Geology of Scenic Canyon
A self-guided tour

Prepared for the Friends of Mission Creek Society

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Introduction

My intent in writing this synopsis of Scenic Canyon geology is to provide an educational resource with detail sufficient for a self-guided tour of the canyon. It is intended for the general public. To achieve this end, my account is brief, and written with minimal use of technical language. I hope this account satisfies most readers' needs. For those readers with a more advanced understanding of geology, I also include reference to some more detailed, and much more technical accounts.

The following map (Fig. 1) indicates the location of the various features mentioned in the text. Also, for those of you who have a GPS, I have provided coordinates to help you locate each site. Our first stop on K.L.O. Creek is off the trail, so the GPS coordinates are especially useful for finding it.

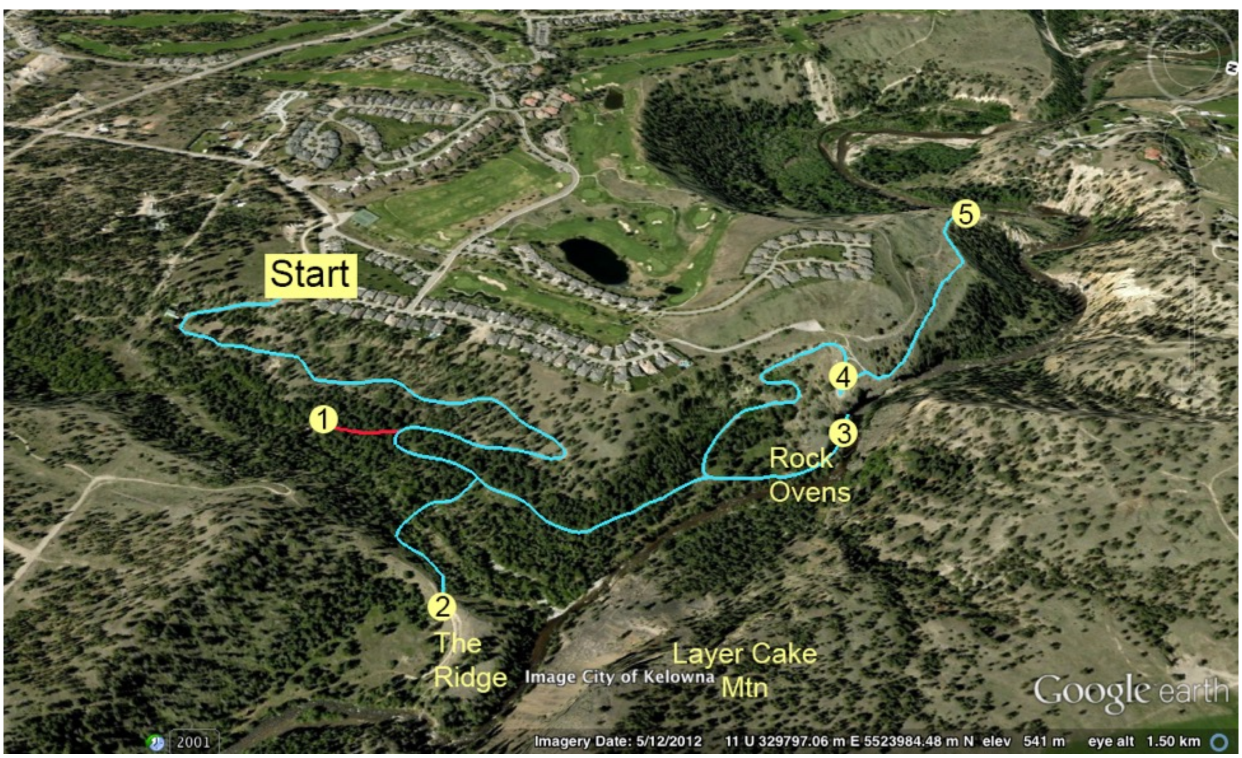


Figure 1. Map of the Scenic Canyon geology walking tour. 1 – Basement rocks, 2 – The ridge, 3 – The rock ovens, 4 – Layer Cake Mountain viewpoint, 5 – White Lake Formation viewpoint.

I. Start – Field Road Parking lot

(Coordinates: 49° 50.361'N, 119° 22.110'W, or UTM: 11 U, 329700 m E, 5523459 m N)

We begin our tour at the Field Road parking lot adjacent to the Pinnacle Golf Course at Gallagher's Canyon. From here we will descend into the canyon, and begin to explore the local geology. Along the way we will begin to encounter four principal features. From oldest to youngest, they are the following:

1) Ancient (Proterozoic?) basement rocks (the Okanagan Gneiss) – exact age unknown, but these rocks are hundreds of millions of years old.

2) Eocene volcanic rocks (Marron formation) – these formed about 50 million years ago, as molten lava was extruded onto the Earth's surface

3) Eocene sedimentary rocks (White Lake formation) – these materials (e.g., sandstones, siltstones, conglomerate) are somewhat younger, probably deposited at least 25 million years ago

4) Quaternary sediments – these comprise a variety of sediments (e.g., gravel, sand, silt) deposited in conjunction with the "ice ages". These deposits are, in a geologist's eyes, virtually brand new. They are loose materials that have not yet been cemented together to form rock. Mostly, they will date to approximately 10,000 to 15,000 years ago.

Ideally, we would encounter each of these features in exactly the order I have mentioned them above. Unfortunately, nature wasn't kind enough to organize them along our path in such a nice, neat chronological order. Instead, our route will jump from 4 to 1, back to 4, and then onwards to 2 and 3. I know this is potentially confusing, but such is nature… It's not my fault.

II. Descending into the canyon

As we walk from the Field Road parking lot down along the trail into the canyon, the trail is, in some places, cut into a series of steep banks. In other places, it traverses comparatively flat or gently inclined surfaces. Note the texture of the materials (chiefly sands and gravels) exposed in the banks and along the trail bed. Also note the rounded cobbles and boulders scattered among the trees adjacent to the path.

These sands, gravels, cobbles and boulders were deposited at the end of the last ice age, as the climate warmed, and the ice rapidly melted about 12,000 to 15,000 years ago). Prior to this, during the height of the last ice age, Kelowna was deeply buried in ice. The ice was perhaps two kilometres thick, deep enough to conceal all the mountains and highlands surrounding Kelowna.

The ice formed part of a continuous ice sheet that spanned the entire breadth of British Columbia, from the Pacific Ocean to the foothills and plains of Alberta. The ice extended northwards through BC into Yukon, and south into Washington. As the ice sheet melted, the mountains and highlands were exposed first, while remnant masses of ice foundered in the valley bottom, and slowly melted away.

Floods of glacial meltwater washed huge quantities of rock, sand and gravel down the creeks, into the valley, and onto the remnant ice. These deposits deeply buried Scenic Canyon, from the greatest depth of the canyon upwards to the parking lot. The Golf Course adjacent to the parking lot is built on the surface of these outwash deposits.

Later, as the last remnant ice at Kelowna and Okanagan Lake melted away, KLO and Mission Creeks were able to carve out their current paths, deep into these deposits. You are currently walking over this outwash, and seeing it exposed in the cut banks. The relatively smoothly rounded surfaces of the boulders, cobbles and gravels are the products of wear, as they tumbled violently down the creeks to where they now lie, often high above the current level of the creek.

III. Stop 1. The Ancient Basement Rocks
(Coordinates: 49° 50.415'N, 119° 21.950'W or UTM: 11 U, 329895 m E, 5523554 m N)

Figure 2. Part of the Okanagan gneiss exposed along the west side of K.L.O. Creek

Buried very deeply beneath the outwash are some very ancient rocks. They are so deeply buried beneath the outwash that they are seldom exposed, and can only be seen at a few locations along KLO Creek upstream of the bridge in Scenic Canyon. You can find them by following the west side of KLO creek upstream from the bridge, but life will be a little easier if you use a GPS.

Think of this as a geocache! Here are the coordinates for the rock outcrop: 49° 50.415'N, 119° 21.950'W (or UTM: 11 U, 329895 m E, 5523554 m N).

The rocks exposed here (Fig. 2) form a part of the Okanagan Gneiss (pronounced "nice", the G is silent). Gneiss is a kind of rock that forms from pre-existing rock deep within the Earth. The original rock may have been either a kind of volcanic or sedimentary rock.

While buried deep within the Earth, this rock was subjected to so much intense heat and pressure that it began to melt. Caught in this deep squeeze, the near-molten rocks were deformed such that the original, thick layers of rock may have been squeezed into thin, sometimes folded bands.

You can model this process with play-dough. Lay out a few different-coloured-layers of play-dough, then repeatedly press the layers tightly together like you were kneading bread dough. Fold the layers of play-dough back into a ball and press again. Repeat. Eventually, if you make a knife-cut through the play-dough, it will reveal a series of thin bands through the mass of dough. (Very gneiss!)

This kneading of the near-molten rock happened deep within the Earth. Eventually the pressure relaxed and the rock cooled and hardened; thus, a new kind of rock formed. Because the rock was changed by this process, geologists say it was metamorphosed, and refer to gneiss as a kind of metamorphic rock.

> The word "metamorphose" means "change". Biologists use the same word in reference to a very different kind of process – i.e., the changes (metamorphosis) that occur as a caterpillar is transformed into a butterfly.

As the overlying rocks eroded away, the masses of rock shifted around along fractures or cracks that we call faults. Some of these rocks have found their way to the surface where we can see them. In fact, the rocks exposed here, adjacent to KLO Creek were formerly buried beneath about 15 km of overlying rock.

Just north of where you now stand there is a great fracture in the Earth. It has sometimes been referred to as the Mission Creek Fault, but it may instead be just a part of the main Okanagan Fault. Movement along this fault uplifted these rocks formerly deeply buried within the Earth. The rocks rose upwards to where you see them today. In fact, the great masses of rock forming the walls of the Okanagan Valley southeast of Kelowna (e.g., in Okanagan Mountain Park) are largely composed of Okanagan Gneiss.

We know the Okanagan Gneiss is very old, but we don't know its exact age. A geology map for the Okanagan Watershed (**Geology, Okanagan Watershed, British Columbia**; Okulitch, A V. Geological Survey of Canada, Open File 6839, 2013; 3 sheets, doi:10.4095/292220) suggests that Okanagan gneiss could be Proterozoic in age (i.e., over 500 million years old). In the case of metamorphic rocks, I suppose you might also ask, "Which date interests you, the age of the original rocks? or the age of the new rocks formed following metamorphosis?

IV. Stop 2. The Ridge
(Coordinates: 49° 50.573'N, 119° 21.742'W or UTM: 11 U, 330158 m E, 5523839 m N)

Figure 3. Cross-section through glacial lake sediments that form the ridge, east of K.L.O. Creek

To reach this site, we will cross the bridge over K.L.O Creek and hike up to a small sandy/silty ridge. I have been asked, "How did this ridge form? Is it an esker? (An esker is a long ridge of gravel and other sediment typically formed within ice-walled tunnels by streams which flowed within and under glaciers.) The answer can be seen in the sediments that compose the ridge, and the features immediately adjacent to it.

If you examine the sediments exposed in cross-section at the top of the ridge (Fig. 3), you will see distinct layers in the sediments. These layers are gently inclined (dipped) towards the west, and are composed of fine sand/silt. There's no gravel or pebbles embedded in the exposure. The sediments have not been cemented into rock.

The absence of any coarse materials in the sediments indicates they were not deposited in a stream; thus, this feature cannot be an esker. These fine sediments were deposited into the calm, quiet waters of a lake that formerly occupied this part of the Mission Creek Valley, presumably near the end of the last glaciation, about 12,000 years ago. The lake was probably dammed up behind remnant ice filling the lower part of the Mission Creek Valley and Okanagan Lake.

Note that the inclination of sediment layers is greater at the bottom of the section; the uppermost sediments lie almost flat. Lake sediments are normally flat-lying; the inclination suggests that they have since been tipped towards the west, but the older sediments have somehow been tipped more than the younger, overlying sediments. How is this possible?

Imagine that the sediments were deposited on top of a wedge of ice, with the thicker end of the wedge lying on the west side of the ridge. As that ice wedge gradually melted from beneath the lake sediments, the sediments started to settle deeper into the valley. Because the ice was thicker to the west, the ice settled more on the west side than the east. In effect, the sediments were slowly tipped westward as the ice melted (Fig. 4 a-c).

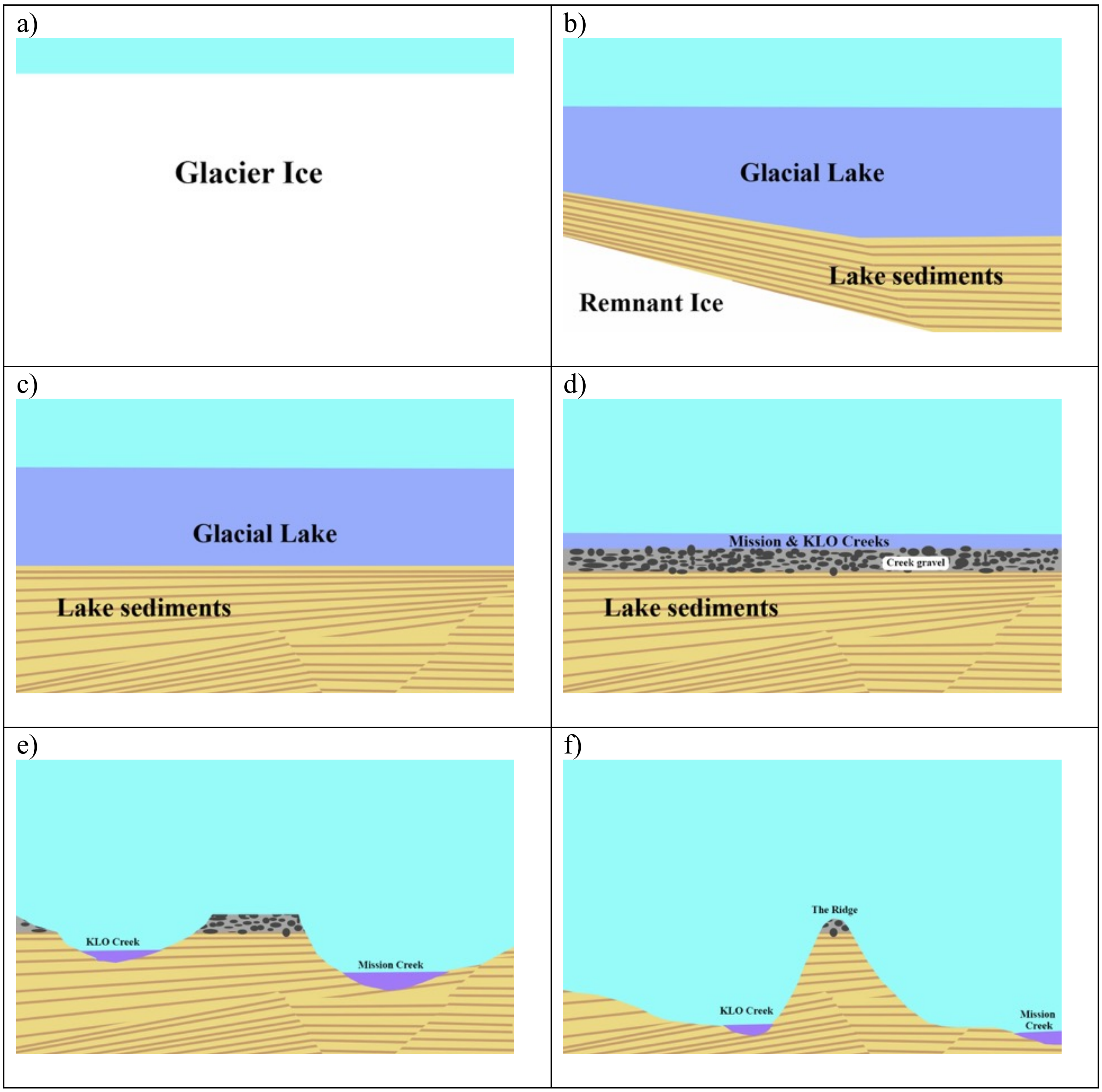


Figure 4. Sequence of events leading to formation of the ridge, east of K.L.O. Creek

The many layers of sediment likely represent annual layers of sediment deposition. Geologists call these varves. The ice was evidently slowly melting over many years beneath the lake sediments as these varves were deposited. The degree of tilt reflects how much of the ice wedge melted away after the varves were deposited. A lot of underlying ice melted after the lowermost sediments were deposited; thus, their tilt is greatest. By the time the uppermost sediments were deposited, all the underlying ice had probably melted; thus, these upper beds lie virtually flat.

How then, did the lake sediments come to form a ridge high above the creek? There are some other features that help sort out this part of story. First, if you climb up onto the ridge just north of this exposure (not easy to do, and potentially hazardous; thus, I'm not recommending you do this), you will discover that the top is covered in rounded cobbles indicating that Mission Creek once flowed directly over top of the ridge. Also, note the flat area east of the ridge is also covered in cobbles, right up to base of the ridge. At some time, evidently, a bend in Mission Creek was running up against the ridge and eroding into the lake sediments that compose the eastern margin of the ridge. On the west side of the ridge, K.L.O. creek is also close – so close that it would also have eroded into the sediments (Fig. 4 d-f).

We see, therefore, evidence of the shifting course of the creeks as they eroded deep into the canyon. Before the ridge was exposed, the creek ran at a much higher level, directly over the ridge. As the creeks eroded deeper, Mission Creek cut into the east side of the ridge, while K.L.O Creek eroded on the west. What remains between the two creeks is this narrow ridge of lake sediments, an erosional remnant harbouring the only evidence of the pre-existing lake.

IV. Layer Cake Mountain

Figure 5. Layer Cake Mountain

As you have been walking down into the canyon, and now retrace your steps to the K.L.O. Creek bridge, you have surely noted the great, layered wall of rock on the north side of Mission Creek. This cliff forms the southern margin of Layer Cake Mountain (Fig. 5). The rationale for the mountain's name is so obvious that no explanation is needed. The greater puzzle – how did this feature form? It is a question that also has intrigued many geologists.

If you search for explanations you may find an old geology map, prepared by Church (Church, B.N. (1981) Geology of the Kelowna Tertiary Outlier (East Half). Province of British Columbia, Ministry of Energy, Mines and Petroleum Resources, Preliminary Map 45). Prominently labelled on his map, where Layer Cake Mountain stands, is "The Geotectobolt". So, you continue your search on-line. Nowhere can you find any definition for a geotectobolt. So, what is it?

A geotectobolt is just an example of a geologist's humour. After viewing Layer Cake Mountain geologists wildly speculated on the processes that might have led to its formation. Noting that the gently inclined layers somewhat resembled the threads on a bolt, they suggested (in jest) that Layer Cake Mountain must have screwed itself up out of the earth. Thus, "the geotectobolt" myth was born.

The truth is more complex. Layer Cake Mountain consists of dacite, a rock that forms as lava cools, sometimes when extruded at the Earth's surface, and sometimes at the core of an old volcano. The obvious explanation for the layering, then, would be – Layer Cake Mountain must be composed of multiple flows of lava extruded on the Earth's surface, with each new layer of rock forming over the older layers. I thought so – but this is wrong!

Local UBC geologist John Greenough examined Layer Cake Mountain, and after extensive study concluded that the mountain formed from a single, large, slowly cooling mass of molten rock. The mass slowly cooled downward, and as it cooled and hardened the upper rind periodically sheared apart from the underlying mass. Thus, the layers gradually formed, very counter-intuitively, from the top down. The details are complex. For a full explanation, see John's paper (Greenough, J. D. & J.V. Owens. 1998. Igneous layering in a dacite: on the origin and significance of Layer Cake Mountain, Kelowna, B.C., Canada. Mineralogical Magazine, Vol. 62, pp. 731-742.)

VI. Stop 3. The Rock Ovens

(Coordinates: 49° 50.796'N, 119° 22.037'W, or UTM: 11 U, 329813 m E, 5524263 m N)

The Rock Ovens lie adjacent to Mission Creek at the greatest depths into Scenic Canyon. Here you can most closely observe the volcanic rocks that form the canyon walls (Fig. 6) and Layer Cake Mountain. These rocks are mapped as being a part of the Nimpit Lake member of the Marron Formation. Their formation dates to approximately 50 million years ago, in the Eocene epoch.

Note that the rock mostly appears to be highly fractured yet remains mostly cemented together. In places the canyon wall is pitted and honeycombed. This may reflect differential erosion due to small scale variations in the quality of the (carbonate?) cement (Fig. 7).

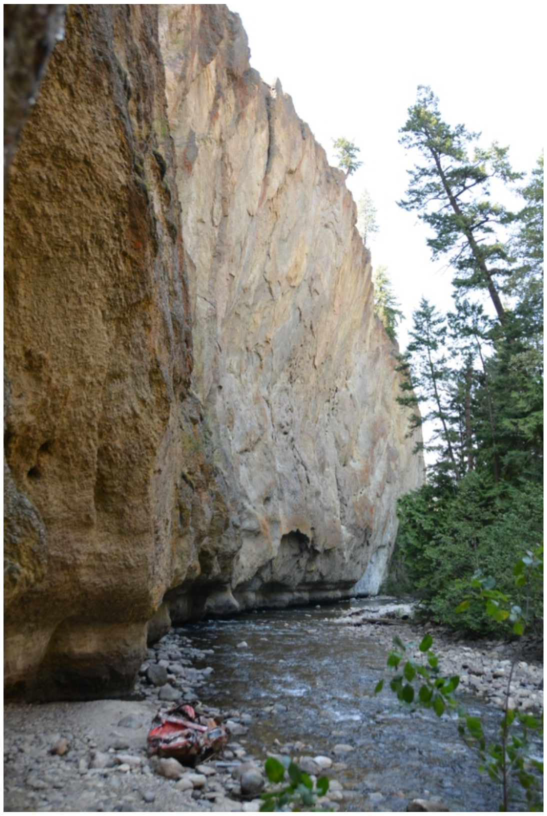


Figure 6. Massive wall of volcanic rocks exposed in Scenic Canyon, immediately downstream from the rock ovens.

Figure 7. Honeycombed Eocene volcanic rocks evident at the rock ovens site.

Figure 8. One of the "rock ovens" adjacent to Mission Creek – formerly providing refuge for Chinese gold miners.

Also note the blackened roofs of several grottoes at the cliff base (Fig. 8). Chinese miners formerly took refuge here as they worked the gravels of Mission Creek for gold.

Gold panners still frequent this part of Mission Creek. The miners are not allowed to dig into the banks, but the creek bed is excluded from the park. This allows miners to pursue gold embedded in the stream bottom, although not at times when it might impact on fish (e.g., when spawning).

Evidence of former placer mining includes pits on the low bench east of the ridge (near Stop 2), and west of this narrow canyon.

VI. Stop 4. The Layer Cake Mountain viewpoint
(Coordinates: 49° 50.800'N, 119° 22.125'W, or UTM: 11 U, 329707 m E, 5524274 m N)

Upon leaving the Rock Ovens, the Greenway trail climbs westward to a viewpoint high above the canyon. This vantage offers an exceptional view not only of Layer Cake Mountain, but also of The Pinnacle, an isolated remnant column of dacite east of the viewing platform.

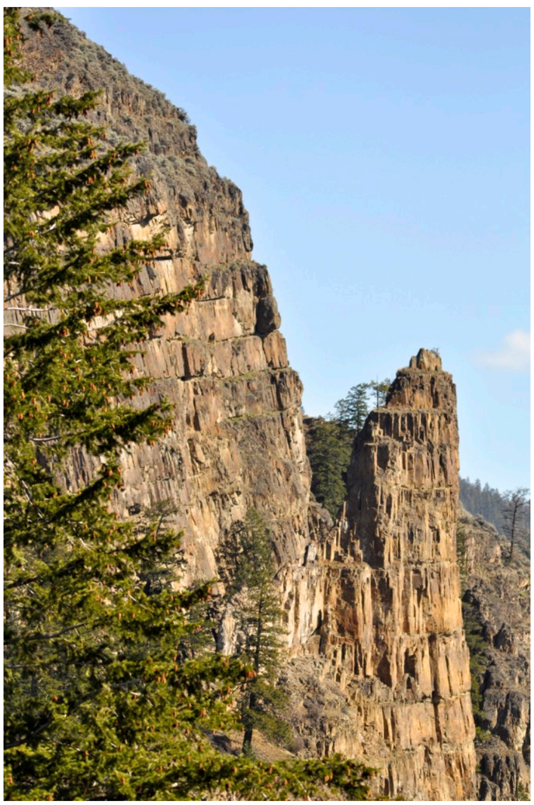


Figure 9. Layer Cake Mountain (left) and the Pinnacle (right), as seen from the first viewpoint.

Figure 10. Exposed wall of sediments as seen from the second viewpoint. At the bottom of the section are Eocene rocks, a part of the White Lake Formation The upper, loose, overlying sediments were deposited more recently by glacial meltwater. These might pre-date the last glaciation

The origin of the Pinnacle is unclear. In *Okanagan Geology* (a book on local geology), Murray Roed notes that the Pinnacle might be an erosional remnant left behind when glacial meltwater was carving the canyon. I find a second scenario he proposes more appealing – that this rock column separated from the cliff wall, and has started slowly slipping as an intact, erect column into the canyon.

VII. Stop 5. Another viewpoint – White Lake Formation
(Coordinates: 49° 50.894'N, 119° 22.500'W, or UTM: 11 U, 329264 m E, 5524462 m N)

The Greenway trail continues westward high above the canyon to another viewpoint. From this vantage, beyond the canyon narrows, new rocks are exposed on the north side of Mission Creek. These rocks are often buried deeply beneath outwash gravel (Fig. 10), and sometimes are steeply inclined, folded (Fig. 11), or completely over-turned. They consist of sedimentary rocks, varying greatly in texture, including sandstone, siltstone, mudstone and conglomerate. In some places there are blackened seams bearing a variety of plant remains. These remains will be best preserved in the finer-grained rocks. Long ago these plants grew at the margins of lakes and streams, that have long-since disappeared.

Figure 11. Pronounced fold in the White Lake Formation sedimentary rocks. North side of Mission Creek.

One of the more common fossils in the White Lake Formation rocks is *Metasequoia*, the dawn redwood. *Metasequoia* is often regarded as a living fossil. These coniferous trees may grow to

45 metres in height. Unlike most conifers, these trees are deciduous, dropping their needles each fall as cold weather approaches.

Although formerly common, *Metasequoia* long ago disappeared from the wilds of British Columbia. Today it survives in China, and has been planted elsewhere as an ornamental tree. In recent years a few *Metasequoia* have been planted in Kelowna, including one tree in the public garden at Guisachan House, and some young shade trees in the midst of parking lot H, at the northeastern corner of the UBC Okanagan campus.

Rocks of the White Lake Formation are commonly regarded as Eocene in age (34 million to 59 million years old), but Church notes that the assemblage of plants they contain (*Metasequoia occidentalis*, *Pinus* sp., and *Comptonia columbiana*) suggests they might be younger, dating instead to the Oligocene, 23 million to 34 million years ago (Church, B.N. 1973. Geology of the White Lake Basin. British Columbia Department of Mines and Petroleum Resources, Bulletin 61.)

If you continue to hike westward, you will have opportunities for some closer views of these sedimentary rocks. Unfortunately, the White Lake Formation rocks are mostly confined to the north side of Mission Creek; thus, there is little opportunity to examine them in detail.

VIII. Return to Parking Lot

We will now retrace our steps to the Field Road parking lot. You can again ponder how these rocks formed and how they came to sit where they lie today.

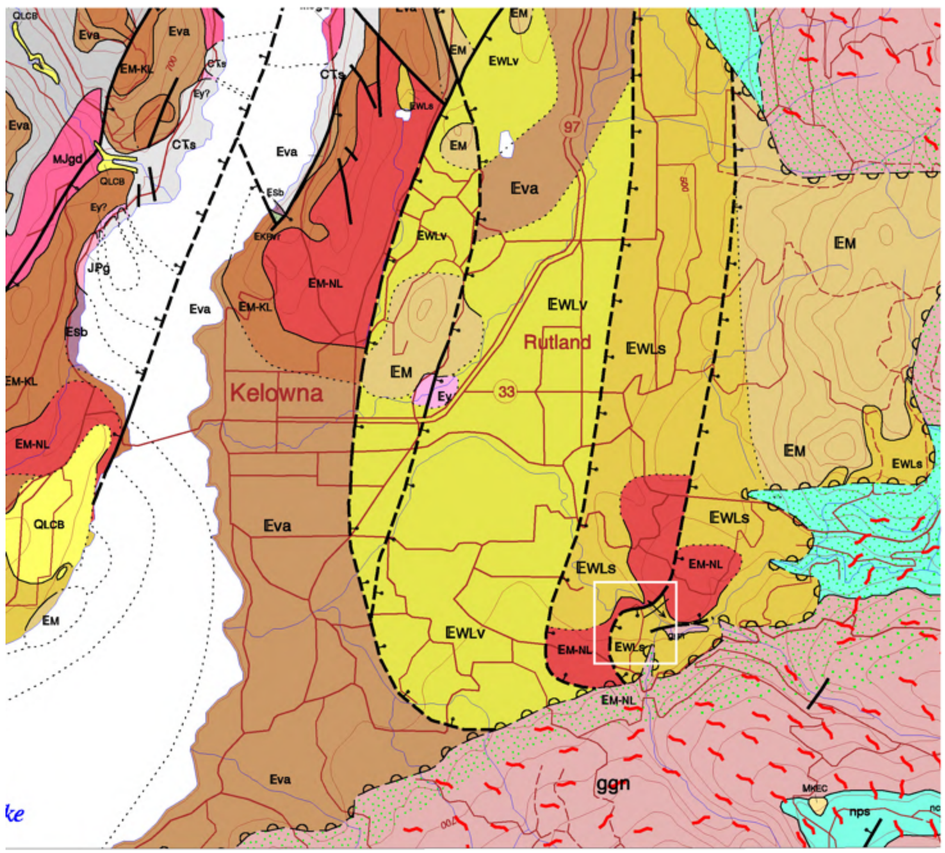
Many other puzzles may reveal themselves as you study the rocks. I have offered you an introduction to Scenic Canyon geology, but much more could be learned. Hopefully this brief introduction is sufficient to spark your interest.

IX. Acknowledgements

The interpretations presented in this pamphlet are based on discussions with several professional geologists with much greater expertise than mine. I am particularly indebted to members of the Kelowna Geology Committee, especially Dr. Robert J. Fulton, Dr. John D. Greenough, and Dr. Murray A. Roed. For more information on local geology, see:

M.A. Roed and J.D. Greenough (Editors). 2014. Okanagan Geology: British Columbia, 3rd Edition. *Kelowna Geology Committee, Sandhill Book Marketing Ltd, Kelowna, BC ISBN: 978-0-9699795-4-8*

Appendix. Bedrock geology of Kelowna



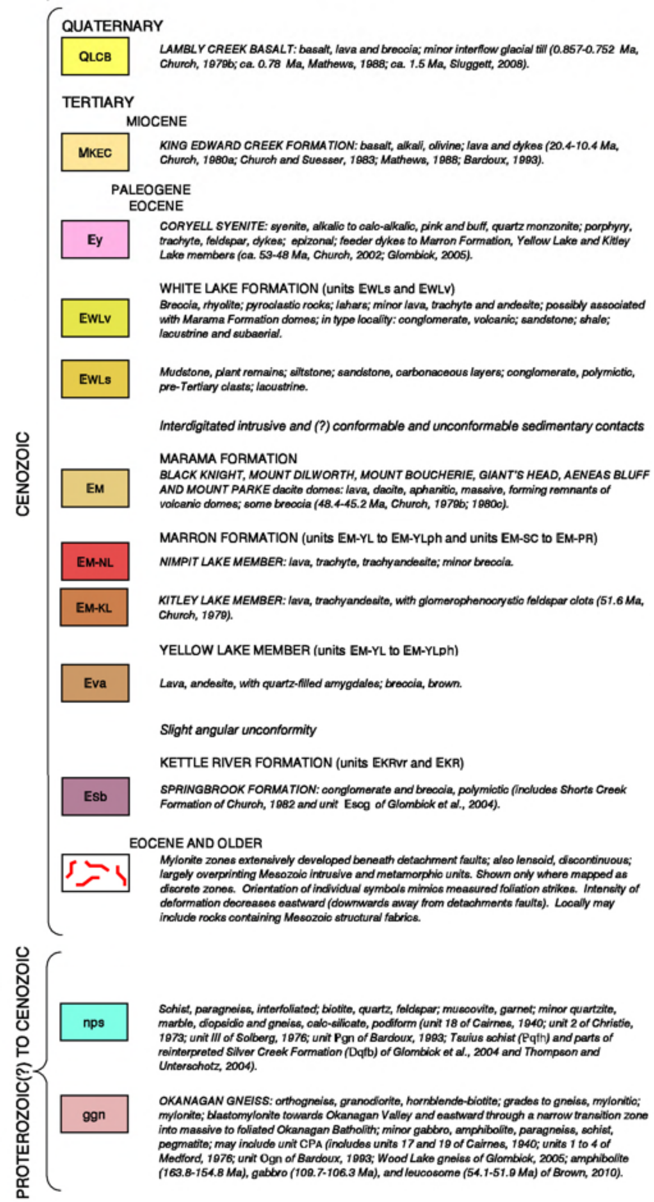


Figure A1. Kelowna bedrock geology map (adapted from Okulitch, A V., Geology, Okanagan Watershed, British Columbia; Geological Survey of Canada, Open File 6839, 2013; 3 sheets, doi:10.4095/292220). White rectangle indicates vicinity of Scenic Canyon.