butler Cave. The description of the minerals of the Chestnut Ridge System is based on photographs and on X-ray analysis of no more than a dozen specimens collected at various times by cavers. Several of these produced X-ray patterns that were not identified. The project would consist of scouting through the Chestnut Ridge System, Helictite, and Wishing Well Caves looking for anything that is not obviously calcite, aragonite, or gypsum. Mostly these will be nondescript crusts and coatings, not large dramatic speleothems. Any such discoveries would be sampled. The investigator would need access of at least an X-ray diffractometer and even better a scanning electron microscope with energy dispersive X-ray spectroscopy. The end product would be a simple inventory: a list of minerals that occur in the cave with perhaps some interpretation as to how they came there.

Why All the Aragonite? ($$)

This problem has been with us for a long time and we are no closer to an answer. Aragonite is a metastable form of calcium carbonate, thermodynamically unstable in the cave environment. Yet there it is. Aragonite is not common in Appalachian caves but it is present in profusion in many of the Burnsville Cove caves. Why? Are there special trace elements in the Helderberg Limestone that favor the metastable precipitation of aragonite? If so what are they and how do their function? This is an MS or PhD thesis level problem that would require some highly selective sampling, chemical analyses, and investigation of the microstructure (possibly nanostructure of the aragonite crystals.

Investigation of Ice-like Speleothems in Helictite and Wishing Well Caves ($$)

The final problem of the list is one for which even the problem cannot be defined. In Helictite Cave especially but also in Wishing Well are stalagmites and stalactites that are not only colorless but have the appearance of ice (Fig. 12.27). Pure white speleothems do occur widely but are usually milky white rather than icy white. Milky white speleothems are milky because there are thousands of tiny bubbles of water incorporated within and between the calcite grains.

So what about the icy ones? Are they exceptionally pure? What is their internal structure? This is a completely open-ended problem. These things exist. Why? Again, this seems more like a thesis problem than a bit of casual research