Snow Bank Detectives

An abundance of snow provided an opportunity to draw analogies to rock layers and make other geology connections.

By Eric A. Olson, Audrey C. Rule, and Janet Dehm

INSET PHOTOGRAPH COURTESY OF THE AUTHORS

In our city, located on the shore of Lake Ontario, children have ample opportunity to interact with snow. Water vapor rising from the relatively warm lake surface produces tremendous "lake effect" snowfalls when frigid winter winds blow. Snow piles along roadways after each passing storm, creating impressive snow banks. When a tractor-mounted snow blower slices through these snow banks, the succession of snowstorms is revealed as interesting layers of different thicknesses and colors.

As science education professors with an interest in geology, we couldn't pass up the opportunity to study sedimentary processes and phase changes with the mounds of snow right in our own front yards. Our colleague—a fourth-grade teacher at a local school with an abundance of snow banks—teamed up with us to create this weeklong snow bank investigation.

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Sedimentary Snow

Prior to our snow investigations, students had been studying the three types of rocks (igneous, sedimentary, and metamorphic). Snow banks, like sedimentary rock formations, are made of sediments deposited from above, creating a layered sequence.

We began the lessons by showing students an electronic slide show of photographs we had taken of snow banks in neighborhoods around the school. Students immediately noticed the layered patterns of snow and suggested that thicker layers represented larger snowstorms. Students easily made the connection to sedimentary rock layers. One student noted the snow banks "all have sedimentary rock forms and are lots of dark and light colors." Students' level of interest was high because they already loved snow for its beauty and for the recreation it provided.

Through our observations, we discovered another geology connection: comparing icicles and stalactites. See "Ice Versus Rock" on page 22 for a companion investigation.

Explanations for Dark Layers

After the slide show, students worked in small groups to examine the snow bank photographs and record their observations. In order to document their initial understanding, we provided questions to prompt observations and inferences: *What features do you notice about the snow banks? What do you think caused these features?* Students, engaged in the inquiry, asked questions of their own: *Why is the snow brown?* and *Why are only some of the snow banks melted?*

Students observed the layers, their different thicknesses, the variety of colors, and the holes or brown spots in the snow banks. Then students used their previous knowledge to suggest explanations. Many children were not aware that plows push snow mixed with salt and sand up onto the snow banks, producing the dark, thin layers. Students assumed instead that cars splashed the dirt: "A car might have gone by and put mud on the snow."

Another idea expressed by some students was that salt turned the snow brown. Some students attributed the darkness of the lower layers more to splashing by cars rather than to compaction because of age. It might have made sense to students that lower layers were dark in color for the same reason cars become dirty. It is a more complex idea to consider that the lower layers are darker because of melting of snow, thereby concentrating the amount of dirt and rock.

However, there were students who understood at least part of the process well: "The snow bank starts white and then the plow came by and turned it brown, then it just kept switching brown and white, brown and white."

Changing Snow

During our next class session, we discussed the changing size and shape of snow banks. We asked students to describe their experiences with snow melting and refreezing. In the morning, they walked over hard snow, but in the afternoon when the Sun was shining, they sunk up to their knees. Our students had firsthand knowledge (e.g., knowing the "right" snow for snowman construction) with the various forms snow takes. One student noted, "It is easier to make a snowball on the way home after school. The snow is too hard in the morning."

Most students inferred relationships between the condition of snow banks and the intensity of sunlight shining on the surface. Shade from trees or buildings and the slope of the ground make noticeable differences in the size of the snow pack. "The Sun and the warmth might explain the difference." A student suggested that being "closer to the grass" would have an effect on melting because the grass would soak up the water. To explain size and appearance differences, one student stated, "Snow banks closer to direct sunlight that have nothing to block it usually melt first."

The Benchmarks for Science Literacy (AAAS 1993) state that "by the end of the fifth grade, students should

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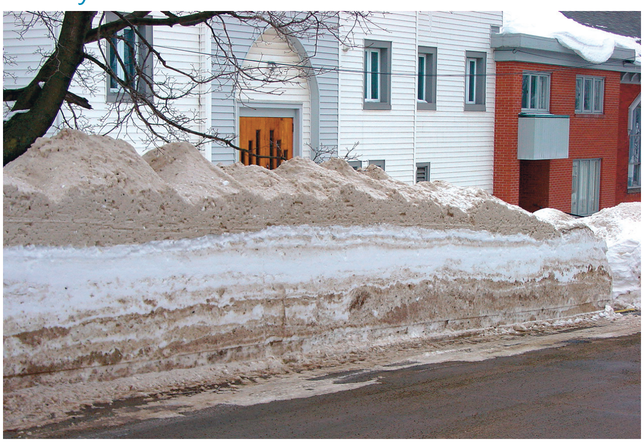
Snow banks around the school resemble sedimentary rock layers.



Students first examined photographs of snow banks and recorded observations.

PHOTOGRAPHS COURTESY OF THE AUTHORS

Ice Versus Rock

Ice formations offer insight into the processes of icicle and stalactite formation through comparison and contrast.

By Audrey C. Rule, Eric A. Olson, and Janet Dehm

During our snow bank exploration, our students noticed "ice caves," or pockets, in some of the larger snow banks, usually below darker layers. Most of these caves had many icicles hanging inside. Students offered reasonable explanations of ice cave formation—squirrels, kids, snow blowers—and a few students came close to the true ice cave-formation process, suggesting that the salt-rich layers of snow (the darker brown layers containing salt, clay, and sand) melted in the Sun and created the voids. The cave icicles formed as the less-salty melt water from the top of the snow bank seeped in and dripped from the cave ceiling, refreezing as icicles.

As in our previous geology-related explorations, our icicle observations led naturally to a discussion of how stalactites form, providing a perfect lead in to a hands-on activity that compared the two processes.

How Alike?

For this investigation, we obtained stalactites that had been collected from the blast zone of a newly constructed entrance to a commercial cave. (Stalactites should not be removed from a cave but left for others to study and enjoy. Ward's Natural Science, *www.wardsci.com*, sells stalactite specimens, and some commercial caves sell specimens recovered from construction of new entrances.)

To begin, we explored icicles. We distributed magnifying lenses, paper towels, plastic trays, and icicles, which we (the teachers) had collected from our roofs and then wrapped in plastic wrap, stored in freezers, and transported to school in a cooler.

A wave of excitement moved through the room as students held the ice and recorded their observations. The icicles were "cold," "wet," "dripping," "slippery," and, as many students experienced, easily broken. Students described the icicles' shapes as "thin," "long," "pointy," "cylindrical," and "tapered." Students felt their textures: smooth but bumpy, hard, and sharper on broken edges and tips. Students looked closer with hand lenses to notice small bubbles and dots of dirt.

Students recorded their ideas about icicle formation in their notes. "They can form on cold and rainy days. Water freezes and makes icicles." "They keep growing bigger and bigger."

Then we turned to examining the stalactites. Students noted similarities to the icicles in tapering shape and bumpiness and happily found the stalactites did not break as easily and were more pleasant to handle. Students were amazed to discover concentric rings on the cross-sections of two of the stalactites. One student wrote, "The ends of it look like a tree cut down." Several students wondered if the circles might indicate the age of the stalactites as tree rings mark the years of a tree.

Students made other comparisons to more familiar objects. "They look like bone on the outside but are crystals on the inside." The surface of another smoother specimen looked "like candle wax." The popcornlike configuration of another piece was likened to a coral reef. Students also noticed the hole in the center of many of the stalactites.

As they had done with the icicles, we asked students to write notes on how the stalactites might have formed. Surprisingly, no one suggested dripping water; in fact, few students could think of a response. The stalactites were dry, making it difficult to imagine a water origin. One student wrote, "Stalactites are made of dust and dirt compacted."

Another student suggested that perhaps the stalactites were pushed through cracks or holes in the cave ceiling, in a way similar to icing being extruded from a syringe. No one connected the concentric rings with mode of formation.

Making Connections

To help students see the similarities and differences between stalactite and icicle formation, we put together a 10-minute electronic slide show of cave-related photographs taken from Internet sites.

The slide show explained the process of limestone cave formation and compared icicles to stalactites. Afterwards, we discussed the show and other differences and similarities between stalactites and icicles.

We talked about how both icicles and stalactites are suspended from ceilings, both contain some dirt or dust, and both range in size from tiny to very large. For differences, we noted: icicles are transparent but stalactites are opaque; icicles are lighter in weight when compared to a stalactite of the same size (the stalactite is *denser*); the stalactites were harder to break than the icicles; icicles had no odor, but the stalactites smelled musty; and icicles appeared solid but stalactites often had a narrow hollow tube down the middle. (Actually, icicles begin with a hollow tube, but after growth stops, the freezing ice expands into the hollow middle area, making it solid.)

Next, we reviewed the similarities between ice caves and limestone caves. Both are related to seeping water. However, the empty space of an ice cave forms as solid ice melts to form liquid water, whereas in a limestone cave, melting is not involved. Instead, a hollow area is created as rock is dissolved by groundwater containing carbonic acid. The weak carbonic acid forms naturally as rainwater falls through the air or moves through soil and picks up carbon dioxide.

Additionally, the formation of icicles is different from the formation of stalactites. Freezing makes icicles, but stalactites are made by the deposition of tiny bits of rock as the water evaporates. Contrasting these two modes of formation helped students notice the essential characteristics of each process.

After our discussion, students completed Venn diagrams comparing icicles and stalactites. Our students were able to diagram many similarities and differences, revealing the understandings they had gained from the experience.

NSTA Connection

For more snow, ice, and stalactite activities, click on the online version of this article at *www.nsta.org/elementaryschool*.

PHOTOGRAPH COURTESY OF THE AUTHORS

Students examined samples of sedimentary rocks and compared their layers with those in the snow banks.

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know that heating and cooling cause changes in the properties of materials" (p. 77). We showed the class two photographs of snow banks taken on opposite sides of the same street. The larger, lighter-colored bank with distinct, even layers faces north. The shorter, darker bank faces south. The major variable accounting for differences is the amount of sunlight shining on them: The north-facing bank spent most of the day in the shade.

Students were able to understand this abstract relationship more clearly when the next day we took them outside to directly observe snow banks. We examined snow banks on the school grounds to find evidence to support or refute our hypotheses and to make new observations. Students noticed melting features of the banks, such as more ice caves in snow banks that directly faced the Sun and larger snow banks in shaded areas.

Core Understandings

Often, when students are exposed to an authentic learning experience and are allowed to fully share their ideas, misconceptions rise to the surface. A few students thought that large snow banks melt from the inside out. These students explained that at night the outer part of the snow bank freezes because of the cold air, forming a crust, but the inside continues to melt. One student was adamant that "the inside of a snow bank is all liquid." Many students at this age also think bulky coats and sweaters generate their own heat (Watson and Konicek 1990). They may transfer this idea to snow banks.

The snow investigation provided the chance for students to observe water's phase changes firsthand. We took the students outside to examine the snow banks around the schoolyard and to take core samples of the different layers. Using a 1 m long, clear plastic tube to take the core sample allowed students to see that the interior of a bank was ice throughout.

Back in the classroom, students pushed the core samples onto a tray and examined them carefully for texture and structure. Students saw evidence of deposition and *recrystallization* within the layers. Sand and salt that had been spread to clear roads appeared in the samples as dark layers in between lighter layers of snow, providing a visual record of deposition.

The snow from the core samples appeared very different from the fluffy flakes that fell during the storm: The core-sample snow had recrystallized into coarse, irregular, pea-sized grains. Students noted these findings in journal entries: Fresh snow is "fluffy and light," while snow bank snow, "looked like ice chunks; it looked like hail."

During the investigation, students also discussed their understandings of freezing and thawing. "When the water comes out of the snow bank, it freezes (at night) and turns into ice. Then day comes and turns it back into water. This keeps happening until the night isn't cold enough to freeze the water."

It was interesting that students assumed that the only way snow disappeared was through melting. They could not explain how salt-free snowdrifts shrank on below-freezing nights through *sublimation*—when water changes directly from ice to water vapor without melting. Students had not yet studied sublimation directly, but this topic would soon be covered in an upcoming unit exploring the phase changes of water and the states of matter.

Examining the snow-bank core samples laid a concrete foundation for that investigation.

Stories About Stratigraphy

We used the hands-on experience of examining snow banks to promote literacy skills throughout this unit. For example, the vocabulary associated with the investigation was the foundation of students' spelling list for the week, and students recorded their thoughts in journals and completed reports to document their observations.

At each phase of instruction, students documented their thinking by writing about their snow bank experiences. Initially, students responded to specific prompts that directed their attention. As their knowledge base of snow bank formation grew, the nature of the writing assignments changed to more open-ended journaling and story creation.

In their writing, many students discussed the ages of the layers. For example, a student wrote, "After the first layer of snow, the snow comes again and leaves a layer on top." Another student wrote, "They have different colored layers, and the farther down, the older it is." This statement reflects emerging understanding of *superposition*, a key geologic concept.

Sample Study

The day after our outside snow bank observations, we passed around several layered sedimentary rock speci-

Figure 1.

Assessment rubric for description of snow bank model.

Criterion	Main Concept	Number of Points: Yes	No
Student states that the sequence of events for snow bank formation starts with the oldest, bottom layer.	Superposition	1	0
Vanilla pudding layers are described as representing snow accumulations.	Snowfall events	1	0
Crushed cookies or sprinkled candies are described as representing salt mixed with sand, clay, or gravel distributed by trucks and pushed on top of snow bank by plows or snowblower.	Plowing events	1	0
Student ascribes differences in snow layer thicknesses to amount of snowfall.	Layer thickness is related to snowfall	1	0
Student notes changes in the appearance of snow banks because of melting, refreezing, sublimation, or compaction.	Mechanisms for loss of snow volume	1	0
All writing is in complete sentences starting with a capital letter and ending with a period.	Integration of writing skills	1	0
All spelling is correct.	Integration of writing skills	1	0
A diagram of the snow bank pudding model is included with parts labeled.	Integration of spatial and communication skills	3	0
Total Points out of 10 Possible Points			

mens. Students easily identified similarities between these and the snow banks. Students quickly concluded that the layers in both the rock sample and in the snow banks represent different episodes of deposition.

A thick layer of snow with a lot of sand, salt, and gravel thrown on top is evidence of the snowstorm that kept them home from school for three days. Other smaller layers represent shorter or less intense intervals of snowfall. Similarly, each layer in a sedimentary rock gives evidence of the conditions under which it formed. For example, strong currents are generally needed to move large pebbles, while silts and clays are deposited in quieter water.

A student explained the sequence of events in a snow bank: "Layers show what happens to the snow bank. First it snows, then the snowplows, road salt, or mud and dirt with rocks come to change the snow bank." Students were also able to correlate thick snow layers from photograph to photograph. It isn't the Grand Canyon, but in the 1–2 m tall snow banks that line our streets for part of the winter, you daily see similar structures evolving on a smaller scale.

A Parfait Assessment

On the last day of the weeklong unit, we presented a final slide show of snow banks interspersed with photos of sedimentary rock layers to help students take notice of their similar features and origins as an accumulation of falling particles. Much of the dialogue focused on how the varied layers of snow banks reveal the history of local storms. Similarly, sedimentary rock layers show the sequence of deposition: the history of floods, sandstorms, beach currents, mudslides, or other geologic processes that affected an area.

As a culminating activity, students created a model snow bank using vanilla pudding, crushed chocolate wafer cookies, peanut butter chips, and chocolate sprinkles. **We took into account any student allergies before planning our food-related activity.**

For assessment, we asked each student to draw a diagram of his/her model and write the story of the evolution of the "snow bank" that was created. The assessment rubric (Figure 1) focused on whether students could supply reasons for differences in layers (position, thickness, color, texture, and composition) in a snow bank in addition to evaluating writing skills. Only after completing a suitable snow bank history and having it reviewed by a teacher, could a student consume the snow bank pudding parfait.

Students enthusiastically built their models and described snowfalls, plow events, melting, more snow, and more episodes of sand and gravel distribution. One student who hadn't before excelled in science shared, "I never thought science could be so interesting, I want to do this again.... From now on I will always study snow banks. I think they are awesome."

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades K–4

Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry

Standard B: Physical Science
- Properties of objects and materials

Standard D: Earth and Space Science
- Properties of Earth materials
- Objects in the sky
- Changes in Earth and sky

An In-School "Snow Day"

Students can perform investigations such as these even in places with limited snowfall. After a snowfall of only a few centimeters, students can make observations of the areas at which snow melts first. Or, an examination of snow footprints may prompt questions. *Why do footprints often remain as icy silhouettes when the rest of the snow covering is gone? Are the footprints the same size as the shoes that created them?*

And, without snow, be on the lookout for other local features, such as road cuts, which may present a similar opportunity. Finding authentic science experiences relevant to students' daily lives is an ongoing challenge. When snow totals aren't quite enough to cancel school, why not make an *in school* "snow day"? Our students enjoyed their snow inquiry immensely. Yours will too. ■

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Resources

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