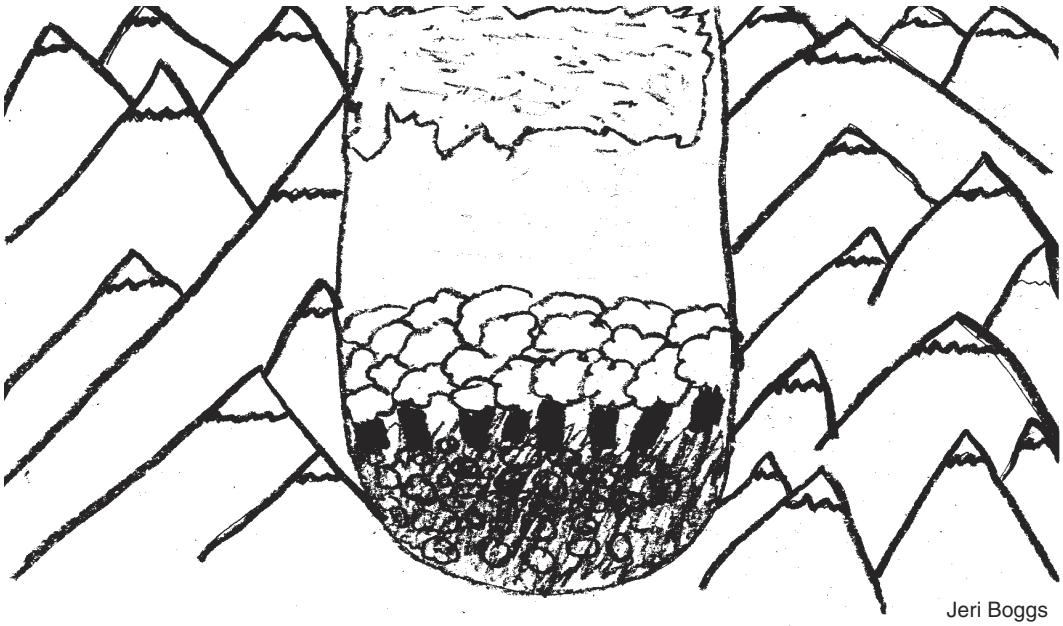
Track 2
Glaciers and Glaciation



Jeri Boggs

Directions and Background

If you choose to follow this track, review all of the background, stories, and activities included. It is recommended that you review *A Geological Story of Glacier National Park* from Track 1. You should also do Activity 1--Cultural How Stories from Track 1 with your class. Glaciers and Glaciation is really a continuation of Mountains and Mountain Building. Glaciers and Glaciation begins with local tribal cultural lore dealing with the ice carved features of this region. You should review this information and adapt it for your use as you see fit.

While the mountains in the area that is now Glacier National Park have been present and obvious as long as Blackfeet, Salish, and Kootenai have lived here, large, conspicuously active glaciers have not been obvious in the last 10,000 years. Native oral tradition manifests a phenomenal memory. Some Native American oral histories preserve traces of a Bering Land Bridge migration from the Asian continent. However, there are not many traditional stories that deal directly with either continental ice sheets or large valley glaciers. Certainly the people who passed through the mountains during the middle of the nineteenth century encountered relatively large glaciers and may have even crossed over them in the Red Eagle Pass area. Those early travellers must have seen enough of the work of ice to speculate that the glaciers were larger in the past. Whether Indians knew that the glaciers had completely filled the mountain valleys and that ice sheets had extended over much of the North American continent is uncertain. There is no doubt that the power of *Ice Spirits* was awe-inspiring. It is certainly conceivable that a memory of interglacial corridors was preserved over more than 13,000 years. These traditions are obviously more common to native peoples who live further to the north.

There are a number of stories among the Salishan, Ktunaxa, and Blackfeet people that indicate an understanding of the glacial dynamics of the area. *The Great Flood In The Flathead Country* and *The Origin Of Flathead River* both give accounts of Glacial Flathead Lake although they do not directly mention the source of all the water. *The Origin Of Flathead Lake* is especially interesting in the context of this program because of its wonderful treatment of beaver habitat. One of the most interesting stories, comprising many accurate observations about the origins of natural phenomena, is the Flathead-Salish account *Bluejay Brings The Chinook Wind.* The following is a paraphrase of the story as it is recorded by Ella E. Clark in *Indian Legends Of The Northern Rockies:*

Bluejay Brings the Chinook Wind
(A west side glacial story)

In the very earliest times, Amotken, The Creative High Mystery, gave part of the North Crow Creek Canyon of the Mission Range to Thunderbird. Coyote was forbidden to enter the area and so Thunderbird was free to raise her young in peace. It was in the canyon that she gave birth to her three daughters: Bluejay, Crow, and Magpie.

Thunderbird was happy to let her friends from the Bitterroot Valley hunt and gather in the canyon. If bad weather was approaching from the East Pass, Thunderbird would make deep growling noises to warn her friends away. After many, many years of this friendly arrangement, a careless hunter neglected to put out his campfire and a huge fire destroyed all life in Thunderbird's beautiful canyon. With no trees and vegetation to hold the water, even the little creek dried up.

Thunderbird was understandably extremely upset about this careless act, and she was determined to punish the Salish people. She invited the cold Northeast Wind to drive the people back to the Bitterroot. The Northeast Wind set up permanent camp in the East Pass. He blew his frosty breath into the Salish country for many endless winters. The great lake of the Salish people froze to the bottom and all the animals were driven with the people to the Bitterroot Valley where they shivered with the cold. Even Thunderbird's daughters: Bluejay, Crow and Magpie followed the people to the south. Alas, the plants were unable to move on their own and they withered away and died.

Finally, after many, many winters the heart of Thunderbird was softened. She grew lonely; she missed her daughters, the other animals, and even the people. Thunderbird went to the Northeast Wind and asked him to leave. Thunderbird said, "The People have suffered enough now. Perhaps if you leave my daughters will come back to visit me".

Reluctantly, the Northeast Wind left the East Pass and returned to his home. A wandering scout was startled by the sudden stillness to the north and rushed to tell the chief of the Salish who was huddled with his people around the Sleeping Child Hot Springs. "Northeast Wind no longer blows and from the north one can hear a gentle rumbling as if Thunderbird were weeping. "

The chief was very pleased and told his people to prepare to move to the north again. He asked Coyote if he knew of a way to please Thunderbird so that she might hasten the warming of the old country. Coyote, was still upset that Amotken had forbidden him to enter North Crow Creek Canyon, and refused to help.

Bluejay had always loved the Salish people, and longing to see her mother, offered to help. She flew to the west and asked her friend Chinook Wind to help her friends return to their old hunting grounds. Chinook Wind, always warm and kind, readily agreed to go and warm the valley. "Show me the way my little friend", he whispered and away they flew.

When they finally reached the little canyon beneath the Mission Range, Chinook Wind settled in for a long steady blow. His warm moist breath melted the thick ice and, as it receded, beautiful flowers and long grasses sprouted up along its margin. Soon there were trees once again in the Mission Valley.

Thunderbird was pleased and asked Bluejay what she could give to her to show her gratitude.

"In the future, Dear Mother", Bluejay said, "Do not get so angry. It is not right that the considerate people should suffer for the offenses of the careless. "

Though the Northeast Wind returns to the East Pass each winter to remind us to live a thoughtful life, he always returns to his home when the Chinook Wind comes back to stay in the spring. For that we can thank Bluejay and a mother's love.

This story gives a fascinating mythical account that closely parallels the physical events as they occurred during the Ice Age. Humans in North America did not see fluctuations as dramatic as the above story indicates but some of the traditions assume that humans had been part of the landscape almost forever. The people who lived along the margins of the mountains spent their lives among the works of ice. They camped by kettle lakes, witnessed the uniformity of drumlins, and understood the composition of various kinds of moraines. They carefully examined the rocks of the mountains in their determination to make the best possible tools. They scratched their heads in wonder when they came across mountain boulders lying in isolation miles from their origin. They needed to find explanations. They needed to answer their children's how and why questions.

Every tribe in the area has a version of the story *Napi Travels With Fox and Punishes a Rock.* The story teaches the animism of seemingly inanimate objects and attempts to provide an explanation for glacial erratics. There was simply no way to explain how huge boulders could find their way miles out onto the prairie when their obvious origin was in the mountains. We now know that they were either deposited by glaciers or that they were rafted there on rotting icebergs in a glacial lake.

Napi Punishes a Rock
(An east side glacial story)

One beautiful Indian Summer day in the long ago times, Napi was walking with his friend Fox in the mountains above Cut Bank Creek. Although it was beyond the Moon of the Falling Leaves, the day was unusually warm. Napi, who always carried his buffalo robe, grew hot as they walked along. He and Fox stopped by a large black rock to rest and look at the scenery.

"Ah, Old Rock, you poor thing", said Napi, "You have to spend the long cold winter up here all by yourself with nothing to keep you warm. Here, take my robe." With that, Napi gently placed his robe over the rock and the two friends continued on their way.

Soon, however, as often happens in Indian Summer, there was a sudden change in the weather. Steel gray clouds began to roll in from the northwest. The wind howled and stinging flakes began to pelt the two hikers.

"Fox, old friend", asked Napi, "would you mind running back to get my robe?"

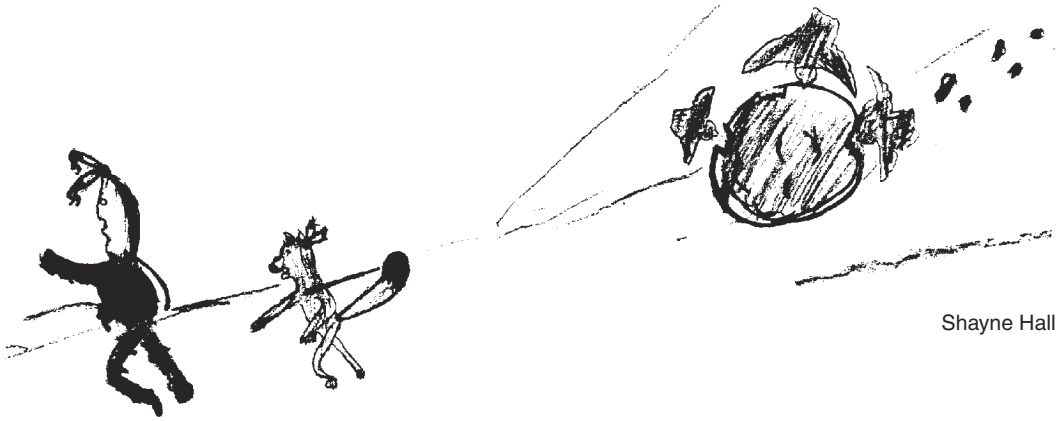
The kind Fox ran back but soon returned with the message that the rock was not willing to part with the robe and that he was quite angry that Napi would have the nerve to take back a gift. Just then they felt the earth shake and heard a loud rumble. Napi looked over his shoulder and saw the boulder rolling down upon them along the path.

"Oh, oh." yelled Fox, "We had better hightail it out of here. I think he is really angry!"

The two fugitives ran out of the mountains and out onto the prairie, but they could not out-distance the rock. Just as they felt they could run no farther, Napi spotted his friends the Nighthawks. "Quickly", he shouted, "stop that rock before it squashes us."

The fast-flying Nighthawks dove at the rock again and again. Each time they pecked at it, another large piece of rock broke off. Soon there was nothing left but a widely scattered trail of smaller rocks. The two friends collapsed upon the ground and thanked the Nighthawks between gasps. "In commemoration of this great deed you will always wear bright white slashes of honor across your wings."

It is because of this memorable chase that you still see these strange rocks from the mountains scattered far out onto the plains.



Shayne Hall

It is uncertain how literally Native Americans received the ancient legends which everyone loved to hear and tell. Many native peoples have an abiding faith and belief in Old Man, Coyote and Napi as superhuman spiritual helpers that once roamed the Earth and did great deeds. Most adults were aware of and appreciated the employment of metaphor and other creative language devices to convey the essence of an oral tradition. Some people regarded the stories as instructive mythology. While the great majority of Native Americans were highly spiritual, all of The People understood that some of the traditional stories were simply meant to provide good entertainment.

A Glacier Story: The Work of Ice

Many people who visit Glacier National Park for the first time expect to see large glaciers with snouts that come right up to the edge of the road. Instead, they catch long-distance glimpses of small glaciers high in the mountains. Visitors who hike have an opportunity to examine the remnants of glaciers that were much larger in times past.

Since the Ice Age began approximately two million years ago, at least four major continental ice sheets have advanced into this area and then receded. As the continental glaciers approached from the north and east, glaciers began to grow and advance in the mountains. The ice got so deep that it nearly covered the tops of the mountains and on several occasions the resulting valley glaciers joined with continental ice sheets on the east side of what is now Glacier National Park.

Glacier National Park was named for the glacially-carved features that give character to the mountain landscape. Today fewer than fifty small glaciers still exist in the park. By studying and comparing the small remaining park glaciers with large glaciers that are still dynamic agents in other parts of the world scientists are able to understand what occurred in this area so many ages ago.

What is the work of ice? What is a glacier? The term "glacier" is derived from the French word "glace", meaning ice. Some two million years ago the climate in this area began to grow cooler. More snow accumulated in the mountain valleys than melted during the warmer months. After a time the accumulated snow began to contribute a

further chilling effect to the weather. As the snow got deeper, it compressed. The underlying snow began to metamorphose or recrystallize into a dense form of ice called firn. By the time the firn reached a depth of about 150 feet it was solid ice.

Because the snow accumulation was heaviest at the higher ends of the mountain valleys, most of the growth originated there. Pulled toward a lower elevation by gravity, the newly formed glaciers began to move slowly down the valleys.

As the front of the glaciers moved to lower elevations, snow continued to accumulate at the head of the valley. Soon the small glaciers became giant valley glaciers. Eventually the accumulation of snow and ice became so extensive that at times only the highest peaks in the park remained above the glaciers.

The base of a glacier is under so much pressure that it behaves like soft plastic, oozing around and sliding over the underlying bedrock and soil. Glacial ice fills every crack and moves house-sized boulders with ease. Once a rock or boulder has been enveloped in the base of a glacier, it becomes a tool for carving and abrading the surface over which it moves. The net result is a relatively straight and flat U-shaped valley where an uneven V- shaped, stream-carved valley previously existed.

Not only does a glacier carve the valley floor, it also plucks material from the surrounding valley walls. While the base of the glacier excavates deep into the bedrock, and the flanks of the glacier pluck and gouge the surrounding slopes, the tail of the glacier continues to pluck away at the headwall. Seasonal temperature fluctuations cause the glacier to melt against the headwall leaving a narrow gap between rock and ice in summer. The gap fills with meltwater that turns to ice each winter eroding the rock by expanding in tiny cracks. This bergschrund, or gap area, undercuts the headwall to the point where the top of the headwall actually overhangs its base. Eventually, the overhang collapses onto the glacier and the process begins again.

Many glaciers move as slowly as a few centimeters a day, while a few large Alaskan glaciers can travel as fast as 150 feet in a day. The glacier does not move as a solid unit. Because of resistance at the base and along the valley walls, the flow of ice near the surface and center of a glacier is often faster than at the bottom and sides. The cracks that result when upper layers of the ice move faster than lower layers are called crevasses. They can be hundreds of feet deep and many feet wide.

Eventually, the snout or toe of a glacier reaches a point where lower elevation or warming temperatures create an equilibrium between annual snowfall and snowmelt. The glacier can advance no further. In the event of a climatic warming trend, the annual snow melt may exceed the amount that falls, and a glacier begins to recede. Most of Glacier National Park's glaciers have shrunk dramatically in the last century.

A glacier carries a tremendous load of eroded material in a constant conveyor process toward the toe and edges of the glacier. Ice at the toe melts and runs off as glacial outwash. New ice is constantly being replaced near the head of the glacier. Rocks break up much more slowly than ice eventually ending up at the toe or sides where they are deposited as glacial till. Till consists of a jumble of rocks, gravel, dirt or other debris that may have been picked up by the glacier. Piles of till along the margins of a glacier are called moraines.

If the moraine occurs at the point of farthest advance of a glacier, it is called terminal moraine. Sometimes a glacier will retreat up a valley and stabilize temporarily at various stages of the recession. In such a case it may leave a series of what appear to be terminal moraines, but are referred to as recessional moraines. If a glacier retreats steadily, it leaves a variety of till and outwash formations along the path of recession back up the valley. While a glacier is moving, till tends to work its way to the sides of the valley and be deposited along the glacier's flanks. During the lifetime of a glacier, the amount of till that builds up along its sides can be impressive. The resulting long, fertile hills, called lateral moraines, are conspicuous along major valley edges in Glacier National

Park. The lateral moraines are most often recognized by dense conifer forests that cover them.

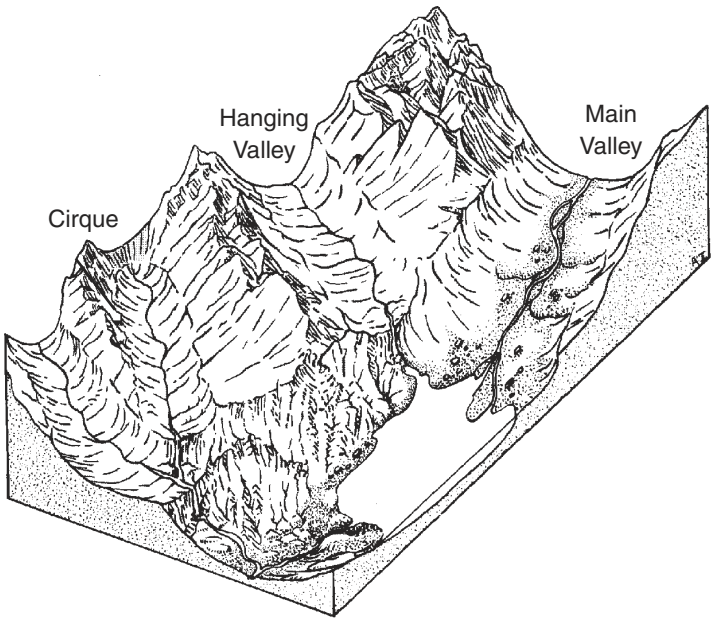
All glaciers have melt water running from their snouts during warmer seasons. The melt water carries a load of sediment for deposit along an outwash plain. Depending upon the volume and speed of the outwash stream, sediments are sorted and deposited along the floor of the plain. Respective weights of the various particles determine where they will be deposited-- near the snout of the glacier or further downstream. Outwash streams are frequently forced to change their courses because they fill with these sediments. The net result is a network of braided streambeds on the outwash plain.

The lightest, smallest sedimentary particles may be carried a long way until the stream has slowed considerably. This pulverized rock is appropriately called glacial flour. Glacial flour is particularly evident in the remnant tarns or mountain lakes that lie in the abandoned cirques near the headwalls of glaciers. The flour is actually the grist left from the grinding force of the glacier. Remnant icefields beneath the headwalls in Glacier National Park continue to color the lakes with their flour. In the park every lake has a slightly different color depending upon the makeup and mixture of rocks. Some lakes have a white tint that actually suggests flour, but more often they are various shades of blue and green.

A number of curious formations left by retreating mountain glaciers are found on both sides of Glacier National Park. Many of the lakes among the foothills on the Blackfeet Reservation and in the Flathead Valley are called kettle lakes. They were formed when a melting mass of glacial ice remained in a depression after the main body of the glacier had retreated further into the mountains. When the mass finally melted, a depression remained. In time, it filled with water. Teardrop-shaped drumlins, or hills, were left where the bedrock resisted the gouging of an advancing glacier. Softer, surrounding rock was worn away and this elevated nuclei collected sediments that built up around them as the glacier retreated. Eskers, elongated hills, were formed by sediments deposited by streams flowing in tunnels beneath the ice. Kames, another form of

depositional hill, were formed when openings developed in stagnating ice. Glacial erratics, the probable source of the matched legends of Coyote and Napi punishing a rock, have long been a source of fascination. Erratics, often found in open country many miles from any possible source, are either unusually large boulders found among smaller till or large rocks that were ice-rafted and deposited on the floor of glacial outwash lakes.

The most dramatic and obvious glacially carved features are found along the courses of U-shaped troughs left by the now-departed valley glaciers. The high sharp peaks are called horns. Serrated narrow ridges left between the headwalls of two adjacent glaciers are called aretes. Along the sides of the main glacial troughs, hanging valleys are often found where smaller tributary glaciers once abutted the main glacier. Beneath the headwalls of each of these tributary glaciers, one often finds a depression called a cirque which may hold a tarn or cirque lake. Along the course of the main glacial trough there are a series of truncated spurs, cliffs bulldozed into the sides of gradual mountain slopes.



Landforms created by glacial action
from *Geology Along Going-to-the-Sun Road, Glacier National Park, Montana*
courtesy Glacier Natural History Association

Classroom Activities

Glacial terminology is interesting, highly descriptive, and exotic. Many of the terms have few applications outside the description of glacially carved terrain. The following exercises will help students explore and internalize some of the vocabulary and concepts that will enhance their understanding and appreciation of the topography of Glacier National Park.

Classroom Activity 1
Breaking it Down

Objective:
Students will learn that as water freezes, it changes form, expands and produces force. Students will also identify moving ice as the primary component of a glacier.

Background:
The description of the work of glaciers in the preceding story mentioned how meltwater in a glacier seeps into cracks in rocks and then expands and breaks up the rocks. Erosion of rock by ice expansion is most dramatic near a glacier headwall, but the process takes place anywhere that ice accumulates in the winter and thaws in the summer.

Materials:
Access to a deep freeze
A tray
A glass bottle or jar with a tight cap

Procedure:
1. After presenting the oral portion of “The Work of Glaciers”, have the class do a short experiment.
2. Fill a jar with water to the point where there is no room for air in the jar, then close the jar tightly.
3. Place the filled jar on a tray and have someone place it in a deep freeze.
4. The next time the class meets to work with glaciers, have someone bring the tray with the jar carefully back to the classroom. The jar lid should be bulged out and the glass should be cracked.
5. Show the tray to the class and set it aside to let the ice melt.
6. Go on to Activity 2; look at the jar on the tray at the end of class or at the end of the day. The ice will be melted and the glass will have collapsed in a heap. This is what happens when glacial meltwater seeps into headwall rocks and freezes. When the bergschrund gap moves slightly away from the headwall and melting occurs, the surface rocks of the headwall collapse onto the glacier.

Classroom Activity 2
Carving Mountains

Objective:
Through individual and group research, students will define specialized glacial terms and learn to recognize the landforms they represent. Students will be able to illustrate the landforms using clay modelling.

Background:
This activity is designed to give students tactile and research experiences by building scale models of mountains with glacially carved features so that they can understand and discuss the topography and dynamics of a mountain environment. This activity will make any visit to Glacier National Park more meaningful and more interesting. Regardless of an individual student's mastery of special terms and vocabulary, he or she will look more closely at the environment after this activity.
This activity will be most meaningful if the students have been exposed to the previous activities in the project dealing with mountain building and the work of water. However, even without previous background and experience, students can still internalize most of the learning implicit in this activity.

Materials:
Research materials to include Earth Science texts, books dealing with the geology of Glacier National Park and Montana in general, and a very good dictionary
Slides or pictures of geological features of Glacier National Park
One or more raised relief maps of Glacier National Park
Paper for recording research
Several recycled 4' by 4' plywood boards
Moist, recycled pottery clay or a large supply of modeling clay
Tools for working clay
An appropriate ruler to establish a reference scale for elevations
Paper or light cardboard for labels
Pins to hold labels
Scissors
Fine-point pens
Plastic covering to prevent drying out of models

Vocabulary:
The following list of terms is supplied as a guide for students to use in compiling team dictionaries of mountain and glacial terms:

Alpine Meadow (Tundra)
Kettle Lake
Lateral Moraine
Arete
Avalanche
Bergschrund
Medial Moraine
Moraine
Cirque
Col

Crevasse
Esker
Mountain Pass
Mountain Range
Fold
Outwash Plain
Peak
Plateau
Glacial Trough
Glaciation
Valley Glacier
Continental Glacier
Tarn
Hanging Valley
Terminal Moraine
Horn
Tree Limit
Kame

Procedure:

1. Divide the students into cooperative learning groups; give each group fresh balls of clay and tell them to sculpt mountain formations on a team board until they are satisfied with what they have done.
2. An appointed or chosen team chairperson hands out labels (or definition cards) provided by the teacher and asks individuals to identify or remold specific features into the group of mountains. This requires alterations of the original mountains. When there is some question about a formation to be labeled, students may use available books and other resources for immediate research.
3. When the labeling and remolding are complete, the students should be able to define and discuss their work. Using the vocabulary and other terms they come across in their research, each team should generate a dictionary of mountain and glacial terms.
4. When models and dictionaries are completed, students should examine other teams' models and help each other refine formations and definitions. This process will help them to internalize their research.

Follow Up:

The next obvious question should be, "What do we do with the clay models when the students finish?". Ask the students! Maybe they would like to paint them, show them to another class or parents, write an adventure story that takes place in the mountains, generate some appropriate weather in their models, pour water over them to trace natural drainage, or make models of indigenous animals and plants to put in their created environments.

Classroom Activity 3
Model Glaciers

Objective:
Students will learn that glaciers are major forces in changing the landscape and were major contributors to the scene we see today. Students will identify terminal and lateral moraines, the headwall, cirques, tributary glaciers, and hanging valleys.

Background:
This activity is designed to give the students a graphic hands on impression of the work that glaciers do.

Materials:
A small sandbox or the trough that was used in the river model activity from Mountains and Mountain Building, A supply of sand, gravel and assorted small rocks, A variety of sizes of elongated plastic containers, Access to a deep freeze

Procedure:
1. Freeze gravel and small rocks into ice blocks so they will have a rough bottom when they start to melt.
2. Keep the sand, gravel, and rocks in the sandbox damp enough to mold into mountains.
3. Have the students form mountains and river valleys in the sand.
4. Produce a large ice block to represent a large mountain glacier and several smaller blocks to represent smaller tributary glaciers.
5. Place the large block at the head of the valley and slowly bulldoze a path down the river valley. Point out the gouging and plucking along the way. When you reach the terminal point of the valley, point out the terminal moraine. Be sure that you are gouging nearly to the bottom of the sandbox or trough. Point out the lateral moraines along the glacier's path.
6. Give some of the students small glaciers and invite them to work a few tributary glaciers. Ask if they can produce hanging valleys, cirques, etc. . . . When they have finished have them leave their remnant glaciers against the headwalls.
7. Some time later have the students look at the debris left in the cirque as the ice block melts. Ultimately there will only remain a little pile of till and a small tarn.

Follow Up:
Be sure to do some glacial visualization with the large relief maps in the Apgar and St. Mary Visitor Centers when you visit the park.

As a special treat and review, get several half gallon blocks of neapolitan ice cream, marshmallow cream topping, ground nuts to represent rocks, and whatever else you might find tasty and relevant. Put the ice cream blocks together, slide them around to talk about the Lewis Fault Thrust, then get down to business with an ice cream scoop. While reviewing glacial terminology and carving formations with the scoop, fill cups for the students who can correctly identify the latest formation. Of course early winners need to give others their chance once they have been served.

Park Visit Activities

Much of the Park Visit for Glaciers and Glaciation will involve investigation of mountain topography. The naturalist will point out features of the landscape that you have researched in your classroom and will answer questions that may have occurred to you during your activities. St. Mary and Apgar are both excellent sites to observe many glacially carved features. These two sites are located at the base of the two largest glacially formed lakes in the park. The glacial troughs in which they lie afford an uninterrupted view of the work of ice.

Park Visit Activity 1
In Winter's Lair
Glaciation in the St. Mary Area

Objective:
Students will define the role glaciers have played in shaping the scenery of the St. Mary Valley. Students will recognize glacially carved features including; lateral and terminal moraines, U-shaped valleys, glacial striations, glacial outwash, till, and erratics.

Background:
The naturalist in the St. Mary area will take the group on a hike and discuss the glacial features and dynamics that are readily visible from St. Mary.

The view up the St. Mary Valley represents a moment of geologic time. It was only about 20,000 years ago that the glaciers began their retreat up the valleys. They have come and gone at least four times in the last 2 million years.

From St. Mary you can look up the length of the glaciated valley toward Logan Pass where many smaller tributary glaciers joined with the main valley glacier. Other tributaries left hanging valleys along the length of the lake. To the southwest, you can see where Red Eagle Mountain tapers into a medial moraine which separated a branch of the main glacier that had worked its way down Red Eagle Valley. At one time, the medial moraine may have extended further along the south side of Upper St. Mary Lake but river erosion has cut some of it away in the last 20,000 years. The thick forests, which lie below Curly Bear Mountain and along the southeastern shore of the lake, grow in a fertile lateral moraine left on that side of the glacial trough. A lateral moraine was deposited along the base of Singleshot Mountain extending along the west side of Lower St. Mary Lake and the west side of Highway 89 into Canada. The terminal point for one of the advances of these glaciers may have been as far to the northeast as Lethbridge, Alberta. The moraine tapers considerably as you move north and has been cut through by a number of tributary glacial/river valleys along the way.

When you look to the east you can see the impressive St. Mary Ridge, a lateral moraine that extends along the eastern side of the St. Mary Valley into Canada. On several occasions during the last two million years, the valley glaciers on this side of the park interfaced with continental ice sheets that advanced from the northeast. Further to the north of St. Mary, there are many sites where continental glacier till is interlayered with valley glacier till. In the road cut across Divide Creek from the park employee housing area, geologists have found lake bottom silts that are interlayered with valley glacier till. At this location a large glacial lake, formed by meltwater from a retreating continental ice sheet, had its western shoreline along the edge of the mountains.

Upper and Lower St. Mary Lakes, known as the “Lakes Inside” or the “Walled in Lakes” by the Blackfeet, were formed when glacial outwash sediments originating further up the valley were deposited on top of a partially melted valley glacier. Deposition on the lateral margins was heavier than over the top of the remnant ice mass. When the ice in the center of the trough finally melted completely, the “Lakes Inside” were left as kettle lakes on an extensive outwash plain. The lakes were probably one continuous lake to begin with, but continued outwash materials from Wild and Divide Creeks filled in the waist of the continuous lake to make two lakes with a short river between the two. The river between them continues to cut down through the outwash materials.

Park Visit Activity 2
Home of the Northeast Wind
Glaciation in the Apgar Area

Objective:
Students will define the role glaciers have played in shaping the scenery of the Lake McDonald Valley. Students will recognize glacially carved features including; lateral and terminal moraines, U-shaped valleys, glacial striations, glacial outwash, till, and erratics.

Background:
The naturalist in the Apgar area will take the group on a hike and discuss glacial features and dynamics that are readily visible from Apgar.

The view of the McDonald Valley trough from Apgar is so ideal for observing the results of glacial dynamics that it could be something a geology professor would design as a teaching prop. Because Lake McDonald lies to the west of the main block of mountains that make up Glacier National Park, and because it was carved out of younger, softer sediments than those in the St. Mary Valley, the McDonald Valley trough is almost straight. When you look up the lake you can see the back of Mount Gould which also overlooks the Many Glacier Valley on the east side of the park. Mount Gould is a horn in the middle of an extensive arete called The Garden Wall. The Garden Wall was part of the headwall for the McDonald Valley Glacier. The back side of the Garden Wall formed the headwall for the Many Glacier Valley. Directly behind The Garden Wall, just to the left of Mount Gould, lies Grinnell Glacier, a young glacier unrelated to the massive Ice Age glaciers.

While occupying the long valley in front of you, the McDonald Valley Glacier also filled an equally large area to the left of the Garden Wall-- the extensive McDonald and Mineral Creek drainages. Near the far end of the valley and to the right, there are two dramatic hanging valleys carved by the Hidden Lake and Avalanche Lake glacial tributaries. The two long ridges to the left and right of the lake are lateral moraines. Howe Ridge is on the left and Snyder Ridge is on the right. You are standing near the end of the valley. The lake is nearly 500 feet deep and has been partially filled with a great deal of glacial outwash material. Imagine how thick the McDonald Valley Glacier must have been in order to deposit that much material along its flanks!

The Apgar Mountains, behind and to your left, and the Belton Hills, to your right, forced the snout of the glacier to squeeze through the narrow valley. Glacial outwash extends far into the Flathead Valley from this point but all of the moraine materials along both sides of the lake are glacial till. Lower McDonald Creek flows over the valley floor formed of glacial outwash, but the outwash materials are most dramatically exposed near West Glacier in cuts made by the Middle Fork of the Flathead River. Apgar Village is located on the terminal moraine of the McDonald Valley Glacier.

Back in the Classroom

Take the time to reinforce the Park Visit experience. Discuss the field trip with the students and decide what worked and what didn't work. Be sure to fill out and return the trip evaluation form. Some follow-up activities for the Glaciers and Glaciation Track include:

1. Have the students write a report about the trip and share it with classmates.

2. Slides and narrative on glaciers are included in the Activity Kit. Have groups of students work together in preparing a slide program for the class.

3. Ask students to collect pictures of glaciers from around the world. Use the materials they gather to put together a bulletin board. Have students write to other parks that have glaciers for information. Mount Rainier National Park, North Cascades National Park, Glacier Bay National Monument, Denali National Park, and Rocky Mountain National Park are good places to start in the United States. Jasper National Park in Alberta, Canada is also noted for its easily accessible glaciers.

4. Write a letter to the naturalist that led the Park Visit Activity. Have the students tell the naturalist a fact learned during the activity.