CAVE AND CLIMATE CHANGE: EDUCATING THE PUBLIC AT RATS NEST CAVE, ALBERTA, CANADA

Charles J Yonge  
Yonge Cave and Karst Consulting Inc.  
1009 Larch Place, Canmore, AB T1W 1S7, Canada  
chas-karst@telus.net

Adam Walker  
Canmore Caverns Ltd.  
200 Glacier Drive  
Canmore, AB, T1W 1K6, Canada  
info@canmorecavetours.com

Andrea Corlett  
Alberta Speleological Society  
1606-924 14 Ave SW, Calgary, AB. T2R 0N7, Canada  
alcorlett@hotmail.com

Abstract
Rats Nest Cave is a Provincial Historic Site whose mandate is to present its natural history to the public. In addition to a suite of interpretive messages, and relevant to this conference’s topic, we have addressed diverse climate change over the geological history of the cave. We start with the cave-hosting rock and the fossils it contains, to its origin along a thrust fault, ending with its enlargement and secondary mineralization during the Quaternary glaciations (the latter having been dated by radiometric methods). We have undertaken a program of speleothem remediation which, visible to the public, serves to reinforce the conservation and sustainability message emphasizing the importance of caves to society.

Introduction
Rats Nest Cave was protected as a Provincial Historic Site in 1987. Public tours began some years afterwards in 1995 supported by interpretive information gained via a number of studies at the cave by the authors and others (Yonge 2012, Yonge 1991 and e.g. Figure 1) and by provincial funding from the Science Alberta Foundation. The tours are wild in nature with horizontal and vertical caving being offered: (www.canmorecavetours.com).

A wide variety of the populace has been taken through the cave over the years, with 2012 numbers at 3,553 participants. Visitors were world-wide (with the female to male ratio at 45:55 %), but the majority have been Albertan (82%) in recent years (Figure 2).

Groups range from independent tourists, corporate, school, church, guide and scout and tertiary institutions. The cave generates considerable interest, with a high rating on Trip Advisor plus several media releases in the media, e.g. TV and radio.

Interpretive information related to climate change
For our public education (on climate change), we start outside (Figures 3 and 4) with the cave-hosting Mississippian limestone (the Livingstone-Mount Head Formation), which contains index fossils: brachiopods, horn corals, and crinoids. Our interpretation here focuses on the corals and therefore tropical paleoclimate of the time, and how that could have been considering that we now experience a Siberian-type climate. The out-of-place fossils give a good opportunity to talk about plate tectonics (especially looking across the valley to the classically folded and thrusted mountains that constitute the Canadian Rocky Mountains). It appears that during the Mississippian, these limestones were laid down just north of the equator along reefs aligned east-west (Gadd, 1995).

In discussing plate tectonics, we introduce mountain building and faults that occurred during the Cretaceous as the ancestral super continent of Pangea was breaking...
up and dinosaurs roamed in and around the ancestral Bears Paw Sea (the world-class Albertan Tyrell Dinosaur Museum exemplifies this era with stunning local exhibits). Specifically we refer to low-angle thrust faults along one of which the cave has formed (Figure 3) and which is readily seen underground (Figure 5).

The climate change story then moves into the multiple Quaternary Glaciations which, when ending at a given interglacial, result in the enlargement of the cave by extensive glacial meltwater (Canadian Rockies Caves are intimately coupled to glaciations leading to classic glaciokarst in the region – Ford and Williams, 1989). At this stage the cave also experiences clastic sedimentation and secondary mineralization, which potentially give proxy paleoclimate records (Figures 6, 8 and 9).

Speleothem dates thus define interglacial periods (Fairchild and Baker, 2012; Ford and Williams, 1989) and at Rats Nest Cave, a number of U-Th dates of speleothems confirm this (Figures 7 and 8).

Calcite speleothem fabrics can yield information about past temperature (and vegetation cover) above the cave.
than speleothems. Just inside the cave entrance, debris has accumulated in a 15m pit, of which bones are a significant component (Table 1 and Figures 10 and 11).

Carbon-14 dating of the bones has yielded a maximum of 7.2 ka, showing that all of the 34 mammals represented are of Holocene origin having fallen in after the last glaciation.

Two artifacts recovered from the pit have been dated back to 3.2 ka and identified as Pelican Lake Culture (Figure 11), a late stage bison-hunting group that arose and thrived during the warmer than today Holocene Hypsithermal period, 7.5-5.0 ka. The fact of this climatic optimum is supported by speleothem stable isotope studies at the cave (Figure 9). Pictographs at the cave entrance appear to be more recent, perhaps 500 years old.

While the prior discussion is somewhat technical for a lay audience, the interpretation can be tailored to suit needs; the audience might of course include climate scientists.

At a less technical level, for example, we conduct an annual field trip from the grade 10's at our local high school: climate change forms part of the curriculum of their so-called Ascent Program.

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![Figure 6. Paleomagnetic sampling of clastic sediments in Rats Nest Cave.](image)

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| Growth phase I | >600,000 yrs |
| Growth Phases II-IV | 215,000-180,000 yrs |
| Growth Phase V | 3,800 yrs |

![Figure 7. A stalactite from Rats Nest Cave, showing growth during interglacial periods with evidence of cave flooding.](image)

*Figure 7. A stalactite from Rats Nest Cave, showing growth during interglacial periods with evidence of cave flooding.*

![Figure 8. Speleothem U-Series dates from caves in the Canadian Rockies compared to those from Rats Nest Cave and Oxygen isotope record of marine and ice cores.](image)

*Figure 8. Speleothem U-Series dates from caves in the Canadian Rockies compared to those from Rats Nest Cave and Oxygen isotope record of marine and ice cores.*

![Figure 9. Holocene stable isotope temperatures based on several speleothems from Rats Nest Cave.](image)

*Figure 9. Holocene stable isotope temperatures based on several speleothems from Rats Nest Cave.*
Speleothem Remediation at the Cave

Rats Nest Cave is a static cave in the sense that no vadose water currently flows through it as streams (Figure 12). The cave in fact is almost entirely phreatic and was completely flooded in glacial times (Yonge 1991, Palmer 2007). That vadose down-cutting is almost completely absent testifies to its glacially-coupled origin: rapidly melting ice sheets would have given little time for passage entrenchment.

Speleothems have accumulated after cave dewatering during the interglacial periods and, as argued above, are very important in determining past climates above the cave.

Because the cave is static, containing copious quantities of clastic glacial sediments, it has suffered as these have been spread around by careless cavers prior to its provincial designation.

The cave contains a great variety of calcite formations and these are of great interest to visitors (Table 2). The interpretation outlined above further adds to their value in the public eye. We have therefore embarked on a remediation plan, mainly tackling dirty and damaged formations (Figures 13, 14 and 15).

With the help of volunteers from the Alberta Speleological Society, the formations along well travelled pathways within the cave are being cleaned. The techniques used...
to clean the muddied formations have been adapted from those described in Cave Conservation and Restoration (Hildreth-Werker and Werker 2006).

Preventing further damage to speleothems is intrinsically important to the remediation process: both the tools and water used to clean formations must be carefully selected. Tools chosen for formation restoration must be non-abrasive to the delicate outermost layers of calcium carbonate. As such, soft bristled tooth brushes, nail brushes and plastic tooth picks are among the cleaning kits. Care is taken by the volunteers when using the cleaning tools to not apply excess pressure on the formations and extremely delicate speleothems are often not remediated to avoid causing further damage. The water required to clean the formations must be collected from a standing pool that self-replenishes from rain and surface water slowly percolating through the rocks above. This pool serves as a reliable source for the vital calcium bicarbonate rich water required to safely clean mud away from the formations without dissolving the outermost layer.

The results so far have varied from poor to outstanding. We have found that the formations that have been growing at a more rapid rate have already sealed the mud under several thin layers of calcium carbonate, while those growing more slowly have come almost entirely clean.

Educating the visitors to Rats Nest is a key factor in the continued conservation of this Provincial Historic Site. To assist in this goal, formations that have been remediated are marked off using flagging tape and signage has been placed to explain the restoration project and encourage visitors to stay on established trails and avoid touching the formations. A secondary benefit of this project is knowledge gained by our many volunteers regarding cave conservation and the spreading of that knowledge throughout the local caving community.

<table>
<thead>
<tr>
<th>Calcite Mineral Formation</th>
<th>Location Where Good Examples are Found</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coatings and Crust</td>
<td>Birth Canal and above the Slimy Climb</td>
</tr>
<tr>
<td>Conolites</td>
<td>Chasm below the High Point, Grand Gallery</td>
</tr>
<tr>
<td>Coralloids</td>
<td>Grotto, Wedding Cake Passage, Rabbit Warren</td>
</tr>
<tr>
<td>Curtains</td>
<td>Grand Gallery, Coyote Descent</td>
</tr>
<tr>
<td>Flowstone</td>
<td>Many areas—Grotto, Great West Highway, Wedding Cake Passage</td>
</tr>
<tr>
<td>Helictites</td>
<td>Great West Highway, Wedding Cake Passage</td>
</tr>
<tr>
<td>Moonmilk</td>
<td>&amp; m pitch near entrance, high dome above the Grand Gallery</td>
</tr>
<tr>
<td>Pearls</td>
<td>Pearly Way, Ranger Way</td>
</tr>
<tr>
<td>Rafts</td>
<td>Sucker Route, Mud Room</td>
</tr>
<tr>
<td>Rimstone Dams</td>
<td>Frozen River in the Wedding Cake Passage, Grotto</td>
</tr>
<tr>
<td>Spar</td>
<td>Above the Slimy Climb</td>
</tr>
<tr>
<td>Stalactites</td>
<td>Numerous areas—Ranger Way, Great North Highway, Grand Gallery, Grotto</td>
</tr>
</tbody>
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Table 1. Speleothem varieties and locations in Rats Nest Cave.

Figure 13. Work in progress on a column, taped off with a notice informing and educating self-guided cavers.

Figure 14. Cleaning work on the column shown in Figure 13.
Conclusions

The coupling of scientific studies to the natural history interpretation of this protected cave site has resulted in a successful management model, which has the added benefit of protecting the cave by a year-round presence. The alternative could have been to recognize the cave as a special scientific area and allow entry solely to researchers. However, with a city of over one million inhabitants within an hour’s drive (Calgary) this strategy would have been a disaster. Without daily presence at the site, the gate would have been compromised and the cave severely vandalized. This has been the result at the more remote Cadomin Cave, which has suffered from spray paint, garbage and disturbance of its bat population.

The results of illuminating the cave’s value as a record of geological history, paleontology, and climate change has been a flourishing business, with 3,533 visitors educated last year.

References

Yonge, C.J., 1991, Studies at Rats Nest Cave: Potential for an underground laboratory in the Canadian Rocky Mountains: Cave Science, v. 18, no. 3,