GEOLOGY 2051: ASSIGNMENT 2

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PART A: Short Answer Questions

1. Foreland basins are formed when a mountain range pushes down on mantle crust and a depression basin forms on either side of this area. As the mountain belt evolves, the thickening of the crust causes immense pressure of the mass causes the lithosphere to bend. Volcanic and fold mountains can create a foreland basin.
2. Sedimentary features seen in the photograph are predominately well sorted sand that is horizontally stratified and cross-stratified. The area is a transitional environment (beach) and there appears to be layers of sediment between the sand (bedding planes). The sand also shows cross-bedding of various angles on the sloping surface.

   Considering the above features, they may have been formed by wind, water, or glaciation. Lower layers may contain marine sediment, and the layers between the sand may be glacial till, since Quadra sand is from the Pleistocene Era. The till may be from the Fraser Glaciation: it has a ridge like appearance that could have been deposited as a moraine.

3. Glacial deposits are called drift, specifically Till, which is poorly sorted drift that is non-stratified. It is deposited directly by glacial ice in ridge-like formations called moraines. Outwash is another type of drift deposited by glaciers. This is mostly gravel and sand deposited by braided streams that have resulted from melting glaciers. Till and outwash along with striated and polished bedrock are indications that glaciers were the reason for the deposit.
4. The deposit in figure 6d is from a glacial lake, while glacial till is deposited directly by the glacial ice before it melts. Figure 6d shows varves, which are couplets of alternating dark and light laminations, representing the year's sediment accumulations. Light layers form in Spring and Summer (silt and clay) while dark layers form when the lake is frozen (clay and organic matter). Glacial till is not striated, is poorly sorted, and is deposited as moraines (ridges). The dropstone in figure 6d must have freed itself from an iceberg and become deposited within the varves.
5. Processes that have led to continental growth occur when material becomes added to the craton ("nucleus" of a continent, made up of a Precambrian shield and a ledge platform of ancient buried rock) from sources like deep sea sediment, river sediment, terrane (lithospheric piece that is different from the surrounding rocks) and igneous rock. Deep marine sediments become added to the edge of a continent when an ocean plate submerges under a continental plate at a subduction boundary. Some sediment from the ocean plate is scraped off and left behind, adding to the continental plate.

Collisions between cratons happen to form orogens, joining cratons creating a larger land mass (ie: collision of Slave and Rae cratons in NW Canada). The Wilson Cycle, is where rifting and opening of an ocean basin contributes to continental accretion. Its closing causes subduction zones and volcanic arcs on both sides of the basin. Terranes can also become attached to a craton by tectonic processes, thus adding to continental growth. Examples of terranes in Western North America are: Wrangellia, Cache Creek, Franciscan and Great Valley, and Baja. Deposition from River sediment in the form of deltas also contributes to continental growth. This occurs when a river or stream enters the sea and deposits sediment called a delta. Sediment is deposited in bottomset beds a distance offshore and foreset beds come to rest on them. Topset beds then form, resulting in the delta building seaward or lakeward. The sediment becomes coarser grained from bottom to top.

6. Endosymbiosis is a special type of symbiosis (prolonged association of two more dissimilar organisms, benefitting both) where Proterozoic symbiotic prokaryotic cells become increasingly interdependent until the unit could only exist as a whole unit. One of the units lives within the other. This is thought to be a theory for the origin of Eukaryotic cells: Eukaryotic cells formed from prokaryotic cells that entered into a symbiotic relationship. Support for this is found in studies of eukaryotic cells containing internal structures or organelles (like mitochondria) that have their own genetic material and synthesize proteins like prokaryotic cells do. This means they probably represent free-living bacteria that entered into a symbiotic relationship and eventually morphed into a eukaryotic cell.
7. Supercontinents are thought to form, fragment, and reassemble in a sort of supercontinent cycle. Cratons, the “nucleus” of a continent collided to form orogens (linear deformation belts where the rocks have been metamorphosed and intruded by magma, cooling to form plutons) This resulted in the cratons being “stitched” along the orogens forming a larger land mass. The Wilson Cycle of plate tectonics also contributes to the formation of supercontinents. Rifting forms ocean basins that eventually close, followed by continent-continent collisions. This deforms the passive margin deposits and rocks of the ocean crust. The deformed rocks are altered by metamorphism, intruded by granite batholiths and incorporated into the Supercontinent. Regarding fragmentation of a supercontinent, one hypothesis is that because the land mass is so large, the mantle temperature is considerably higher than a regular continent. The supercontinent creates an insulation effect. Mantle eventually wells up to cause the supercontinent to break apart (fragment). Reassembly of the continents eventually occurs.
8. Using cladistics to classify organisms reveals primitive vs. derived characteristics, and is useful for groups with poor fossil records. Other systems, such as the Linnaean system is more simple. Organisms belonging to the same Kingdom, for example, may not be very similar. Cladistics groups organisms based on shared, derived, characteristics that can be traced to a particular group’s most recent common ancestor. It shows more

closely how different organisms are similar because members of a group share a more common history than visible traits.

PART B: Ediacaran Fauna (20 points)

1. The Ediacaran fauna are soft bodied organisms preserved as fossils found throughout the world, and were first discovered in the Ediacara Hills of South Australia in 1946. Ediacaran fauna is now the name for fossils similar to those found in Australia, which are found everywhere in the world except for Antarctica. This discovery revealed that a higher level of evolution occurred during the Precambrian Era than was originally thought. The animals from which these fossils came were the first metazoan animals (having more than one cell) needing oxygen to grow and develop. The organisms were soft bodied, similar to jellyfish, lichen, soft corals, sea anemones, sea pens, and seaweed. Some of the organisms look nothing like any that are known today, and existed on and near the surface of continental margins. They were found in coarse-grained sediments in the shallow continental shelf areas or else on the deep continental slope of margins from the late Precambrian. These rocks range in age from approximately 600 million to 541 million years old, with the most detailed and complex forms being found in the last 20 million years of that range. Australia was a part of Gondwana and located at the equator from about 542-510 million years ago. The composition of the fauna changes with different locations due to environmental conditions. The forms from Australia and Russia are similar, with rocks indicating a shallow water area, while the forms from Newfoundland contain elements indicating a deeper water habitat.

The rocks in which the Ediacaran fossils are found are above glacial tillites. There has been suggestion that Ediacaran organisms grew more as the climate improved after the ice ages but some have been discovered between and directly below the beds of till. Another suggestion is that a rise in the atmospheric oxygen level gave rise to the beginnings of Ediacaran fauna, followed by rapid growth and development. It was questioned how such soft animals could be preserved and still be recognizable, but they may have been covered by mucous (like other marine life) and when the sand covered the decaying animal, the shape was held by the sand. Another theory is that when the organism died, it was covered in a mat of bacteria that may have helped the surrounding sand hold the shape of the organism together. The bacteria could fix iron into its pyrite form that would also create a cement -like substance to hold the shape of the animal. This idea is supported since Ediacaran fossils have a higher iron concentration that the surrounding rocks in which they are found.

2. Types of Ediacaran organism and their Phyla:

Cnidarians

These are the most primitive multicellular organisms, the fossils were first categorized as jelly fish or sea pens: **Charnia** is a genus of Ediacaran organisms that are frond-like, with leaf like ridges branching to the left and right in a zig-zag pattern. It was named after the Charnwood Forest in Leicestershire, England where the first fossil of this type was found. It grew on the sea floor and is thought to have fed on nutrients in the water. It has a fern like appearance but the fossil extraction areas indicate that it originally lived in deep water below where photosynthesis could occur.


Charnia

Charnia:

Phylum: Petalonamae

Genus: Charnia

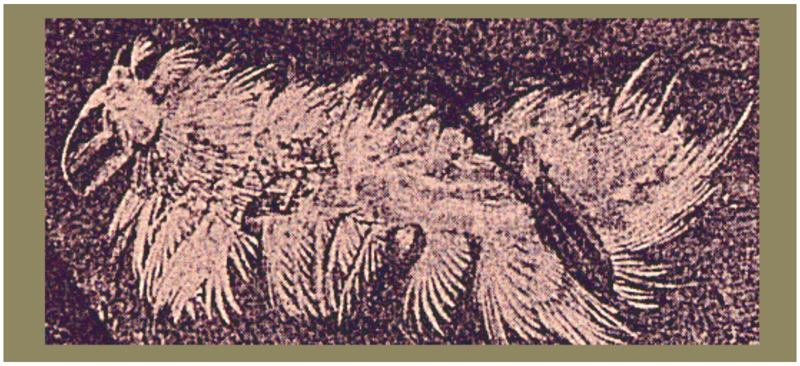
Species: C. masoni

Similar related organisms today are jellyfish and sea pens


Sea pen (a modern cnidarian)

Annelids: Phylum: Annelida

They are a phylum of invertebrate worms, with modern examples known as earthworms and leeches.



Above is “Canadia”, an Annelida from the Middle Cambrian Burgess Shale of British Columbia.


Above: actual photos from the Burgess Shale, British Columbia. Left: trilobite, Right: small, branching tubes, possibly an early relative of coral (Murray Helmer photos)

<u>Kimberella:</u>

Kingdom: Animalia

<u>Bilateria</u>

Kimberella is a slug like organism found in the rocks of the Ediacaran Hills in Australia, as well as near the White Sea in Russia (558-555 million years ago) It fed by scratching on the surface on which it lived.


Kimberella quadrata fossil

Phylum: Anthropodia-some Ediacadaran fossils are thought to be primitive members of the Phylum Anthropodia (insects, spiders, crabs etc)

<u>Spriggina</u> (possible ancestor of trilobites)

<u>Phylum: incertae sedis</u>

Spriggina is a segmented organism about 3-5 centimetres long, having a bottom side covered with two rows of strong interlocking plates. The top side was covered with one row of the same plates. The fron few segments were fused to form a type of head which may have had eyes and antennae. It is the official fossil of South Australia, as it has been found only there.

Spriggina

Citations:

An Introduction to the Ediacaran fauna
Ediacaran: An introduction to the Ediacaran fauna
https://www.ediacaran.blogspot.com/2008/11/introduction-to-ediacaran-fauna.html

Ediacaran Biota
Ediacaran biota - Wikipedia
https://en.wikipedia.org/wiki/Ediacaran_biota

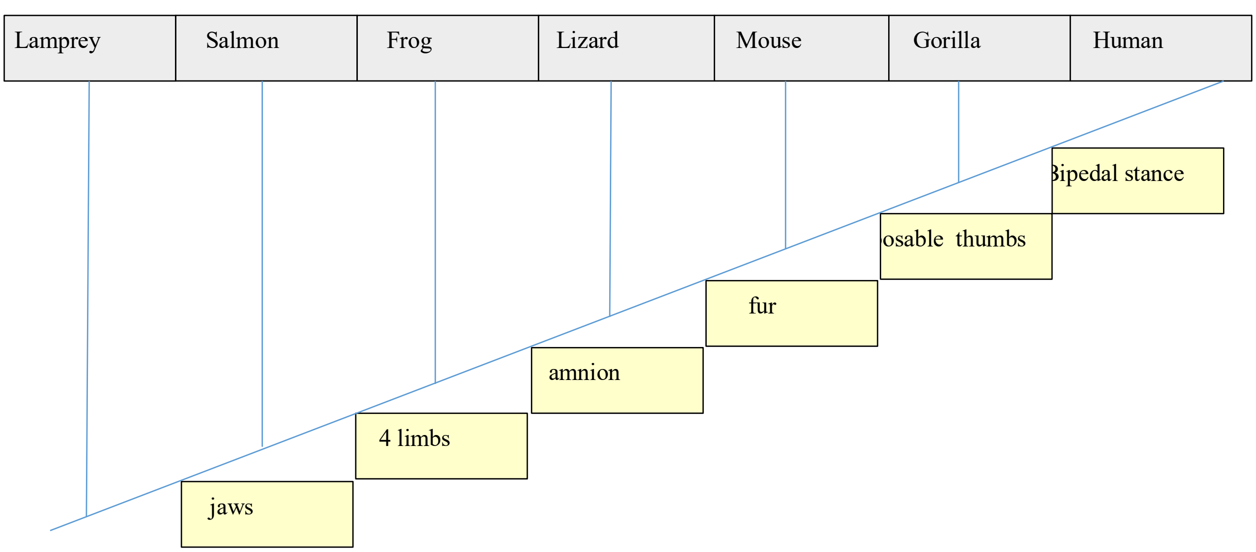
Ediacara fauna, Fossil Asssemblage
Ediacara fauna | fossil assemblage | Britannica.com
https://www.britannica.com/science/Ediacara-fauna

PART C: CONSTRUCTING A CLADOGRAM

Taxon	Characteristics
Mouse	jaws, amnion, fur, four limbs, backbone
Human	amnion, fur, four limbs, opposable thumbs, bipedal stance, backbone, jaws
Gorilla	opposable thumbs, backbone, jaws, amnion, four limbs, fur
Lamprey	backbone
Lizard	jaws, amnion, backbone, four limbs
Salmon	jaws, backbone
Frog	four limbs, backbone, jaws

	Backbone	Jaws	Four Limbs	Amnion	Fur	Opposable Thumbs	Bipedal Stance
Mouse	1	1	1	1	1	0	0
Human	1	1	1	1	1	1	1
Gorilla	1	1	1	1	1	1	0
Lamprey	1	0	0	0	0	0	0
Lizard	1	1	1	1	0	0	0
Salmon	1	1	0	0	0	0	0
Frog	1	1	1	0	0	0	0

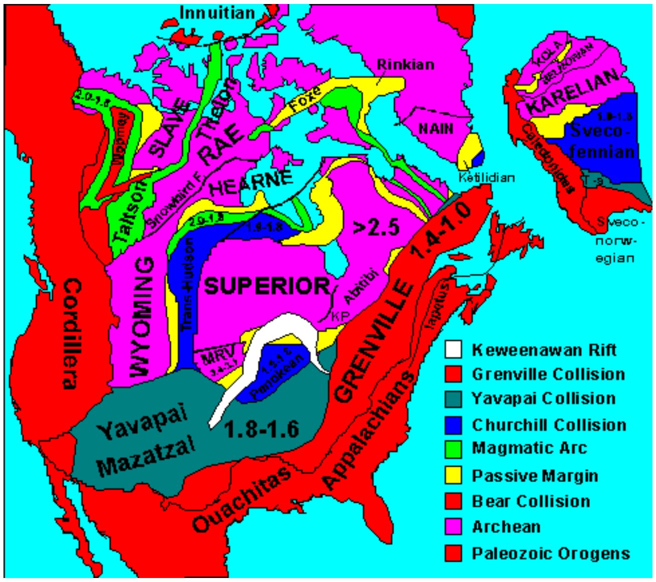
Cladogram:

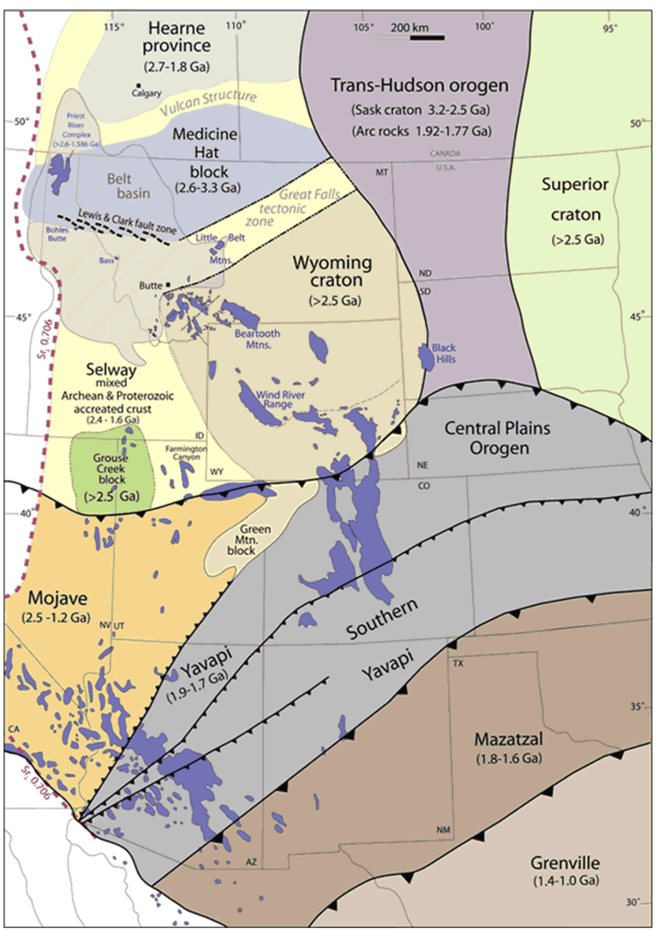


PART D: THE ANCIENT HISTORY OF LAURENTIA

Youngest	Grenville Province (1.3-1.0 bya)
	Granite-Rhyolite Province (1.35-1.55 bya)
	Mazatzal Province (1.65-1.76bya)
	Yavapai Province (1.65-1.8 bya)
	Wyoming Craton (1.74-1.78 bya)
	Trans-Hudson Orogen (1.82-1.84 bya)
	Wopmay Orogen (1.8-2.0 bya)
	Hearne Craton (1.8-2.0 bya)
	Mojavia Craton (2.0-2.3 bya)
	Grouse Creek (2.5-2.5 bya)
	Medicine Hat Craton (2.6-3.3 bya)
	Saskatchewan Craton (2.5-3.2 bya)
	Rae Craton (2.7-2.9 bya)
	Superior Craton (2.7-3.0 bya)
Oldest	Slave Craton (4.03 bya Acasta gneiss, 2.7 – 3.0 bya greenstones)

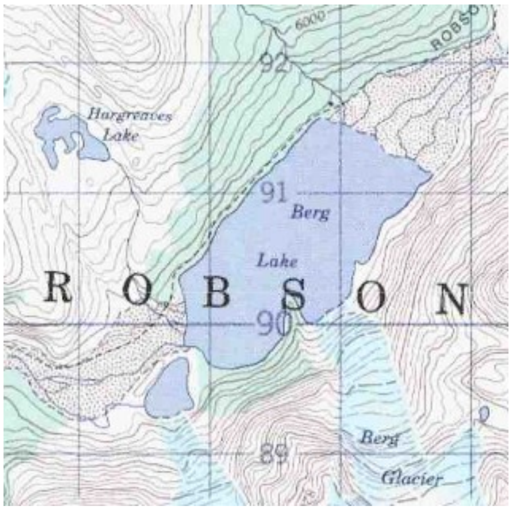
Map Citation Sources: (used in combination with the textbook)

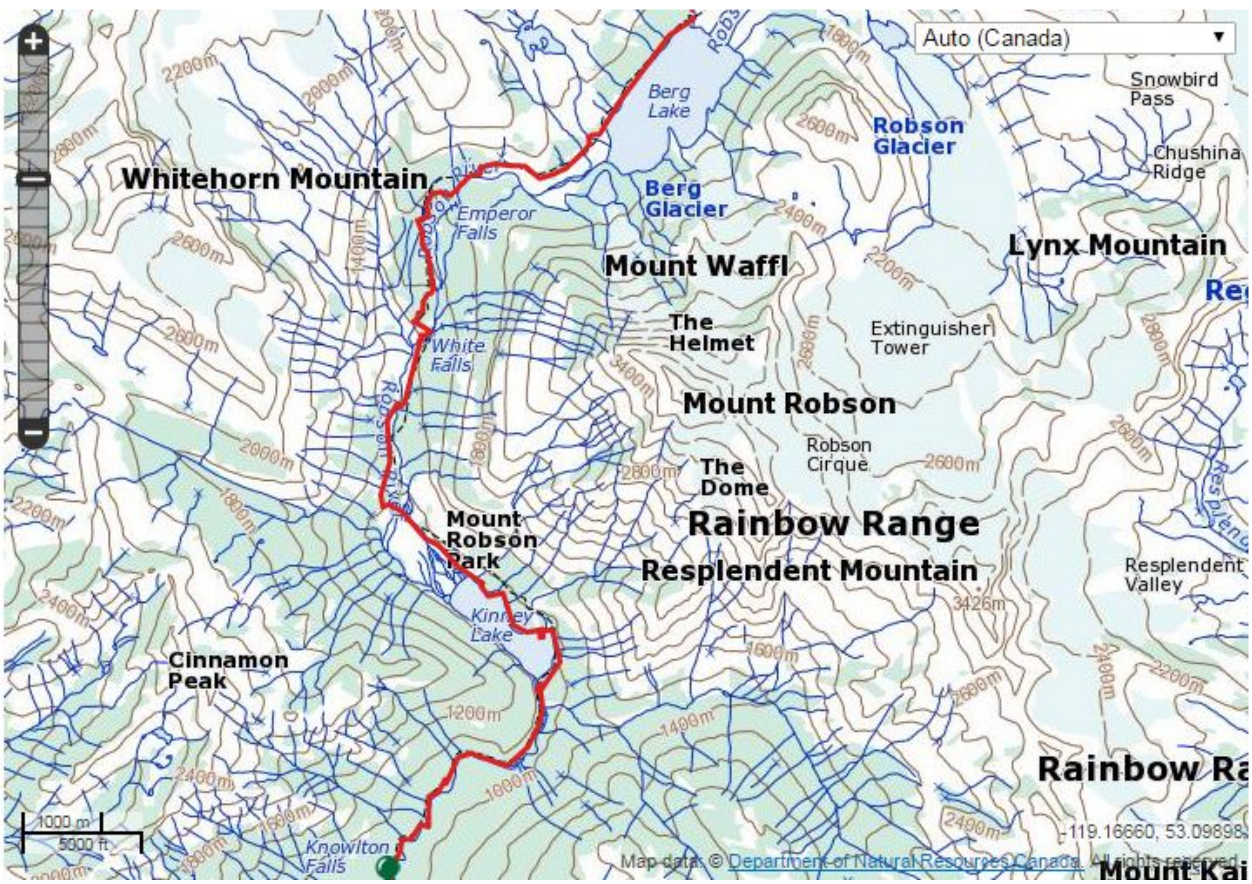




PART E: FIND AND DESCRIBE A DEPOSITIONAL BASIN

Mount Robson, Berg Glacier, Berg Lake, British Columbia, Canada





Formation Assessment:

Berg Glacier and Berg Lake is located in Mount Robson Provincial Park, British Columbia, Canada. The primary inflows to the lake are Robson River, Toboggan Creek, Hargreaves Lake, and Outlet Stream. The lake is also glacial fed by the Berg Glacier, and the primary outflow is the Robson River. Glacial erosion most likely created the Berg Lake, as the valley is wide and u-shaped, typical of glacial erosion. As melting occurred, the inflowing rivers filled the valley with water to become Berg Lake. Since this lake is not confined to a cirque, it would be considered a finger lake. There is a smaller lake off to the side that is confined by a moraine and could be a moraine lake. Besides the Lake, the glacier has created other sedimentary deposits, such as moraines containing till, and outwash plains from the braided streams.


Berg Glacier, Berg Lake

Source of Sediment/Method of Transportation

The Berg Glacier is the likely source area of the sediment into and around the Berg Lake. The slope of the land controls the glacier flow, and the glacier moves because the ice surface is sloped. The slope causes stress on the ice, and below a certain depth, the ice behaves in a plastic manner and will flow. If the base of the glacier is warm there may be a film of water between the ice and material underneath to cause the ice to slide. The front edge of the glacier either melts or calves (shedding icebergs) into the water, and within the iceberg is sediment that is then deposited into the lake. Sediment is also carried within (and under the ice), and deposited directly from the ice as well. Berg lake receives sediment from calving, and also directly from the Berg glacier in the form of till/moraines. There is also outwash in the area, associated with braided streams. Although it cannot be seen in the photographs, there could be accumulations of sediment at the bottom of the lake. There may be varves, containing silt and clay (light layers) from the Spring, and dark layers of clay and organic matter from the Winter.

Calving in Berg Lake (sometimes the icebergs look like cats swimming!)

Estimation of grain size

The grain sizes of the till and outwash from the Berg Glacier range from silt and clay which would be near the streams and bottom of the lake, to pebbles and boulders in the till and moraines deposited directly by the ice. Although not directly visible, there may be clasts that have broken off the surrounding sedimentary formations. They may be rounded from abrasion.

Grain sizes of the clay would be <0.002mm and the silt would be between 0 002 and 0.06mm. Sand would be between 0.06 and 2mm. Gravel sizes would range from 2.0mm-63mm (also called pebbles), and boulders would be anything over 256mm.

Citation: Grain size - Wikipedia
https://en.wikipedia.org/wiki/Grain_size

<u>Sedimentary Structures forming within Sediments</u>

Structures that may be forming within the Berg Glacier and Lake could include the dark and light lamination couplets called varves. These would be forming and the bottom of the lake from the yearly sediment accumulation. Light layers in the Spring would be silt and clay, while the dark layers would be from the Winter, consisting of organic matter and clay. The poorly sorted till deposited by the ice would be forming ridges called moraines.

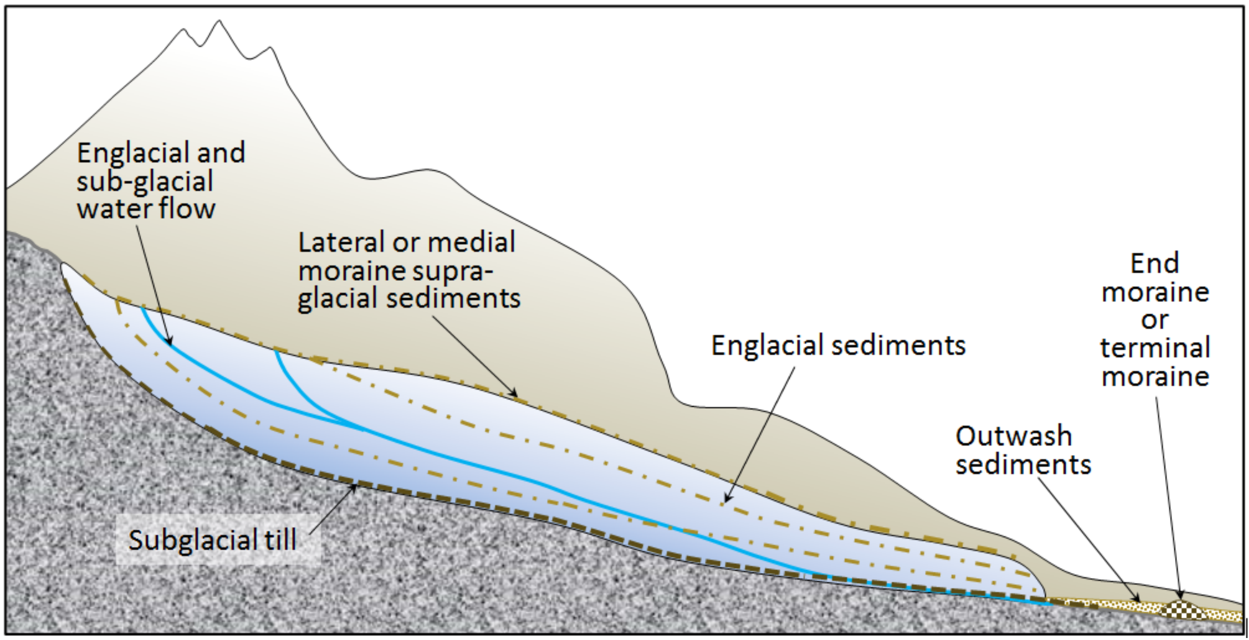
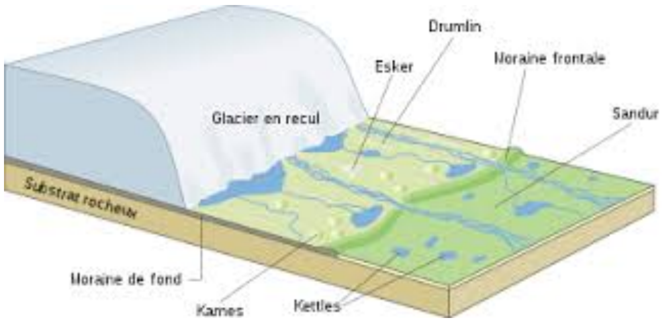


photo from opentextbc.ca

<u>Drumlins</u> may also be forming underneath the current glacier. They are oval shaped hills that look like a half buried egg, made by glacial ice acting upon underlying till or moraine.

<u>Eskers</u> are another depositional landform that may be forming underneath the Berg Glacier. It is a long winding ridge usually consisting of sand and gravel, formed by streams that flowed within and under a glacier. When the ice walls melt away, stream deposits remain as the ridges.



Drumlins and Eskers may be distinguished from moraine as running with the flow of the glacier instead of perpendicular to it (like moraine).

Two types of till may be associated with the glacier: ablation till, deposited on the ground when the ice melts, which is fine, coarse and angular rock fragments, and lodgement till, material eroded directly from the underlying rock with wide grain sizes, high in silt and clay.

water flow underneath the ice, potential esker (left)

Potential Fossils Present:

There have been Ediacaran Fossils found at Mount Robson Provincial Park.

(photo next page)

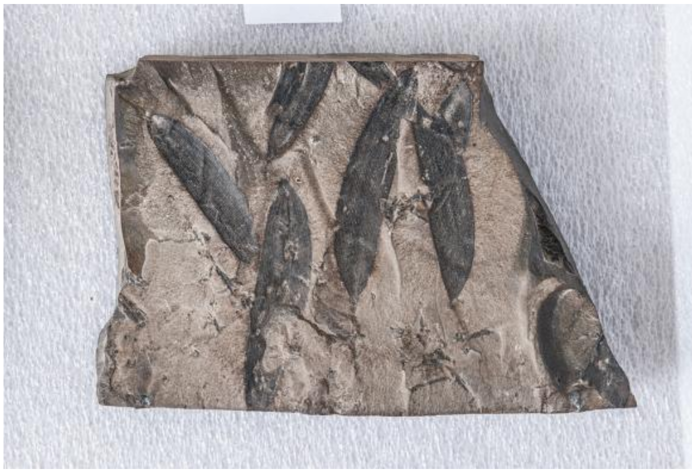
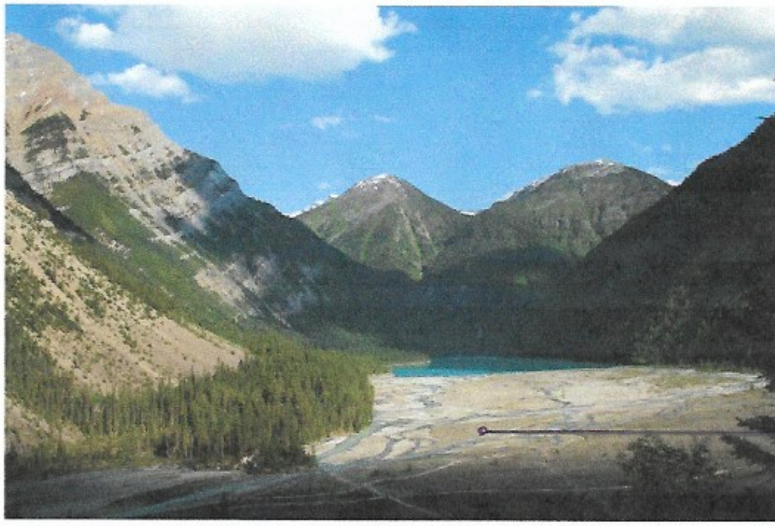


photo from Paleontology, royalbcmuseum.bc.ca

These fossils have been identified as Cyclomedusa davidi, Irridinitus sp., and Protodipleurosoma sp. They occur in a greenish-gray shallow water siltstone that surrounds stomatolite mounds on the Yellowhead Platform in Mount Robson Provincial Park. (Ediacaran fossils from the Miette Group, Rocky Mountains, British Columbia, Canada. www.http:/pubs.geoscienceworld.org)

Potential Rock Formation in the Berg Glacier/ Berg Lake Basin

Aside from the presently visible sedimentary and glacial depositional landforms at Berg Lake Glacier, continual varves may form beneath the current lake. These may be seen in the future if the lake ever dries out or completely drains. Most of the rocks that would form from a glacial depositional environment would be sedimentary. There is a potential for some sort of metamorphic change should a large-scale tectonic event occur, such as an earthquake. If some of the sedimentary rocks become buried and subject to intense pressure and heat, they have the potential to become structurally altered. Chances are, for the area of Berg Lake, erosional processes may occur before any metamorphic changes could occur, producing continual sedimentary glacial-based landforms.


outwash-
braided
streams
draining
from Berg
Lake


toe of receding
glacier
ablation till
end moraine
(terminal)
calved iceberg
containing sediment

Continual erosional and sedimentary depositional processes are likely to continue in the Berg Glacier/ Berg lake area, with possible fluvial processes should melting of the glacier continue.

*Berg Glacier/Lake photos were taken Canada Day weekend, July 2012.