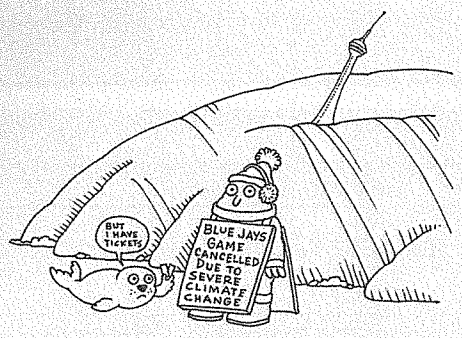
Glaciation of Canada



◁ **Fig. 11-18** *Some scientists think that glaciers may cover Canada in the future. During the last Ice Age, which ended less than10 000 years ago, Canada was covered by ice at least four times. Other scientists think that the glaciers that are left may melt away due to global warming.*

KEY TERMS

- ice ages
- ice sheets
- glacier
- advance
- retreat
- alpine glacier
- U-shaped valley
- continental glacier
- zone of accumulation
- till
- striation
- spillway
- misfit stream
- till plain
- moraine
- drumlin
- erratic
- esker
- lake plain

Even though our attention is directed today toward global warming and its consequences, some scientists think that some day we may have a new glacial advance (Fig. 11-18). After all, there have been many times during the earth's geologic history when ice ages have developed after warm periods.

Ice sheets have covered most of Canada several times during the past two million years. This has caused enormous changes in our topography. How did this glaciation happen? What were its effects? Could it happen again soon?

INTRODUCTION

Did you know that ice is one of the hardest substances on earth? This seems strange when we see fragile ice crystals on window panes, or ice cubes floating in cool drinks. Yet ice had the power not only to damage the hull of the Titanic, but also to transform the shape of the land.

The earth has experienced several **ice ages**. About 250 million years ago, parts of South America, Africa, India, Australia, and Antarctica were glaciated when they were part of Pangaea, the supercontinent. North America and Europe were not glaciated at this time because they were located near the equator. There is also evidence that there were several previous ice ages, including one 2 billion years ago and another 600 million years ago. For most of the earth's geologic history, however, glaciers have not covered large parts of the land. The last Ice Age began between one and two million years ago. **Ice sheets** covered almost all of Canada and parts of the United States, Europe, and South America during each of its glacial advances. Enormous volumes of the world's water were frozen in these ice sheets. This caused the level of the oceans to fall well below current levels.

The lower ocean levels created a land bridge between North America and Asia where the Bering Strait is today. Find this in an atlas.

During the last Ice Age, **glaciers advanced** and **retreated** at least four times. Between each period of glacial activity, the climate was as warm, or warmer, than today. Why did such a cycle occur? No one is quite sure, but some theories suggest it has to do with changes in the earth's orbit around the sun as well as changes in the tilt of the earth's axis, or changes in the heat output from the sun.

When the term "Ice Age" is used with capital letters, it refers to the last ice age which occurred during a part of the Cenozoic era called the Pleistocene. When the term is used uncapitalized, it refers to any period of major glacial activity.

The Ice Age's last period of glacial activity began about 100 000 years ago, and ended in most parts of Canada about 6000 years ago. A period of glacial activity begins when the earth's climate cools, and the snow that falls in the winter does not completely melt in the summer. Over thousands of years, the snow gets deeper and becomes hundreds or thousands of metres thick. The tremendous weight of the snow on top causes the bottom layers to turn to ice. The most remarkable fact about a glacier, other than its tremendous size, is that it can move. Solid ice acts like a very thick liquid, and moves along or flows very slowly.

For comparison, the CN Tower in Toronto stands only 553 m high.

Glaciers move in different ways, depending upon their location and the climate. In mountainous regions, **alpine glaciers** move down valleys from high elevations to low elevations under the force of gravity. This movement is usually only a few centimetres per day. Alpine glaciers sharpen the upper portions of the mountains and give them a rugged appearance. When they move down valleys, they scrape away the valley walls to produce broad **U-shaped valleys**.

Alpine glaciers are also known as valley glaciers.

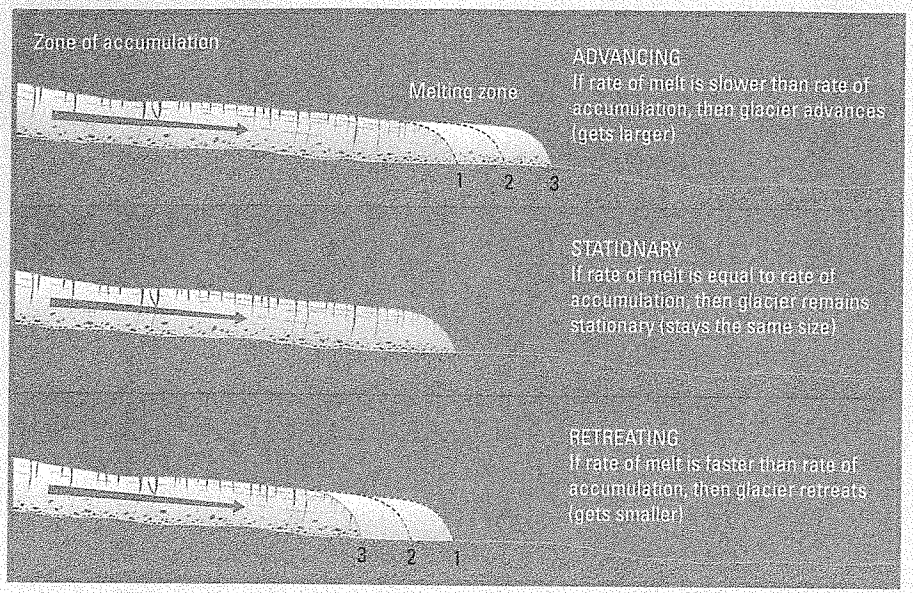
If you would like to learn more about glaciation, check athena.wednet.edu/curric/land/global/climchng.htm#ice

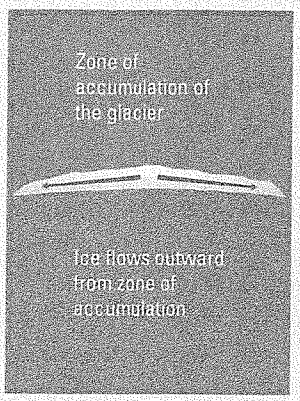
Alpine glaciers exist today in Canada in parts of the Western Cordillera and the Arctic islands. The Columbia Icefield is a mass of ice located along the British Columbia-Alberta border between Banff and Jasper National Parks. It is the largest area of ice in Canada south of the Arctic. It contains 30 glaciers covering about 300 km^2 to depths of 365 m. Waters from this icefield flow into three different oceans. Tourists from all over the world come to our western mountains to enjoy the beauty created by glacial activity.

Canadians appreciate glaciers for more than their beauty. The Cline glacier in Alberta once had an ice mine. Ice was chipped from tunnels in the glacier and shipped to Japan where a 1.5 kg bag sold for about US $30. The glacial ice cubes were much denser than regular ice cubes so they lasted much longer in a drink. The ice was highly prized because it was formed before industrial pollution and acid rain. The mine did not operate for very long because of objections from environmentalists.

Continental ice sheets, or **continental glaciers**, are different from alpine glaciers in that they occupy greater areas of land, and move under their own weight. During the last glacial advance, about 8 million square kilometres of North America were covered by a continental ice sheet. In some spots, this ice sheet reached a thickness of 4 km. The enormous

Between 25% and 30% of the earth's surface was covered by glaciers about 20 000 years ago. Today, continental ice sheets occupy less than 10% of the earth's surface.





△ **Fig. 11-19** *Glaciers move like a very thick liquid.*

◁ **Fig. 11-20** *The advance or retreat of a glacier is determined by the balance between the ice build-up and the ice melt. In all cases the ice continues to move outward from the zone of accumulation.*

weight of snow and ice causes the ice to spread outward from its centre or **zone of accumulation** (Fig. 11-19). Although the ice of a continental glacier is constantly moving outward, the outer edge or margin of the ice sheet may advance, retreat, or stay in one place. Fig. 11-20 explains the conditions under which each of these movements occur.

Continental glaciers give the landscape a smoother appearance by eroding higher points on the land and filling in lower areas with the eroded material. Today, continental glaciers exist only in Greenland and Antarctica.

You can demonstrate the movement of a continental glacier with a ball of pizza dough. Place the dough on a flat surface and press down on it slowly with your palm. Notice how it spreads outward in all directions.

(Once you have got the dough to the size you want, top it with cheese, sauce, and other toppings and bake in an oven.)

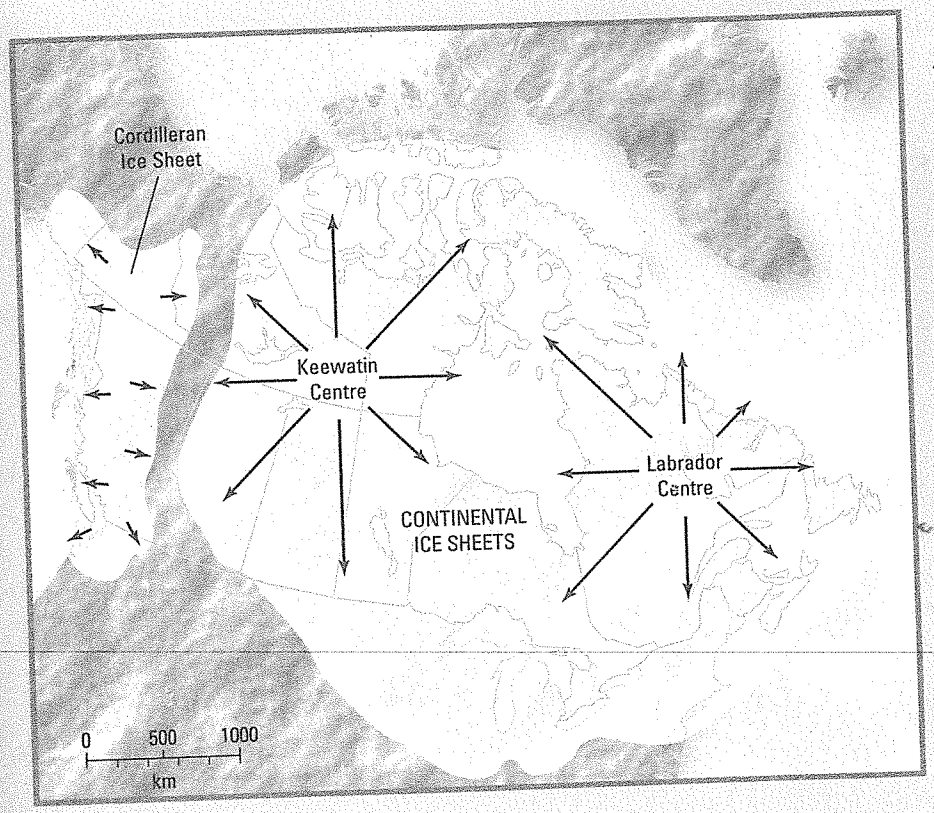
THE GLACIATION OF CANADA

Glaciation is the process most responsible for the topography that we see in Canada today. There are two reasons for this:

1. Glaciation is an extremely powerful force.
2. Glaciation happened very recently in geologic terms, and there has not been enough time for the glacial features to be worn away.

Fig. 11-21 shows the maximum extent of glaciation about 20 000 years ago. As the ice sheets spread outward from three locations, they changed the face of the land. The weight of the ice sheets had a dramatic effect on the level of the land. Over a period of thousands of years, the ice compressed the land downward. When the ice melted, the land rebounded upward, but at a relatively slow rate. In fact, this rebound continues today in much of Canada.

The land is rebounding at a rate of approximetely 1 to 2 cm per century.



◁ **Fig. 11-21** *Continental glaciation in North America. Notice that the ice sheets did not spread out from polar regions.*

To see the effects that the ice sheets had on the landscape, we will examine

a) features caused by erosion
b) features deposited
   i. directly by the ice sheets
   ii. by meltwater from the ice sheets

Erosional Features Caused by Glaciation

The continental ice sheets were often several kilometres thick. As they advanced, they expanded existing river valleys. These deeper and wider troughs are known as U-shaped valleys and are similar to those formed by alpine glaciers. The ice also gouged out the basins of existing lakes making them deeper and wider. The Great Lakes were formed in this fashion.

As the ice sheets moved, they eroded huge amounts of soil, sand, gravel, and rock. This material was carried by the ice and acted like sandpaper as it scraped and ground away the surface of the land. Grooves called **striations** were often gouged out in the bedrock under the ice sheet by rocks frozen in the ice (Fig. 11-22). Striations are often visible on the bare rock of the Canadian Shield. They run in the same direction as the movement of the ice sheet, and allow geographers to determine its path.

△ **Fig. 11-22** *The movement of glaciers gouged out scratches called striations in bedrock.*

Have you ever looked at a wide valley with a tiny stream and asked yourself how such a small river could cut such a big valley? Chances are that glacial meltwater formed the valley. Huge volumes of meltwater carved out deep, wide valleys called **spillways** (Fig. 11-23). Once the ice sheets melted away, these spillways became the pathways for small present day rivers, called **misfit streams**.

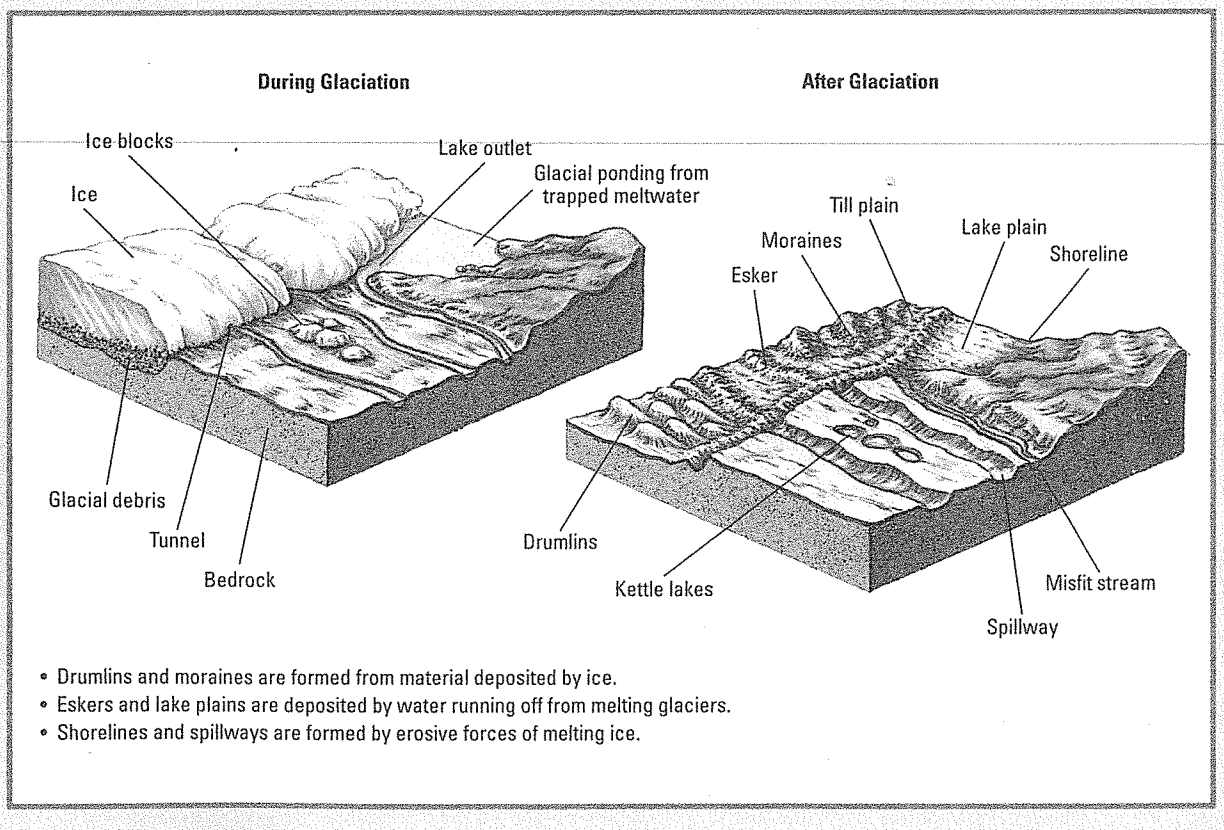
Depositional Features Created by Glaciation

ICE DEPOSITS

Till is material such as clay, sand, and gravel that is deposited directly by an ice sheet. It is unsorted; that is, large and small particles are all mixed together. The rock fragments have angular or pointed shapes because they have not been rounded by running water.

Sometimes the till deposited under the ice, formed a gently rolling landscape called a **till plain**. Till plains are very good for growing crops because deep, well-drained soil developed here. Sometimes an ice sheet deposited ridges of till at its edge. These ridges of till are known as **moraines** (Fig. 11-23). Moraines are not very good for growing crops

▽ **Fig. 11-23** *Landforms created by continental glaciers*



- Drumlins and moraines are formed from material deposited by ice.
- Eskers and lake plains are deposited by water running off from melting glaciers.
- Shorelines and spillways are formed by erosive forces of melting ice.

◁ **Fig. 11-24** *Drumlins are oval-shaped hills formed by materials deposited by glaciers. The steep side of the drumlin faces the direction from which the ice came.*

because they are thin-soiled, hilly, and swampy. Moraines are better suited for grazing and forestry. A well-known moraine runs between Orangeville and Trenton in southern Ontario.

Ice sheets formed other features which are evident today on Canada's landscape. One that is particularly recognizable is a **drumlin**, an egg-shaped hill (as seen from above) with a steep side at the wide end, and a gentle slope on the other. The steep side points in the direction that the glacier came from (Fig. 11-24). Drumlins usually occur in clusters called drumlin fields. A large drumlin field is located near Peterborough, Ontario. Farmers often plant crops on drumlins because the soil is deep and well-drained.

As they moved forward, the ice sheets often picked up large rocks and carried them hundreds of kilometres. These rocks are called **erratics**. For example, rocks from the Canadian Shield were picked up by the ice, carried along, and deposited many kilometres away in the surrounding lowlands. They can often be identified because they are made of rock which is different from the bedrock of the region in which they were deposited.

MELTWATER DEPOSITS

Running water played an important role in the deposition of glacial material. Rivers flowing within or under melting ice carried sand and gravel along with them and laid down this material in the river bed. When the ice sheet melted, the material that had been deposited in the river bed was left as a steep-sided ridge winding across the countryside. This is called an **esker** (Fig. 11-23). The esker follows the path of the river that created it thousands of years ago. Today, eskers are a source of sand and gravel for the construction industry.

Materials carried off the ice sheet by meltwater were sorted, smoothed, and rounded by the running water. The action of the moving water deposited larger rock particles in one layer and the smaller rock particles

in another. Today you might find a deposit of coarse gravel where a fast-moving glacial stream once existed, or silt where a glacial lake once was.

About 14 000 years ago, the climate became warmer and the glaciers started to melt. Enormous amounts of meltwater flowed into lakes along the margins of the ice. Some of these lakes, known as glacial ponds, were small. Others, like Lake Agassiz in Manitoba, were larger than any lake in the world today. The Great Lakes were also much larger than their present size. Today, the fertile flat **lake plains** that were once the bottom of ancient glacial lakes are used for agriculture. You may also find fine clay in an area that was once a glacial lake.

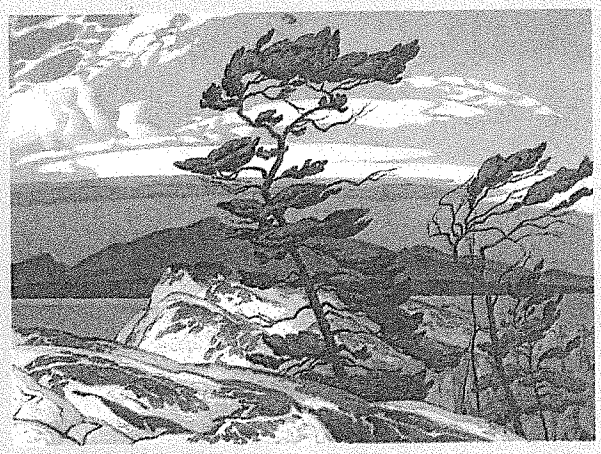
As the glaciers melted, the sea rolled in and covered large areas of depressed land in the St. Lawrence River Valley. Today, these areas are dry, but you can see beaches and sand dunes now located far above current sea levels. By about 6000 years ago, the last Ice Age had come to an end, and the Canadian landscape as we know it was visible.

The ancient sea that occupied parts of the St. Lawrence and Ottawa valleys is called the Champlain Sea.

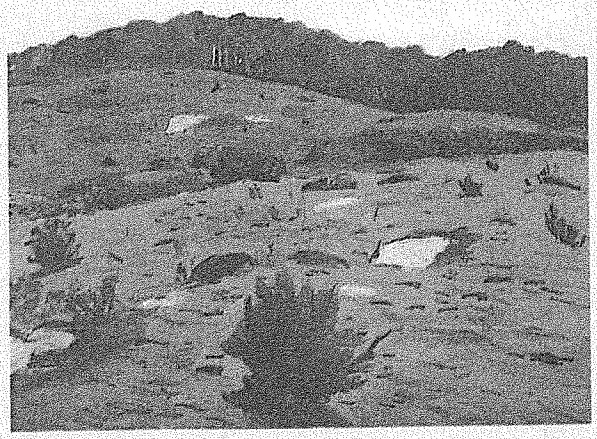
GLACIATION THROUGH THE EYE OF THE ARTIST

Artists portray the world in which we live. It is not surprising that Canadian artists have frequently chosen landscapes shaped by the action

▽ **Fig. 11-25**
White Pine *by A. J. Casson, is an artist's view of how glaciation affected much of the Canadian Shield. Notice the bare rocks and the trees bent by the winds blowing across the lake.*



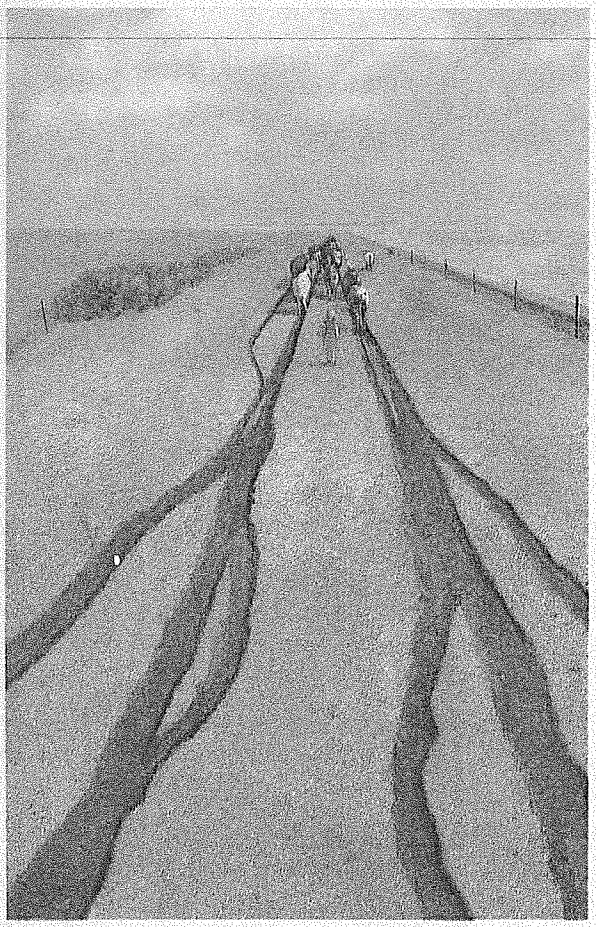
▽ **Fig. 11-26**
Hillside, Lake Alphonse *by William Goodride Roberts, shows the rolling landscape that was created when glaciers deposited till in many parts of southern Canada.*



of glaciers as the subject of their paintings. These landscapes are found throughout most of Canada and some are awe-inspiring in their beauty. Examine Fig. 11-25 to 11-28 to see the variety of landscapes created by glaciers.

IN CLOSING...

For thousands of years, glaciers have sculpted the Canadian landscape, and there is no reason why an ice age should not occur again. We know that average yearly temperatures would need to drop only about 4C°! However, it is safe to say that many questions about ice ages and climate change remain unanswered.



◁ **Fig. 11-27**
No Grass Grows on the Beaten Path *by William Kurelek, shows a flat lake plain created in many parts of Canada under glacial meltwater.*

▽ **Fig. 11-28**
The Glacier *by Arthur Lismer, illustrates the results of alpine glaciation. The rugged triangular mountain peaks are called horns and are created by alpine glaciation.*

QUESTIONS

CHECK YOUR UNDERSTANDING

1. a) How does glacial ice differ from regular ice?
   b) How does a period of glacial activity begin?
   c) What causes snow to turn to glacial ice?
   d) What causes alpine and continental glaciers to flow?
2. During the last Ice Age:
   a) Which parts of the earth were covered by ice sheets?
   b) What happened to ocean levels? Why?
3. "The movement of a glacier is determined by the balance between ice accumulation and ice melt." Consult Fig. 11-20 and draw a series of diagrams to explain this statement.
4. What appearance does a landscape have that was glaciated by an alpine glacier compared to one glaciated by a continental glacier?
5. Construct an organizer in your notebook similar to Fig. 11-29. Complete each column.
6. By observing the deposited materials, how can you tell which materials were deposited directly by a glacier and which materials were deposited by glacial meltwater?

ANALYZE AND APPLY

7. Each of the paintings (Fig. 11-25 to 11-28) depicts a landscape that is the result of glaciation. Analyze each painting using the following questions as a guide.
   a) Describe the physical appearance of the landscape the artist is portraying.
   b) Explain the glacial processes that created this landscape. What evidence is visible to support your explanation?
   c) What economic activities could this glaciated landscape be used for?
8. In Fig. 11-23, there are some glacial features that have not been discussed. Based on your examination of the diagrams, how were the following features formed and what is their appearance:
   a) spillway
   b) kettle lakes
   c) shorelines (from glacial lakes)

THINK AND COMMUNICATE

9. a) Is the use of paintings an effective way to study geography? Why?
   b) What are the advantages and disadvantages of this approach compared to other methods of presenting geographic information?

▽ **Fig. 11-29**

Glacial Feature	How Formed	Appearance	Uses
a) striations			
b) spillways			
c) till plains			
d) moraines			
e) drumlins			
f) erratics			
g) eskers			
h) lake plains			