

Stop 1 Introduction

Hello, my name is Chani and I'm Todd and we're instructors at Okanagan College in Penticton, British Columbia. We're going to be your leaders on a virtual tour of geomorphological features of the south Okanagan. So we're gonna learn why the landscape looks the way it does today. So we're gonna, we're gonna, visit sites that demonstrate glacial and fluvial processes, some weathering, plate tectonics, faulting, all sorts of good stuff. All of the different um processes that have come together to create the beautiful south Okanagan landscape that so many people enjoy today.

Words on video:

We respectfully acknowledge that this field trip takes place on the traditional and unceded territory of the Syilx Okanagan people. The Syilx Okanagan people have taken care of their homelands for thousands of years. We are respectful of the Syilx Okanagan people, their knowledge, language, and history, as well as their ongoing relationship to the land and natural world. To learn more about Syilx Okanagan people, their homelands, governance, and of special interest to fieldtrip, their relationship to water, please visit <https://www.syilx.org/>.

Stop 2 Munson Mountain

[00:03] We're starting our field tour up on top of Munson Mountain, which unbeknownst to most people is a volcano. "What?" I hear you ask, "There's a volcano in Penticton?" Mhhmm. The cool thing about this volcano though is that it wasn't actually formed here, it was formed much further to the east. Well how on earth did it get here? Another question we want to answer, why is Okanagan Lake where it is today? Why does the Okanagan valley have the shape that it does? Well, to start telling this story we have to go far back in time to the formation of British Columbia. British Columbia was formed by the process called accretion of terrains. Volcanic island arcs off the coast were pushed via plate tectonics up onto the North American Craton. In doing so we created these north-south trending valleys, one of which is the Okanagan valley. Now the Okanagan valley actually came into being when those pushing forces relaxed. At that point in time we also got this volcanic activity which created Munson Mountain. As I said though, Munson Mountain wasn't created where it is located today. Instead, it was further to the east, again closer in time to today we had other movements. Uplift to the east which pushed some of those volcanic features um to slide down off to the west. Now the Okanagan valley, it sits at the boundary between two major geologic belts the um the Intermontane belt to the left and the Omineca belt to the right or to the east sorry, the Omineca belts to the east and the intermontane belt is to the left. This is the major reason why we have such different types of rocks on the east side of Okanagan Lake compared to the west side.

[02:03] *Words on screen: A bit more detail on the plate tectonic action.*

Let's take a look at the formation of B.C. in a little more detail. So, this all occurred during the Jurassic period which lasted from 180 to 60 million years ago. At this time the North American craton, basically it ends at the Rockies where Alberta is, was moving to the west. At the same time an intermontane super terrain had gathered together off the coast from a series of volcanic island arcs was heading east. When these two masses crashed into each other, material that had been on the seafloor off the coast of the craton was pushed up to form the Rocky Mountains. With the forces involved in the intermontane, the intermontane super terrain smashing into the craton, the Omineca belt, so the region sitting closest to the craton, was metamorphosed.

[03:19] During an Eocene from 55 to 34 million years ago we saw a major change in the forces that were being applied to our area of interest. Instead of being compressed, we had relaxation off to the west here. With this crustal relaxation and crustal thinning, we got a lot of volcanic activity. At the same time the climate was a lot wetter and so large river systems developed. It was large paleo river systems, such as those that contributed to the White Lake formation. During this time the Penticton group volcanics were also developed. So, these are interlayered formations of material deposited by volcanic eruptions covered up by paleo river deposits covered up again by volcanic eruptions.

[04:20] It was during the Oligocene 36 to 24 million years ago that the Okanagan fault finally pulled apart to create the Okanagan Valley. Two forces combined, uplift of the Okanagan metamorphic complex which created the Monashee Mountains and this continued tensional force pulling off to the west. The result was the Penticton group volcanics, the volcanic and

sedimentary formations that had been sitting on top of the metamorphics, slid off to the west leaving stranded on the east side of the lake Munson Mountain. Now I say east side of the lake because in the south Okanagan the Okanagan fault runs pretty much straight through the center of the valley, which is straight through the middle of the lake. Now the Okanagan fault is a normal fault, the foot wall rose.

[05:16] Words on screen: *Back to the view...*

Before we move on let's do a 360 tour of all the different places that we can see from here many of these you'll visit as you go through your field trip today. So starting to the north behind me we have the beautiful Naramata bench, which is some very delicious wine growing on top of some sediments deposited by glacial processes. Further into the distance, um you can see Okanagan Mountain Park. Moving around the very deep um rather large Okanagan Lake which runs all the way from north of Vernon down here to Penticton. On the west side of Okanagan Lake, you'll notice a number of features that look um smooth on one side and like little drop-offs on the other. So one of the most famous is Giant's Head. Moving further around we have Mount Nikwala. Now both of these were formed by a combination of volcanic and glacial processes. Underneath um closer down to the lake you see the silt cliffs again deposited by glacial processes. Moving around even further sitting down here on this very, very flat area we have Penticton itself in full bloom in these lovely fall colors. In the distance, you see the other lake that we have sandwiching us here in Penticton, Skaha Lake. Now once upon a time, Okanagan Lake and Skaha Lake were one lake and you'll learn in a different field stop how Penticton itself came to be where it is. Moving all the way around here to the east we have Campbell Mountain famous as a local very excellent place to go mountain biking provided you can stay on the trails. Also, home, not so much a geomorphological feature but very important to the local community is the landfill. Enjoy.

Stop 3 Giants Head

[00:05] Welcome back to our tour of the south Okanagan. At this stop we're looking across the lake so we're up above uh the village of Naramata and the Naramata bench looking across at a feature called Giant's Head. Giant's Head is an extinct dacite dome volcano erupted in the Eocene, um, and it has been highly modified by glacial activity, it's shape. So we're going to zoom in a bit on Giant's Head here so we can look at its shape. All right, so um, this area was glaciated, as we all know, glaciers flowed from the north to the south and we can see on the north side, the right side, of giant's head here we have um a fairly gentle and smooth slope leading up to the summit. Whereas on the left side or south side we have essentially a cliff a very steep, steep slope and this is a function of the way that glaciers, as they're flowing, interact with obstacles in their path and in this case it creates a feature called a *roche moutonnée*.

[01:14] So what happens is we have ice flowing in from the right um, from the north, it encounters this obstacle and that increases the pressure at the base of the ice. This pressure increase causes a decrease in the pressure melting point, allowing the ice to melt at temperatures below zero, which means we get liquid water on the bottom. Allows the glacier to flow over top um with sort of a little bit less erosive power; and then as it crests the summit and starts going over, that pressure is released and the um ice refreezes or the pressure decreases and the ice refreezes and it can pluck out chunks of rock. Resulting in this very steep face.

[02:09] We can also see I'm just going to zoom out, whoops, zoom out here, that these features are pretty common in this area. So just to the south of Giants Head we see another similar um feature and then as we're looking back south towards Penticton, we have Separatist Mountain and Mount Nikwala that both show these same shapes.

Stop 4 A Glacial Erratic

[00:05] Good morning, welcome to another beautiful spring day in the Okanagan. I brought you here to Campbell Mountain today not just to look out over the calm lake, but to show you this feature over here, my favorite glacial erratic. For scale we have a few smaller people up on the rock and we know it's a glacial erratic because it's not related to the rock the Campbell Mountain is made up of. And so that tells us that it was deposited by some other force and the force at play here is, you guessed it, glaciers. Glaciers are so powerful they can pick up rocks of all kinds of shapes and sizes and they don't sort them as they deposit them, they just pop them down wherever and this particular rock got popped down right here on the side of Campbell Mountain

Stop 5 Till

[00:05] Hello and welcome back this stop we're up Penticton creek near the Penticton water treatment plant and we're going to look at some glacial till. So at the top of our image here um this bit here is glacial till. We don't actually see a lot of glacial till outcrops in the south Okanagan it's certainly around but it's not um super prevalent. The kind of till we're looking at in the bottom section, so down in here, is um a lodgment till or a basal till. So this means material that was deposited at the bottom of a glacier. So we know tills have been deposited in direct contact with ice, this type of till um is deposited on the from the bottom of the glacier. So we've got this glacier plowing across the landscape picking material up um and plastering it down and then eventually the glacier melts and it leaves behind this deposit.

[01:06] Interestingly, here we also have at the top part a little bit of ablation till. This ablation till was deposited off the top of the ice um as the glacier wasted away and so we can tell the difference between them due to differences in particle size. So the ablation till typically has a bit less fine particles, so sand, silts, clays, um and it may even have a little bit of sorting and we might even be seeing a slight amount of fluvial material on the top of that deposit. The lodgment till is more compact, so it's denser, as well as a higher proportion of sand, silt and clay, so fine materials, but we also see um particles from boulder size all the way down to um fine silts and sands. So, um the material is very mixed, so unsorted, um very dense and was deposited from the bottom of the glacier.

[02:18] Okay so I'm just going to zoom in on the top here. So we can get just a bit better look at those different types of till.

[02:32] *Word on screen: Now for a close up*

Here we're looking at the lodgment till and we can see particles from boulder size all the way down to fines. As we go up through this section um we can see towards the top fewer fine particles, but we still have a mix of particle sizes and what looks like it might be some fluvial material at the very top.

[03:01] *Words on screen: Once again, slightly less wobbly*

Stop 6 Glacial Lake Penticton from the KVR

[00:05] We've come up the KVR today to take a look at some of the remains of Glacial Lake Penticton. Not the beautiful lake that we see over here on my right I'll show you in just a moment, but the lake that existed when there was a giant ice dam further to our south at McIntyre Bluff. So, the dam at McIntyre Bluff actually caused Glacial Lake Penticton to flow north the complete opposite direction to the way that the Okanagan River flows today. Back in this time the lake drained into the Shuswap River approximately near Enderby. Now when was this? So Glacial Lake Penticton existed between about thirteen thousand and ten thousand years ago. At its maximum the surface of Glacial Lake Penticton was approximately 100 meters higher than the current surface level and that explains why I can stand above today's lake level and show you remains of what was deposited on the base of Glacial Lake Penticton.

[01:07] So the sediments that we see here were deposited on the bottom of Glacial Lake Penticton. Today we see them as silt cliffs on either side of Okanagan Lake. The really interesting thing about the silt cliffs on either side of Okanagan Lake is that this layering that we find um, the varves, doesn't actually match up on both sides of the lake; and what that tells us or has led to is this hypothesis that Glacial Lake Penticton actually had an ice core at its center. So back to our varves, like all varves we see this layering in the system. So, we have layers of very fine sediment that were deposited during winter when flow conditions were um slow to stopped, and then we have these thinner the coarser layers which were deposited it deposited in summer. Now these silt cliffs were um oh sorry are primarily made up of silt and fine sand there's very little clay present. Also, it's important to note that this um apparent rock isn't rock, it was never lithified. It has never been subjected to enough pressure to turn it into rock and so the cliffs, although they look stable, they are not and that has led to a number of slope stability issues.

[02:37] So these slope stability issues have happened or continue to happen at a number of different scales. Here we have a really small slope failure, but back in 1949 about 300 meters that way up the KVR, in the middle of the night, the train actually had to divert and plunge off the cliff down towards the lake because of a landslide. Now luckily nobody was hurt, but it does really emphasize the lack of stability we have in these silt cliffs.

[03:10] As many of you are probably aware, the Okanagan and especially Naramata Bench, which is what we're on here, is a really prime wine growing region and part of the reason for that is this silt material. It's really um great at holding onto water and nutrients, so makes it really um great for agriculture. However, it's also really susceptible to being over irrigated. So, the producers on the bench have to find that balance between putting enough water into their soil to help the vines grow and making sure they don't over irrigate and lead to slope failure.

[03:46] So let's finish off this stop with a bit of a view out over the location where we are. So this trail that you see here is what used to be the KVR, bring it around to um Okanagan Lake you'll spy Giant's Head in the background, which you've already visited, and then over on the other side see those silt cliffs on the other side and remember in between when this was Glacial Lake Penticton there was a giant ice core.

Stop 7 Weathering

[00:08] So here we are at the top of Carmi, um also called the Garnet Trails Interpretive Site, so there's a bunch of stops that talk about um the wildfires of 1993.

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[00:23] Words on screen: *The power of vegetation*

What we can see here is a tree growing out of the rock and it's actually displacing chunks of rock; and has lifted them up from a relatively flat position to quite an inclined position. Quite a large tree it's probably the order of 60 to 100 years old and so over time it's managed to displace these chunks of rock. So, what kind of weathering is this an example of?

[01:02] Words on screen: *The power of water freezing and thawing*

So, we're up again above Ellis Creek Canyon just outside of Penticton and we're going to look at another type of weathering today. Here we have some frost shattering or frost weathering. So, we have this um metamorphic bedrock it's very hard um but when we get water down into the cracks and we naturally get some cracks and fractures associated with the foliation of these rocks. Water can infiltrate into these cracks and we know that when water freezes it increases in volume by about nine percent and so over hundreds or thousands of years freezing and thawing of water has expanded these cracks and broken these rocks apart.

[01:57] Words on screen: *The power of water + vegetation + time*

Here we have another example of a frost shattered rock. Um so we've got a bit of a boulder probably a glacial erratic though the rock wasn't moved very far because it's similar bedrock to what we see here. And we can see down in the crack in between lots of organic material has accumulated over time we've got strong surface coverage of lichens. Um so again chemically breaking down the rock um and then if we get vegetation growing in this crack, in this organic derived soil we could see trees growing up potentially and forcing those rocks apart

Stop 8 Summerland Rock Slide 2019

Castanet Video: Slope still moving

[Music] *Casnet News Brief*

[00:05] *Dwayne Tennant (UBC Professor):* It's a constant um battle and threat to our highways in this province.

[00:12] *Alanna Kelly (Reporter):* UBC Okanagan engineering professor Dwayne Tennant says there's a potential for four times the amount of the rock that we've already seen come down still to fall.

[00:22] *Dwayne:* This size and maybe including down here as well. So, a much larger piece of our slope could be under motion right now.

[00:32] *Alanna:* About four thousand cubic meters of debris and boulders came crashing onto highway 97 on Saturday. Since then a new crack has been discovered spanning 50 meters on each side.

[00:44] *Dwayne:* So, this area has already fallen out, but these geological structures continue along the whole rock faces, upper ones, there's multiple essentially small faults. We could have 20 maybe 25 thousand cubic meters of rock that's moving. The people that are surveying that and monitoring the movement will be able to fine-tune that estimate.

[01:09] *Tom Kneale (Ministry of Transportation and Highways):* We're in the process right now of trying to determine the boundaries of the failure and this is you know every day we're seem to be faced with new movement and in different locations. We don't know exactly how large this thing is, but we're monitoring it and every day that we get information we're getting a better handle on the extent of it.

[01:25] *Dwayne:* They'll have to determine how much of that rock has to be removed to stabilize the slope. Not necessarily all of it'll have to be removed and your kind of hoping that we don't chase the mountain. So that when we remove a little bit of material it doesn't trigger yet another one higher up the slope and yet another higher one up the slope.

[01:40] *Alanna:* In the past in this same stretch of area there have been three other rock slides and crews will need to determine just how quickly this rock is moving.

[01:49] *Dwayne:* If it moves slowly there's less of a risk, but if it moves like we saw on that spectacular video imagery from Saturday that is, you know, we don't want to have people with anywhere near there.

[02:00] *Tom Kneale:* The monitoring equipment we have right now is survey hubs that are located on the slope so we can identify movement you know upwards of I think it's two millimeters or so.

[02:09] *Alanna:* Highway 97 remains closed with no estimated time of reopening for castanet news I'm Alanna Kelly in Kelowna

[02:17] [Music]

Stop 9 Why Penticton Is Located Where It Is

** Italics denote words on screen*

[00:06] So we're up um above Ellis Creek Canyon just to the east of Penticton and we can look down on the city of Penticton and we can see um a little bit about how Penticton itself formed. So, Penticton is formed where three different um alluvial systems flowed together into the valley at a fairly narrow point after um the ice melted and so we can see over here is Shingle Creek coming in from the west. Down here we have Ellis Creek and over here we have Penticton Creek. And so post glacially there would have been all sorts of um available sediment up in the hills and mountains around Penticton. And the streams and rivers, these three streams, brought that material down into the valley bottom and basically blocked the valley off separating what is now Okanagan Lake to the north over here and Skaha Lake which we can't see but would be to the left or south.

[01:20] *Which is the technical name of the landform on which Penticton is built?*

[01:22] *Sediment was supplied by three creeks and deposited...?*

[01:24] It originally was deposited into water and so this feature that Penticton sits on is called a fan delta. An alluvial fan because we have the sediment settling out as it exits steep mountain valleys and a delta because it's being deposited in water. So, a fan delta. Because we have these three rivers all coming down towards the same place Penticton was created.

Stop 10 Penticton Dam & The Channel

**italics denote text on screen*

[00:04] From our noisy vantage point here at the dam at the bottom of Okanagan Lake, we're gonna have a look at a few of the hydrology features that we find. So, looking up at the mountains the ridges that we see they form the drainage divide between each of the smaller or the nested catchments that corral the water into flowing down towards Okanagan Lake. So here, for this area, for this larger drainage basin, Okanagan Lake forms for local base levels. Now, Okanagan lake is a natural feature, but it also has a man-made control structure. So, Okanagan Lake yes, it's natural lake, it's also a reservoir. So, the dam here is holding up the water level and allowing it um the one level in the lake to be controlled to suit the needs of downstream users. So, in some ways it's a flood control structure with all of the associated benefits and issues that we discussed. One of the main issues with the dam and with all the dams down the Okanagan River is that they get in the way of the salmon migration. Now we remember that the Okanagan River used to flow slightly differently, but for the purposes of maintaining the channel in a place that reduced flooding for the town of Penticton, it was channelized back in the 50s. Here we are looking down the channel slightly upstream from where it started flowing.

[01:59] There really is quite a striking difference between the flow path of the historical Okanagan River before channelization, which is on the left and after channelization, which we see here on the right. The image on the left is from Penticton Archives and it shows the Penticton [Okanagan] River as it once was meandering across its floodplain. The image on the right from google earth shows us the channelized way that the Penticton [Okanagan] River passes through Penticton today. So channelized in fact, so contained that most people that live in Penticton aren't even aware that it is a river and simply refer to it as a channel.

[02:42] This pattern continues as we travel north along the Okanagan River, or the channel as it is commonly known today, towards the place that we started this stop on our field tour at the dam at the outlet to Okanagan Lake. The river is contained very much within concrete structures. However, we can still see this evidence of the historical path of the river in the form of oxbows, three of which are pointed out here with white arrows. Oxbows are created when meander bends are cut off from the river either naturally or through artificial processes such as in this case. Now this is a story that is common throughout the Okanagan River system. In fact, approximately 50 percent of the length of the river has been lost in the last 100 years.

[03:41] *The loss in stream length led to*

[03:45] *loss of river-floodplain connection*

[03:48] *loss of riparian vegetation and instream diversity*

[03:50] *significant declines in native species*

[03:54] *and thriving exotic species*

There are currently some restoration initiatives underway to work at returning at least some portions of the river back towards its historical nature.

[04:08] Let's finish off this field stop by looking back at the comparison of the historical flow path of the Okanagan River to what we have today. We're looking here again down towards the south where the channel, or Okanagan River, drains into Skaha Lake. Looking at the image on the left we can see that even before channelization there are a number of features, floodplain features apparent around the Okanagan River.

[04:38] Here we have a natural oxbow.

[04:42] Here a group of meander scars. Now, let's have a look at a comparison and see what happened over time.

[04:49] This section, this white arrow here shows us the creation of an oxbow out of a portion of the historical river by the creation of the channel and the change of a historical oxbow into a meander scar. The real beauty of fluvial systems is that they are constantly evolving landscapes. So, what does the future hold for the Okanagan River as it passes through Penticton? Well, only time will tell, but perhaps we can hope for a return to a slightly more meandering stream. With a little more aquatic habitat so that some native species can return and thrive as they once did. While at the same time maintaining a sense of safety for the community of Penticton.

Stop 11 White Lake Formation

[00:04] Fluvial processes as an agent of geomorphic change are not a new thing here in the Okanagan Valley. In fact, the White Lake Formation located behind me gives us a window back into the Eocene, a time when the climate was warmer and wetter and large paleo river systems flowed over the landscape.

[00:26] The history of this paleo river system is recorded for us today in the bedrock of the White Lake Formation. So, this coarse material here this coarse sandstone, it was deposited when the river had a lot of energy, so high energy braided fluvial system. Some of the sediments that it was depositing it had eroded from those recently formed volcanoes that were active in the area during this Eocene period. Next up we have these finer sandstones to siltstones that were deposited when the river was flowing with much less energy, so more slowly. Some of them in fact um are considered to be over bank deposits.

[01:06] Thirdly, we have this carbonaceous siltstone that was deposited in floodplain marshes or wetlands where the flow was very slow to still, and so a lot of the plant material was able to decompose and form the low-grade coal that we have today. Now you can see looking across the formation that these fluvial processes, these changes, occurred repeatedly during the history um that led to the formation of this rock.

[01:38] So how do we know that it was a warmer wetter period in time? Well, one of the cool things about the White Lake Formation is that it contains a large number of plant fossils and it's from these fossils that scientists have been able to infer historical climate conditions.

[01:56] Analysis of Eocene plant fossil communities from nearby sites in southern BC, so around Princeton and also over the border in Washington state near Republic have been used to infer that the mean annual temperature during the Eocene when these paleo rivers were flowing was about six to seven degrees warmer than present, with the coldest monthly temperatures about seven to eight degrees warmer than the present. Really interestingly from a river point of view, the mean annual precipitation has been estimated to be about 11 000 millimeters a year. Compare that to the current amount of precipitation we get on average in Penticton these days at about 350 millimeters a year. So, the results indicate a microthermal mesothermal climate with low seasonal variation in temperatures. The plants that have led us to this understanding are plants that include ginkgo, metasequoia, alder, conifer needles and also palms.

[03:19] The White Lake Formation provides us with a great reminder that the major agents of geomorphic change in our landscape themselves change over time. So back in the Eocene it was volcanic activity and giant paleo rivers. Then in the Pleistocene through came the glaciers reworking the landscape. Today, what do you think the major agents for geomorphic change are?

Stop 12 Wrap Up

[00:04] We're going to wrap up our field trip today by looking at the major events that led to the opening up of the Okanagan Valley and then the filling in, the deposition of sediment since the Pleistocene. The cross section that we're looking at is located just to the north of Penticton and in this area the Okanagan Valley fault is located essentially straight through the middle of the center of the valley through the center of Okanagan Lake.

[00:34] So when the fault activated the end of the Oligocene, the Okanagan Metamorphic Complex, located to the east, lifted up, lifted up to the east. In doing so, it pushed the volcanics in the sedimentary formations that were sitting on top of it off to the west. Vancouver is located behind me in this image. During this process of sliding off, some volcanic formations were left stranded on the east side of the lake, one of which you recall is Munson Mountain.

[01:11] During the Pleistocene this region was subjected to a series of glacials and interglacials. During the glacial periods, glaciers flowed from north to south, so out of the page towards you. As they moved south through the valley, they carved out the rock that was there to create the traditional U-shaped glacial valleys we see at so many different scales.

[02:02] As the glaciers receded sediments were deposited. The lowest sediments are ancient Pleistocene deposits. These sit over the bedrock the bottom of the Okanagan Valley. About 20 000 years ago during the Fraser Glaciation, tills were deposited on top of these ancient Pleistocene deposits. Here in the south Okanagan, the next major event was Glacial Lake Penticton.

[02:48] Glacial Lake Penticton deposited the silt cliffs that we visited, with different varves on each side of the lake because of the ice core in the center. Note that the water levels were much higher than they are today. With the melting of the glaciers and this water drained away the hydrology changed, and the lake level lowered towards the level that we see it today. During this process, alluvial gravels were deposited on the base of Okanagan Lake and also in some places up on top of the silt cliffs.

[04:11] So there we have it. The major events that led to the formation of the Okanagan Valley, as we see it today.

[04:20] Thanks everyone for joining us on this virtual trip through the south Okanagan we hope you've learned a lot about the fascinating landscape and how it was formed. We also hope that it's inspired you to get out and take a closer look at the landscape around you, wherever you are.