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This Issue Edited by Rodney D. Horrocks, Wind Cave National Park

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Caption: Stan Allison collecting microbiological samples during the October camp trip from corrosion residue in the southeastern end of Jewel Cave in a place called The Addendum.

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DUST DEPOSTION ALONG THE OFF-TRAIL ROUTES IN WIND CAVE, WIND CAVE NATIONAL PARK

By Marc Ohms,
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INTRODUCTION

People have been exploring Wind Cave for well over 100 years and during that time established many trails throughout the cave. Historically, string was left behind as a marker to guide the explorers deeper into the cave and back to the surface. Some of the historic trails are now paved with concrete and lit for tours for the general public.

Modern day explorers use plastic flagging tape instead of string to mark trails. Not every route or passage is marked; instead only those routes which are established as main trails to significant parts of the cave are flagged. Each trail has a different color of flagging tape to differentiate one trail from the other. This technique of marking the trails was started in 1990 and was based on the system being used at Jewel Cave National Monument. Within Wind Cave there are eight flagged trails that are used by cavers conducting survey and research in the cave. There is an additional flagged trail that is used for a caving tour for the general public.

The park staff has noticed an accumulation of dust along the trails that appears to be unnatural. It was obvious that dust was being deposited; the question was how much was natural and how much was caused by cavers.

METHODS

The methodology used during a similar study along the Candlelight Tour route (Ohms 2003) was replicated during this study. To determine how much dust is being deposited, a series of three Petri dishes were placed in three locations along each trail. A single dish was placed nearby but off of the trail to serve as a background. Of the eight trails, five were chosen for this study to obtain a variety of typical annual usage. The dishes were in place for one year. On the Caving Tour, two sets of dishes were used, one during the summer months when tours were given and one set during the winter months when no tours were given. The second set of dishes was placed in the same locations as the first set to ensure comparability.

To determine the level of dust deposition, the dust particles were counted on each dish. Using graph paper, a template was created on which the dish was divided into four quadrants. Ten squares were then randomly selected in each quadrant, which were used to count dust particles for all samples. The number of dust particles reported is the total for the 40 squares counted on each dish, and termed the “sample area.” A microscope was used to magnify the samples in order to increase accuracy in the counting procedure.

RESULTS

With an average of 87 particles per sample area, the Bishop Fowler’s Loop had the lightest dust deposition of all the trails monitored during this study. Although, this trail is primarily used for recreational caving, in 2004 there were no recreational caving trips permitted. Without people traveling along this trail over the study period the dust that accumulated was only from natural airflow.

The blue flagged trail, which leads to the Lakes, saw an average of 129 particles per sample area. With the background being 90 particles, the dust along this trail is only slightly above natural conditions. Bimonthly trips were taken along this trail to conduct groundwater level monitoring, with a total of 20 people participating on all the trips. On average each person deposited 1.95 dust particles in the sampling area *(total average dust particles minus background divided by number of people.)* It should be noted that each trip passed the sites twice; once on the way into the cave and once on the way out. Therefore each person deposited 0.97 particles per pass.

The pink and black flagged trail leaves the Caving Tour near survey station CL18 and winds through the Colorado Grotto Section to Mammoth Canyon. There were 3 trips during the course of the study period with a total of 10 people. The three trips only went past the first two sites, Thomas Paine and Xerox Room. There were no trips past the third site in the Citadel during the study period, which predictably had the lowest dust accumulation with 116 particles. The background for the trail was 120 particles. The average accumulation of the three sites was 260 particles per sample area, with each person depositing 14.0 particles on the sampling area. However, it should be noted that each trip passed the sites twice; once on the way into the cave and once on the way out. This means 7.0 particles were deposited per pass. This route had the highest per person deposition during the study. The site in Thomas Paine had the highest accumulation with 502 particles per sample area. Thomas Paine is a small series of crawls connecting the Colorado Grotto Section with the rest of the cave. Airflow through this passage is greater than at the other two sites along this trail, and this site also consists of much smaller passages. The increased airflow could be the reason for the increased dust levels and may indicate high natural levels for this passage. It also might be that cavers stir up more dust while crawling and squeezing than they do while traversing larger passages.

The red and white flagged trail starts in Rome and ends in the Western Fringe area, north of Half-Mile Hall. Besides the Caving Tour, this is the most frequently used and by far the longest trail. During the study period there were a total of 30 trips with 103 people. The background level for this trail was 180 particles, while the average for the trail was 466 particles per sample area. However, only the site at the Frostline saw all 30 trips; the other two sites, at the Chinese Mushroom and BB29, only saw 18 trips with 63 people. It should be noted that each trip passed the sites twice; once on the way into the cave and once on the way out. For the latter two sites each person deposited 3.08 particles on the sampling area; 1.54 particles per pass. The Frostline had the highest accumulation with 650 particles per sample area, but saw nearly twice the visitation of the other two sites. Each person deposited 4.56 dust particles on the sampling area at this site, but only 2.28 per pass.

The Caving Tour is currently being offered daily from May to September with a maximum of 10 visitors per tour, with one leader. During the 2004 summer season there were 74 tours with 475 visitors plus 74 leaders. There also were 20 trips taken to train leaders with an additional 40 people, for a total of 589 people during the study period (Laycock 2005). This trail is a loop, therefore each group passed by the sites only once. During the summer period, the Caving Tour had dust accumulation more than 10 times higher than that of the winter period, and four times that of any other trail. The winter samples averaged 157 particles per sample area while the summer samples averaged 1,739 particles. On average each person deposited 2.69 particles on the sampling area. The Newspaper Room had the highest accumulation of any site during the study with 2,269 particles compared to 157 particles during the winter period, with each person depositing 3.59 particles. The site at survey station CL18 was 8 feet above the floor while the other two sites were at or near floor level. This was done to determine if the dust was being deposited at height. The CL18 site had a summer accumulation of 1,274 particles compared to a winter accumulation of 179 particles.

The pink and black trail had the highest per person deposition rate, mainly due to one site; Thomas Paine (see figure 1.) However due to the low number of trips taken along this trail the overall deposition is relatively low. The per person deposition rate on the Caving Tour is not significantly higher than the rate on the other routes, but due to the sheer number of people on this trail every year the overall deposition is substantially greater (see figure 2.) Simply put, the more people, the more dust being deposited.

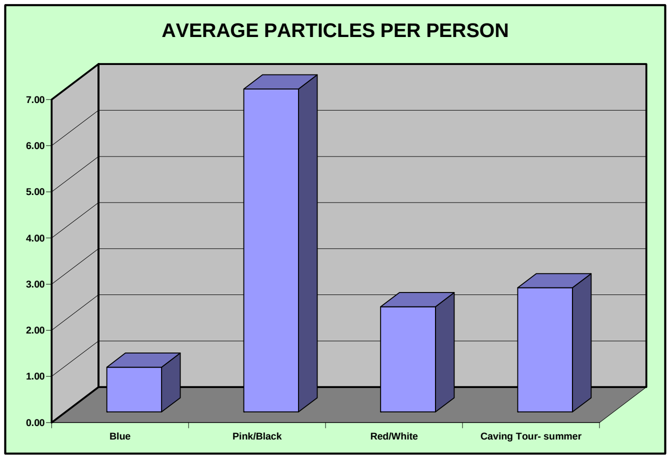

Figure 1

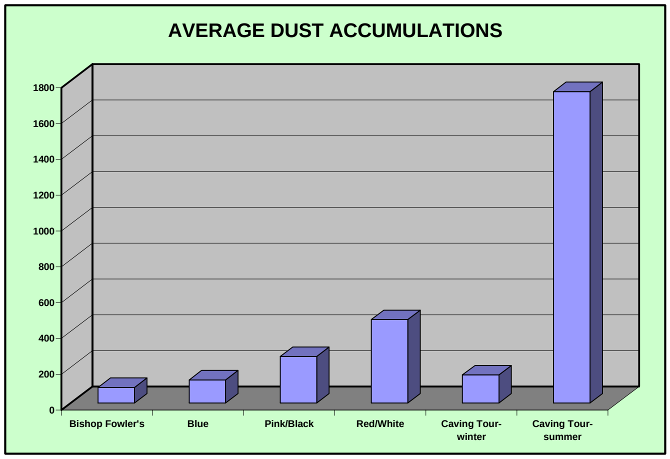

Figure 2

POTENTIAL IMPACTS

The rate of visual degradation by dust fall in the cave is imperceptibly slow, so a cave manager may be unaware that damage is occurring (Michie 1999). Michie states that ten years is the time scale for serious degradation. There are several resources that may be affected: cultural, geological, biological, and visitor satisfaction.

Cultural: Dust accumulating on cultural artifacts can affect those resource in several ways. When dust accumulates on fragile resources such as newspaper and string, the dust holds additional moisture, which causes the paper or string to deteriorate more readily. Thick dust accumulations will cover historic signatures making them illegible.

Geological: Since the cave is generally dry; dripstone formations along the trails are not common. However, they are present along the Bishop Fowler's Loop. Also, there is a wide variety of evaporate mineral deposits such as gypsum, aragonite, and hydromagnesite along all of the trails. These mineral deposits are extremely fragile, and a layer of dust could impede their growth or even break them due to the weight of the dust. These minerals are generally white in color, but when covered with dust they turn brown. Due to the fragility of these minerals restoration work is not an option.

Biological: Due to the great distance of these areas from the Natural Entrance, there are no known vertebrates that live in or routinely use these areas of the cave. However, research conducted in nearby areas of the cave has found a diverse presence of microorganisms (Jesser 1998). The unnatural dust accumulation may have an effect on their presence, population levels, or diversity.

Visitor Satisfaction: If resources are being damaged, destroyed, or hidden by dust, visitors and cavers are not being provided with a quality experience. Visitor satisfaction greatly decreases as the cultural items and speleothems turn brown from being covered with dust. The true beauty of the cave becomes hidden beneath a blanket of dust.

RECOMMENDATIONS

By creating trails in the cave we accept some impacts to the passages and resources along the trail. The truth is that we cannot go into the cave without having some impact. Although generally small, the impacts accumulate over time as more and more people use a particular trail. However, we must not consider these areas to be sacrificial. The entire cave is a significant resource that we as managers of a national park are mandated to protect, therefore we cannot simply pick and choose areas to protect. We must do what we can to ensure that impacts are lessened to a degree we find acceptable to ensure impairment does not occur.

The next step is to determine what level of impact is acceptable and at what point do we take action to mitigate the impacts. Following are a set of options the park can pursue to reduce or eliminate the impact from dust. Consultation with other divisions may yield more solutions than those listed here.

Option 1- Discontinue use of the trail. This would obviously stop the dust from being accumulated at an unnatural rate, but may not be feasible due to the nature of the trail and the reasons people are using it. However, if all else fails this may be the only solution.

Option 2- Reduce the size and/or frequency of the trip/ tour. This option would be the easiest to pursue and this study could be duplicated to determine if the efforts are successful. The question has been asked if we reduce the size of the group or the frequency the trip will there be less dust accumulation. The answer is quite simply- we will never know unless we try.

Option 3- Conduct yearly restoration along the trail. Unfortunately, this option is not realistic. The park does not have the staff to keep up with the dust and lint along the paved trails, let alone the off-trail routes. Due to the delicate nature of many of the speleothems, restoration work in many areas is not even feasible. This option does not deal with the problem directly; it continues to allow the problem to occur and only deals with the impacts after they have occurred. Logically, we should be dealing directly with the dust problem to stop or control its occurrence. Limited mitigation efforts are in order in many areas, but only as a restoration effort after the dust problem has been solved, not as a solution to the problem.

Option 4- Compact the sediment or install mats. Compacting sediments will only work in areas with moisture within the sediment, but these are not the problem areas. The areas that are problematic are dry with very fine-grained sediments. The dry sediments are not compactable as evidenced by the fact that many years of human travel have not compacted the sediments. Actually the converse is the case; many of the sediments were naturally hardened, but have been broken and pulverized by traffic.

Installing some sort of rock path or man-made mats along the dustiest areas has been suggested. In Mammoth Cave a boardwalk made from cypress and recycled materials as well as stone pavers were used to build a path where there formerly was a dirt trail (Fry and Olsen 99.) This effort has been successful in controlling the dust; however this is in large flat-floored walking passage, not a small crawlway with uneven floors. Due to the undulating and rock strewn floors of Wind Cave this technique has limited potential for success. However, it should not be ruled out as it may work in some areas.

Option 5- Reroute the trail. Moving the trail to a passage with less dust or one with a hard floor may be a viable option in some situations. The trails are where they are for a reason, and many times that is because it is the only way to go. However, in some cases an alternate route may be found that bypasses a dusty area.

There are a few simple procedures that cavers can follow to help reduce the amount of dust being accumulated.

- ✓ Ensuring that clothes and cave gear are clean before entering the cave.
- ✓ Wear clothing that is in good condition without threads and pieces ready to be torn off by the cave.

- ✓ Wear clothing that does not shed excessively.
- ✓ Travel slower than normal in dusty areas to reduce dust disturbance.
- ✓ Travel in single file and stay on the flagged trails.
- ✓ Explorers entering newly discovered passages should pick the route resulting in the least impact.

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Park Updates (Listed alphabetically):

BUFFALO NATIONAL RIVER

By Chuck Bitting, Geologist

Staff at Buffalo National River, in cooperation with Arkansas State University, are completing analysis and reporting on a two-year study designed to evaluate the quality of endangered bat roosts. Temperature and humidity data were generated for fifteen roost caves and mines using HOBO® Pro H08 series dataloggers. Human disturbance events were measured with HOBO® H06 Light event recorders. Ancillary data collected includes bat census data and appearance of human activity within the roosts. Preliminary data suggests that most of the hibernacula are poorly suited for the Indiana bat (Myotis sodalis), but well suited for the Gray bat (Myotis grisescens). The report will also include information on environmental conditions at summer roost sites.

Caption: Temperatures were recorded using HOBO® Pro H08 series dataloggers. Human disturbance events were measured using HOBO® H06 Light event recorders.

JEWEL CAVE NATIONAL MONUMENT

By Andy Armstrong, Cave Management Intern

Rescue Packs

Eight locations within Jewel Cave had been stocked with rescue packs. These are in prominent locations along main travel routes. They contain basic first aid and survival gear including food, water, and shelter. Over time, the perishable items need to be replaced. In 2005, the packs at Cloud Nine and Seventh Heaven in the eastern portion of the cave were replenished. Perishable items in the new packs are vacuum sealed in order to increase shelf life. Stabilized oxygen was added to the water in the packs in order to prevent the growth of anaerobic bacteria in the containers. Water treated in this way can remain potable for up to five years.

Digitized survey notes

Following the lead of Carlsbad Caverns National Park, Jewel Cave National Monument has begun to scan all survey notes into digital form. This allows the notes to be accessed more easily and also serves as a backup for the originals. To date, 214 surveys have been digitized into the PDF format.

Research

Dr. Andreas Pflitsch's airflow study continues here at Jewel Cave, with regular trips to replace data cards and batteries for the ultrasonic anemometers. On the October exploration camp trip, corrosion residue samples were taken in the Stratosphere and near the Addendum. These will be examined by Dr. Diana Northup for possible microbial activity. Also on the

October trip, a pressure datalogger was left at the camp site. It will record atmospheric pressure every 15 minutes for over a year.

Rope and ladder replacement
All handlines and ladders between the Scenic Tour Route and Hell's Half Acre have been replaced. These are along the main travel route to the western reaches of Jewel Cave. Also, in the east, the ladders at the Slicken Slide and at the Point of No Return have been replaced. The new ladders are 7mm rope with fiberglass rungs; manufactured by Lyon Equipment.

Restoration Camp
The Black Hills Cave Restoration Camp took place on May 9-13, 2005. A small crew of volunteers removed lint from the Scenic Tour Route. The crew worked from Spooky Hollow on to the elevators, cleaning about ¼ mile of passage.

New Intern
Andy Armstrong has accepted the position of Cave Management Intern. Armstrong is a volunteer who will be helping the Cave Resource Office this winter. Some of his duties include data management, water quality monitoring, drafting maps, lint and algae removal, and maintenance of ropes, ladders, route flagging, and rescue packs within the cave. Additionally, the intern will have the opportunity to assist with exploration and survey.

Caption: Volunteer caver, Larry Shaffer, completing an inventory form next to a giant rim discovered on a survey camp trip in Jewel Cave in November.

Exploration
Since the last issue of *Inside Earth* there have been ten exploration trips into Jewel Cave, including two four-day camp trips. These trips have added 1.9 miles to the known cave, with 3.96 miles surveyed in 2005. The cave length now stands at 134.26 miles. Cavers on the day trips surveyed new passage in the Thrill of Victory, Discovery Room 9999, Snow Pudding Passage, and the Curio Shop. The Columbus Day and Veteran's Day camp trips were highly productive in exploring new passage out beyond "The End" in the eastern part of the cave. The area beyond Dark Descent is showing the most promise, with several leads remaining for the upcoming camp trip in January 2006.

OREGON CAVES NATIONAL MONUMENT

By John Roth, Natural Resource Specialist

The Monument's subsurface management plan was submitted to the Northwest Region for approval and release for public comments. It will presumably be posted soon at ftp://ftp.den.nps.gov/incoming/orca. 177 pages were added to a US and Canadian cave (approx. 11,000 species), groundwater, and marine list totaling about 45,000 species, including accidentals, troglexenes, etc. This is one of the world's largest geographic distribution lists. Roth will be attending the All Taxa Biological Alliance conference in the Smokies to get input on how to get funding to continue this project and how to put the data into Access so as to obtain the maximum amount of information on extinction, speciation, and migration patterns. Doing so, for example, may help verify the conclusion of a recent article that subsurface species (cave, groundwater, and marine infauna) have lower angle biodiversity slopes from the equator to the poles both because speciation rates are higher (more subject to isolation of small populations) and extinction rates are lower (fewer temperature or humidity fluctuations) compared to ground surface and above ground surface species.

USGS and park staff helped with a multi-park water quality monitoring program and a paleoclimate study, respectively. Averaging 12 temperature sites indicate a cave warming of about 1.50 F. in Oregon Caves since the 1950s. Vital Signs for the Monument were established and the protocols for monitoring cave entrance species are being developed. DNA analysis showed 15 cave fungi and about 8 bacterial species. 96 (rubble, lint) and -200 (algae, bacteria) square feet of cave surfaces was restored. More tarps were emplaced to capture human organics. A room by room fragility/hazard classification of cave trails was largely completed. A cave scientist address list was updated.

WIND CAVE NATIONAL PARK

By Rodney D. Horrocks, Physical Science Specialist
& Marc Ohms, Physical Science Technician

Some of the cave management highlights that have occurred at in the park since the last issue of Inside Earth are:

Jason Walz just accepted a winter seasonal cave physical science technician position at the park. He'll be primarily working on a microbial research project, entering backlog cave inventory data, and updating the cave quadrangle maps.

Projects:
We just completed our first profile view of the three major tour routes in Wind Cave. This profile view includes the surface, surface buildings, elevator shaft, and geology of the immediate vicinity. People were included in this view for visual scaling purposes. This profile view was added to the recently completed plan map of the tour routes in Wind Cave and printed in poster format.

We just completed a project to document all the known historic (1890-1893) signatures of Alvin McDonald found in Wind Cave. Alvin made the first map of Wind Cave and explored an estimated nine miles of the cave, much of it solo. A total of 43 signatures were located and added as a layer to our Geographic Information System.

Research:
Bjoern Zindler, from Ruhr University in Bochum Germany, just completed his Masters Thesis on the microclimatological conditions in the Walk-In Entrance area of Wind Cave. He found that the existing revolving door leaks as much air as the Natural Entrance and that by adding a more airtight seal to the Walk-In Entrance we could reduce the impact from freezing temperatures during the winter to the floor of that area, sparing the unstable ceiling.

Karst Interest Group Workshop:
The Park was one of the scheduled field trip stops on the Southern Black Hills Karst Hydrology Fieldtrip for the Karst Interest Group (KIG) Workshop held in September. Rod also presented a revised version of his cave potential article at the workshop and filled in for Dr. Louise Hose as a luncheon speaker for a National Cave and Karst Research Institute (NCKRI) update.

Cave Survey & Inventory:
Tom McBride, a summer volunteer, was able to write a program that allows us to enter our cave inventory data into an Access database. Because contracting this project out to someone with Tom's programming skills would have cost us over $24,000, we would have never have been able to accomplish this project without his volunteer services. Using Visual Basic, Tom wrote over 800 lines of program that allows us to enter ranges of survey data into a single field. His program then takes those ranges and enters each station and associated features individually as a single line in an Access database (the computer does all of the hard work for us in a couple of seconds). His program also allows us to enter text into a comment field for stations that have unusual features. Tom's new program has reduced the time it takes us to enter a single inventory sheet from a half hour to seven minutes! In addition to writing the program, Tom removed all of the duplicate data from our old database. Although, this reduced the number of stations in our database from 23,000 to 13,000, it gave us accurate data. We are now in the process of error checking that data and are beginning to enter all of the backlog data that has accumulated in the previous six years (about 350 sheets), along with all of the comments from cave inventories conducted between prior to 1998. Once the backlog data is all entered into the database, we will be able to use GIS to query the complete database. We will undoubtedly learn many things about Wind Cave that we never suspected before.

We recently nominated the Colorado Grotto for the George B. Hertzog Outstanding Volunteer Group award for their contributions to the survey and inventory of Wind Cave. They were chosen by the Midwest Region of the National Park Service to be that regions nominee for the national award. Although, they weren't chosen for the national award, the region presented the grotto with a very nice plaque commemorating their regional selection.

Since the last reported length of Wind Cave in the Inside Earth newsletter, volunteer cavers have increased the surveyed length of the cave by 1.07 miles, establishing the current length of 117.82 miles.

Caption: Wind Cave park staff haul a volunteer victim on a SKED during a mock search and rescue recently held in conjunction with a two-day NCRC cave search and rescue class taught by Marc Ohms. The patient was extricated from the half way point, on the Wild Cave Tour in Wind Cave, to the surface, in two hours.