GEOTOUR GUIDE

FOR THE WEST KOOTENAY, BRITISH COLUMBIA

GEOLOGY, LANDSCAPES, MINES, GHOST TOWNS, CAVES, AND HOT SPRINGS

Figure 1. *Slocan Lake, the lakeside village of New Denver (Site 11), and the Valhalla Range from the Idaho Peak viewpoint (Site 10).*

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CHAMBER OF MINES of Eastern British Columbia

BRITISH COLUMBIA | Ministry of Energy, Mines and Petroleum Resources

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GEOTOUR WEST KOOTENAY SITES

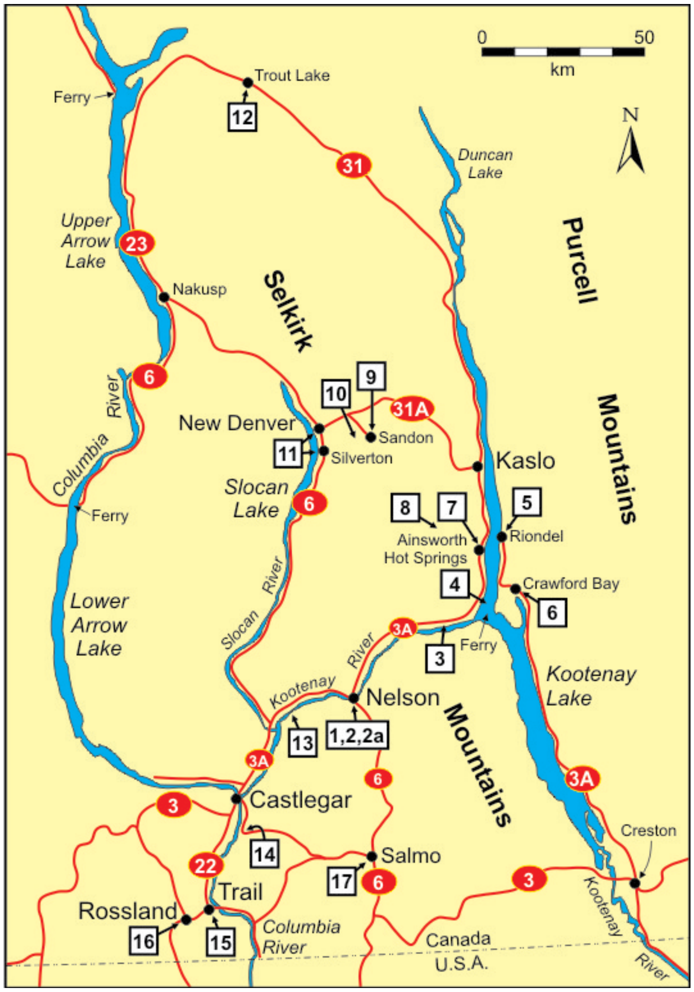


Figure 2. A map of the West Kootenay area showing the location of GeoTour sites in this guide.

1. **Historic downtown Nelson –** rich mining heritage.

2. **Gyro Park viewpoint of Nelson –** Nelson's big picture and rock foundations.

2a. **Pulpit Rock viewpoint of Nelson –** Nelson's really big picture.

3. **Kokanee Creek Provincial Park –** where mountain stream meets lake.

4. **Kootenay Lake ferry –** why is there a big lake here? And a tectonic suture line.

5. **Riondel –** a famous former silver mine with gushing hot waters.

6. **Crawford Bay dolomite mine –** a good neighbour mine ... and another limestone story.

7. **Ainsworth Hot Springs–** deep Earth heat and plumbing.

8. **Cody Caves Provincial Park –** dissolving limestone and subterranean worlds.

9. **Sandon ghost town –** billion dollar boomtown and the Silvery Slocan silver rush.

10. **Idaho Peak Lookout –** a stunning view of lake and mountain.

11. **New Denver-Silverton –** twin towns, silver mining heritage, and beach geology.

12. **MAX molybdenum mine, Trout Lake –** a brand new mine.

13. **Kootenay River hydropower –** powering the Kootenays because of an ancient diversion.

14. **Castlegar Lookout –** a terrace town on a giant river.

15. **Trail smelter viewpoint and interpretive centre –** industrial giant and story of environmental recovery.

16. **Le Roi gold mine, Rossland –** going underground into a historic mine.

17. **Downtown Salmo –** stone murals of 540 million year old rock.

WEST KOOTENAY – BEAUTIFUL, DIVERSE, AND CURIOUS

Figure 3. *A collage of West Kootenay landscapes: (Top) Kootenay Lake viewed from the Balfour-Kootenay Bay ferry; (Middle left) the high peaks of Kokanee Glacier Park; (Middle right) Nelson's famous heritage stone buildings; and (Bottom) the Columbia River valley near Trail.*

The West Kootenay region is a land of contrasts: the rolling pastures of the Slocan Valley and rich floodplain farms near Creston; the big Kootenay, Slocan, and Arrow lakes; the heritage downtowns of Nelson and Kaslo; the high glacier peaks of the Selkirk and Purcell Mountains; and the industrial landscape of Trail.

To the curious mind, the West Kootenay is a landscape full of questions. Why is the West Kootenay region so mountainous? Why do most of the valleys run north-south? Why are the major lakes long and skinny? Why do the Columbia and Kootenay rivers follow such convoluted routes. Why are there hot springs? What source of wealth financed the fine heritage buildings in Nelson, Trail, Rossland, and Kaslo?

This guide helps us explore these questions and others. Is there logic to the landscape? Let's go take a look!

First, Let's Talk Geology

Geological Materials *What are they?*

The geological materials that underlie the West Kootenay, as well as all of British Columbia, fall into three basic types (*Figure 4*).

1. Rocks of the Earth's crust lie below the entire West Kootenay and are commonly exposed at the surface in the peaks of the Selkirk and Purcell mountains, in rocky cliffs at lower elevations, and in river canyons such as along the Kootenay River near Brilliant.
2. Ice Age sediments deposited over the last 2 million years form a widespread blanket that covers much of the underlying rock. This blanket is often thin on mountain slopes and thickest in valleys.
3. In the 10,000 years since the end of the last Ice Age, rivers have eroded Ice Age sediments in the valleys and deposited sand and gravel as river plains or deltas along rivers and in lakes.

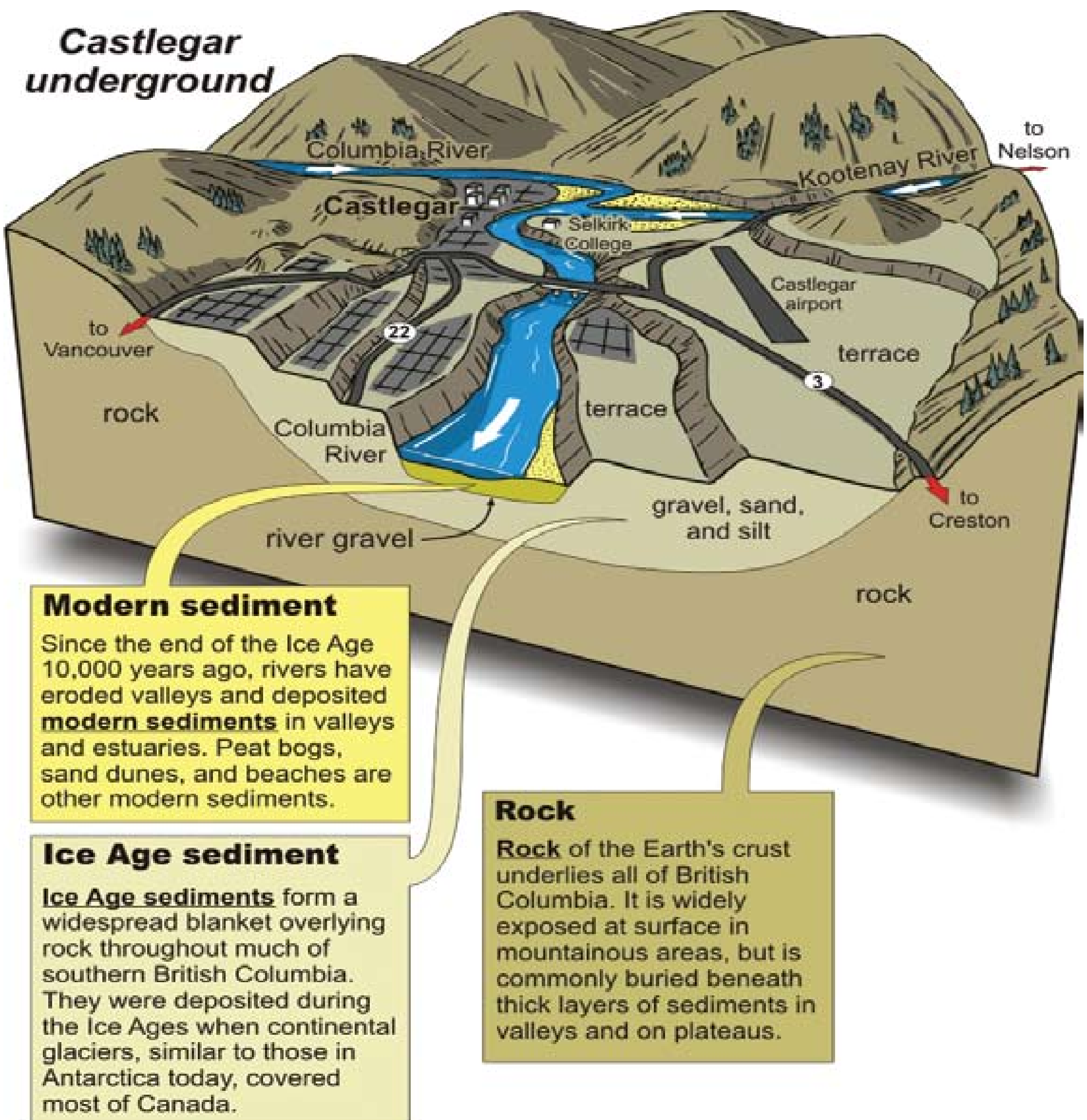


Figure 4. *This geologist's cut-away diagram illustrates the distribution of the three main geological materials that comprise the landscape in the Castlegar area. The distribution of these materials throughout the West Kootenay region is presented on the map in Figure 5. On the map, the category of rock is further divided into major rock types.*

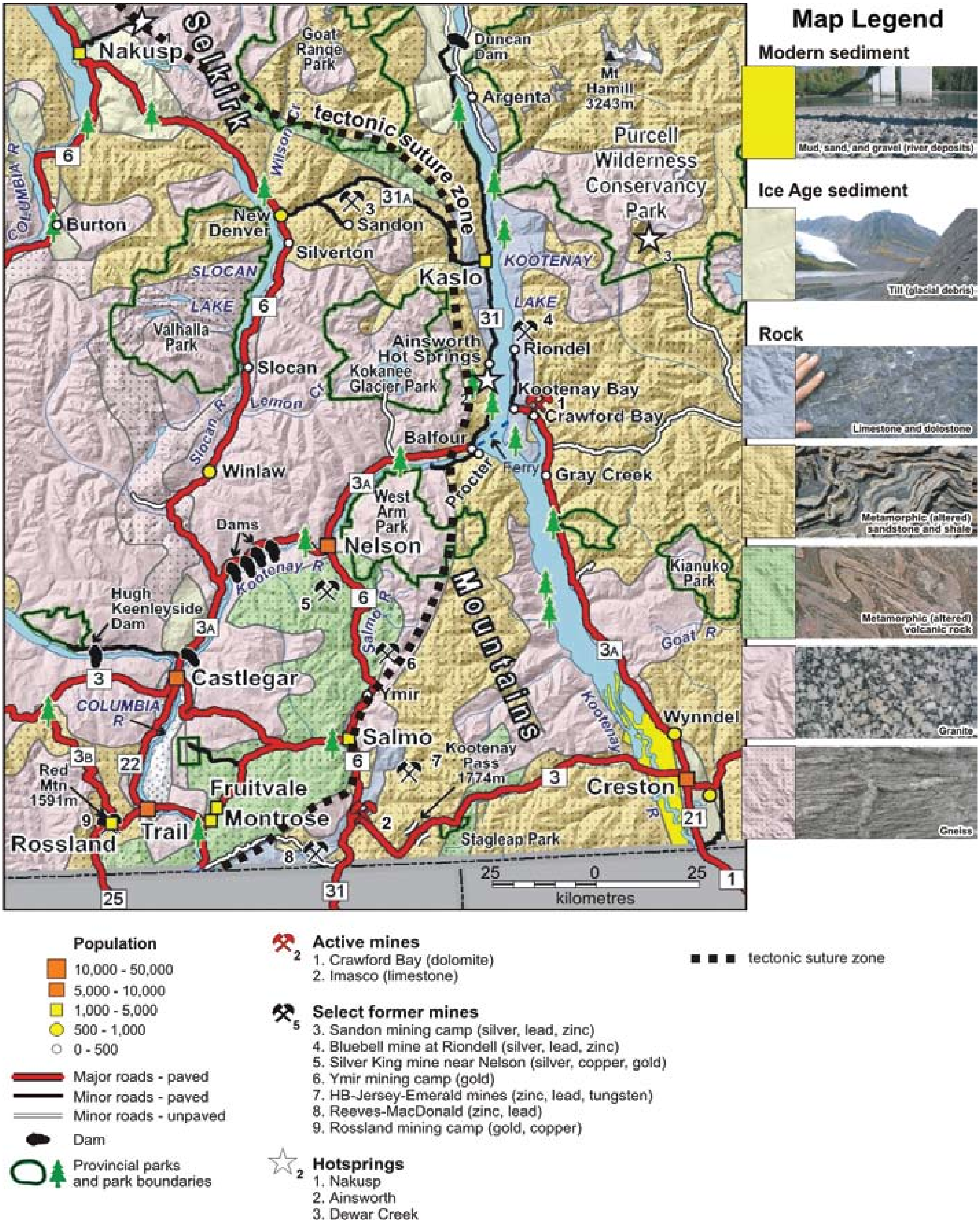


Figure 5. *This geological map of the West Kootenay region displays the distribution of geological materials that has been determined by geologists. Note that metamorphosed or altered sandstone and shale (stippled gold) underlie much of the eastern and northern areas, while granite (pink) and volcanic rock (green) are dominant to the west. These two domains, in the east and west, represent ancient North America and ancient Pacific Islands respectively, now welded together along a tectonic suture.*

How did all these geological materials form?
A quick tour through geologic time

How old is the West Kootenay? There are several ways that question might be answered. We know that European settlement of the West Kootenay goes back to the mid 1800s. First Nations settlement in the region is much older and goes back thousands of years. The land however is much, much older. We're talking deep time; a span of time that challenges our comprehension and that contains a quite fantastic history. What follows is a brief summary of that geological history of the West Kootenay, pieced together by the work of geologists over the past century.

The region is carved from a mosaic of diverse geological materials; a patchwork quilt presented on the geological map of Figure 5. The clock in Figure 6 reminds us that each material in this mosaic has a unique age and story that ranges across more than 500 million years of time.

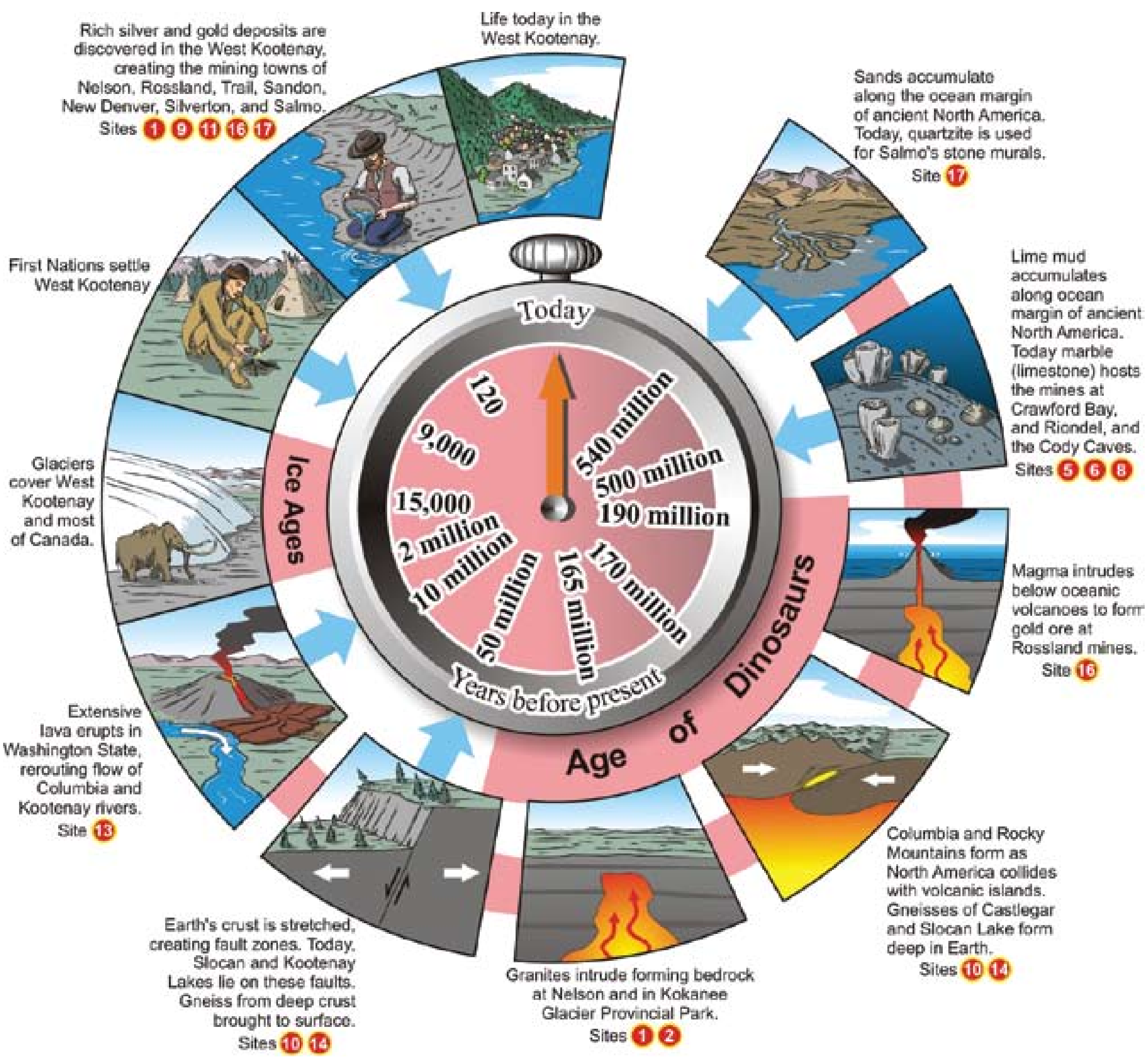
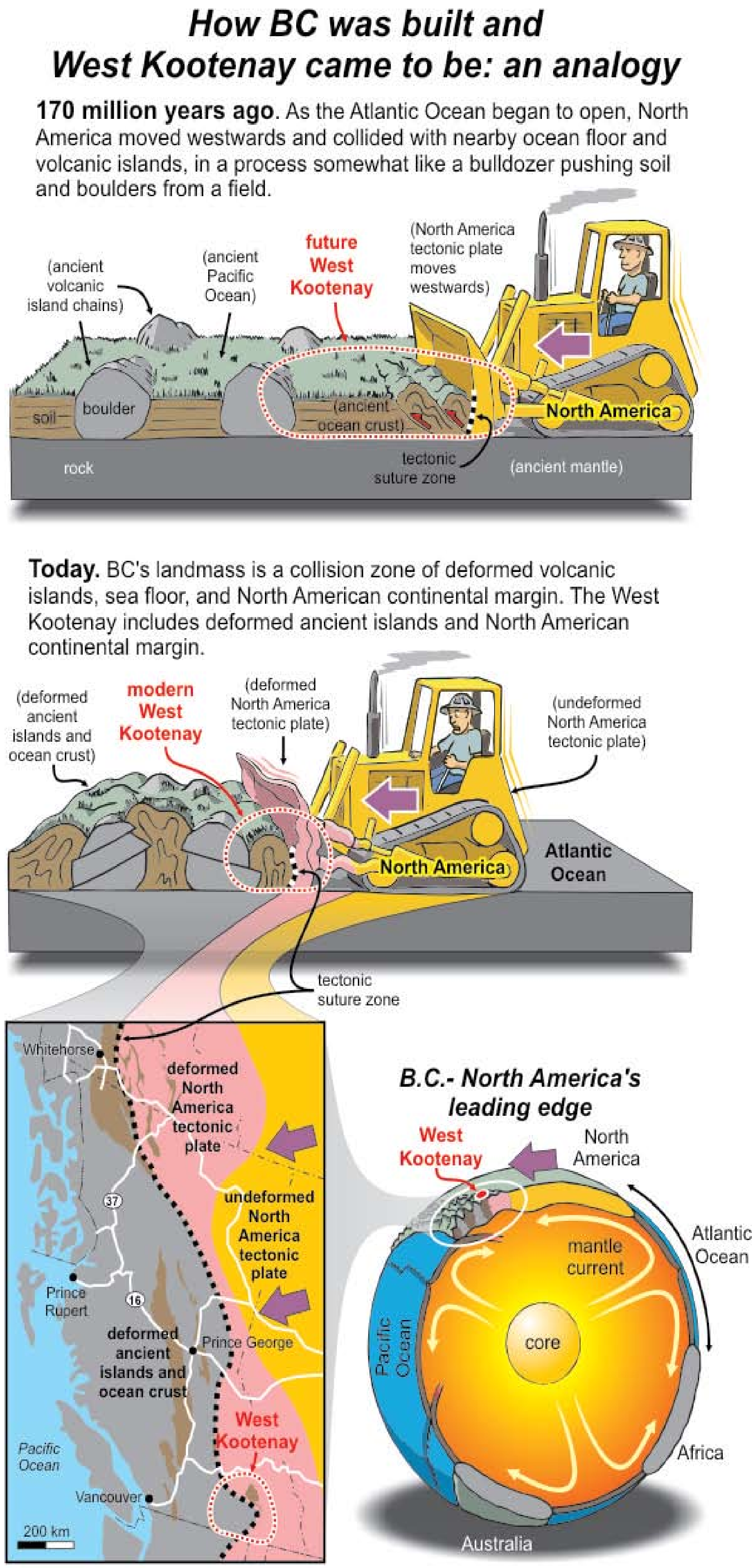


Figure 6. The geological history of the West Kootenay region is presented as a clock. Each geological material, along with the fossils or radioactive elements that it contains, records a period in geological time. Much ancient history has been destroyed by erosion of the geological materials over geological time, leaving many gaps in this history. Note that for ease of display, equal divisions of the clock face represent highly unequal periods of time.



The West Kootenay straddles a great tectonic suture that runs along the west side of Kootenay Lake and down to the Salmo River valley (Figure 5). This suture divides rock masses that formed far from each other but were brought together in a great collision that built the mountains of the West Kootenay. To the east are sedimentary rocks that were deposited as mud, sand, and limestone along the shores of ancient North America. To the west are volcanic rocks, mudstone, sandstone and granite that formed as islands in the Pacific Ocean. These rocks were welded together in a titanic collision 170 million years ago.

First, let's consider the ocean sediments deposited off the shores of ancient North America. The high peaks of the Purcell Mountains east of Kootenay Lake are carved from sandstone as old as 1.5 billion years old, the oldest sedimentary rock in BC. A younger belt of limestone, sandstone, and shale extends along Kootenay Lake and the Salmo River valley and ranges from 700 to 300 million years old. The Cody Caves, the Ainsworth hot springs, the mines at Crawford Bay, Riondel, and Trout Lake (Max) all occur within these rocks **(Sites 4, 5, 6, 7, and 8)**. The stone blocks in the Nelson courthouse and Salmo stone murals **(Sites 1 and 17)** were quarried from these same ancient sediments.

Further west and across the ancient suture is a discontinuous belt of mudstone, volcanic rock, and granite that forms the Selkirk Mountains from Nakusp to New Denver and Sandon **(Sites 9 and 10)**, and south to Nelson **(Site 2)** and Rossland **(Site 16)**. Streams erode these mountain rocks and carry gravel to lake shore beaches at Kokanee Creek Provincial Park, New Denver, and Silverton **(Sites 3 and 11)**. These rocks were once sea floor mud or volcanic islands in the ancestral Pacific Ocean that collided with the western edge of North America 170 million years (Figure 7). This collision welded these rocks to North America, adding landmass and causing North America's coastline to jump westwards. The collision caused mountains to rise as the rock was deformed into folds (Figure 8) and broken by faults.

Figure 7. *Let's use an analogy to understand how the Earth's tectonic forces created the West Kootenay and British Columbia. The West Kootenay straddles the suture between oceanic volcanic islands and ancient North America that came together in a titanic collision 170 million years ago. Imagine a tractor plowing a stony field. The tractor represents sandstone, mudstone, and limestone on the ancient continent of North America, the soil ahead of the tractor represents mudstone and limestone on the ancient ocean floor, and boulders in the field represent ancient volcanic islands. As the tractor moves forward, its blade pushes together soil and boulders, deforming the soil and breaking the boulders. The tractor blade, representing the edge of North America, is also damaged.*

For millions of years erosion carved the mountains. Then fifty million years ago, the land pulled apart along great sloping faults, raising rock from 30 km depth or more. This once partly melted rock (gneiss), reminiscent of Canadian Shield rock far to the east and north, is exposed today in the Valhalla Range and the shores of Slocan and Arrow Lakes, and above Castlegar. Rivers selectively eroded the fault zones of crushed rock, creating long trough-like valleys. During the Ice Age (Figure 9), glacier ice further carved and deepened these valleys, rounding the tops of hills and low mountains throughout the Kootenays. As the glaciers melted, lakes formed where plugs of glacier ice and sometimes glacial debris dammed the valleys. Plants and animals re-colonized the land as the glaciers melted, and First Nations peoples followed, hunting game, foraging plants, and fishing for salmon. Euro-Canadian settlers came later, first as fur traders and prospectors, and later as miners, farmers, and business people, building the villages and towns of the West Kootenay.

Figure 8. *Folds in sedimentary layers in rock outcrop near the west end of the bridge across the Kootenay River at Taghum west of Nelson reflect the great tectonic forces at play during a great tectonic collision 170 million years ago.*

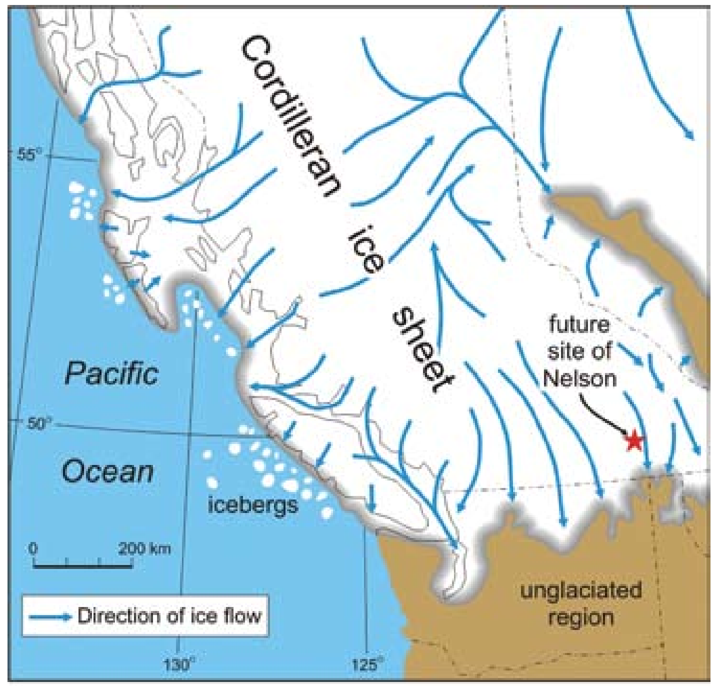


Figure 9. *At the peak of the last ice advance 15,000 years ago, almost all of British Columbia was covered by a great ice sheet similar to that of Greenland today. The valleys of the west Kootenay region lay below two or more kilometers of south-flowing glacier ice. Only the highest peaks poked above this vast ice cover.*

LET'S START THE GEOTOUR OF THE WEST KOOTENAY

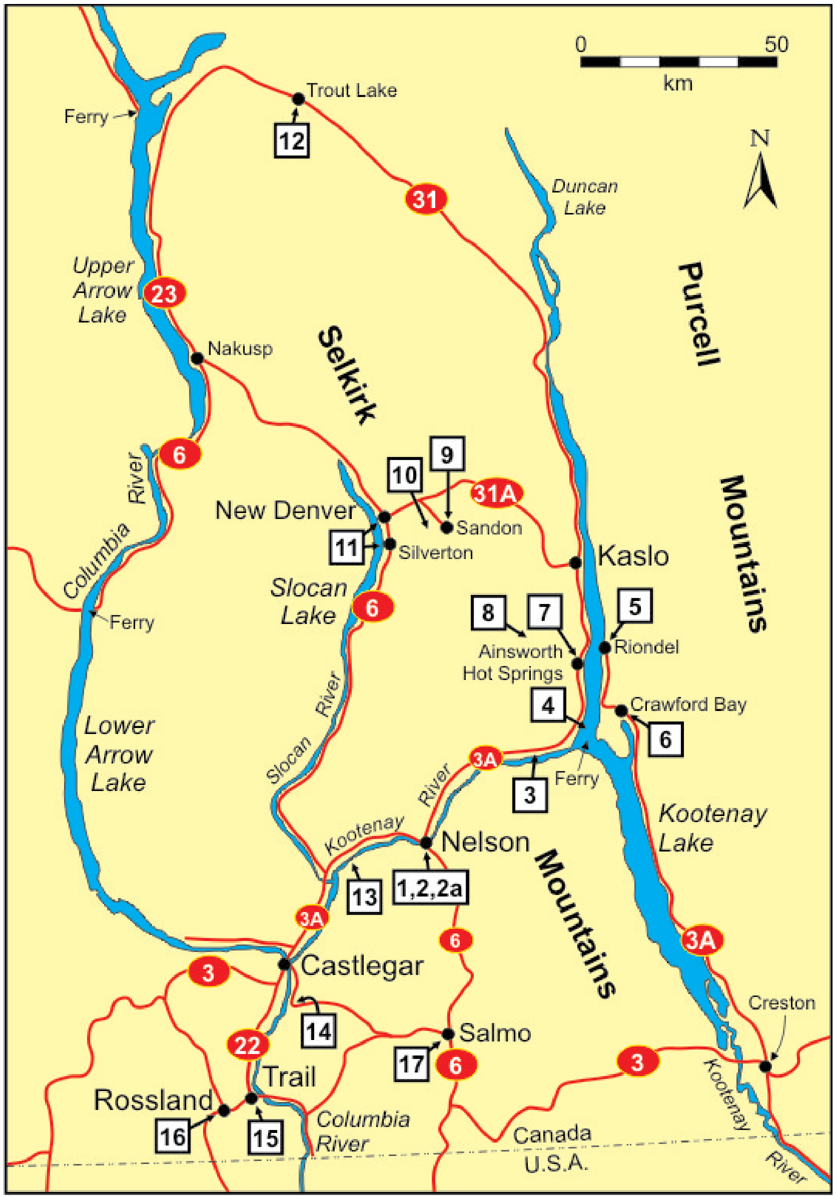


Figure 10. A map of the West Kootenay showing the location of GeoTour sites in this guide.

In this guide we explore the geological landscapes of the West Kootenay from Trout Lake in the north to Trail in the south, and from Slocan Lake on the west to Kootenay Lake on the east. The order of the 17 sites is somewhat arbitrary, but the tour starts in Nelson and travels north, then returns to Nelson and travels south. Each site is easily accessible by car, though travel along forestry gravel roads is required for sites 8, 10, and 12.

The GeoTour starts with a walk downtown (Site 1) and view (Sites 2 and 2a) of Nelson, a vital centre of the west Kootenay. Driving north along Highway 3A, we stop at a mountain stream and lakeside beach where kokanee salmon spawn (Site 3) and then take the ferry ride to the east side of Kootenay Lake (Site 4). There we visit a former lake-side mine at Riondel (Site 5), and an active mine at Crawford Bay (Site 6). Returning to the west side of the lake, we head north on Highway 31 to the hot spring at Ainsworth (Site 7), and a limestone cave high on a mountain side (Site 8). The next stop is past Kaslo at the ghost town of Sandon (Site 9), and a nearby lookout with a stunning view over the Selkirk Mountains and Slocan Lake (Site 10). The last stops on the northern leg are the historic lakeside towns of New Denver and Silverton (Site 11) and the metal mine near Trout Lake (Site 12).

The southern leg of the tour starts from Nelson and heads south on Highway 3A along the Kootenay River past hydroelectric dams and power plants (Site 13) to a lookout high above Castlegar and the Columbia River valley (Site 14). Heading south from Castlegar on Highway 22, we visit the giant industrial smelter complex at Trail (Site 15) and then up the hill to Rossland and an underground tour of a former gold mine (Site 16). From there we head east to Salmo and its stone murals (Site 17), our final stop.

(Site 1) HISTORIC DOWNTOWN NELSON :
RICH MINING HERITAGE

A walk around downtown Nelson can be a geological tour if you know how and where to look. The Chamber of Mines office is a hub for the local mineral exploration community, and a place you just might bump into a prospector. Nelson's heritage buildings are a reminder of the wealth that was created by the early silver mines. The stone used in these buildings comes from local quarries that tell us about Kootenay geology. And the Touchstone Museum has excellent displays about early Nelson, and the nearby mines that built Nelson.

Chamber of Mines of Eastern British Columbia office

Start your walking tour at the Tourist Information office on Hall Street where you can pick up a copy of the excellent pamphlet "Architectural heritage walking tour guide" for Nelson's downtown area. Next door at 215 Hall Street is the office of the Chamber of Mines of Eastern British Columbia. Step inside and take a look at the extensive collection of ore samples from the many historic mines of the West Kootenay. The library of technical books reflects the work of government agencies such as the BC Department of Mines and the Geological Survey of Canada over the past 130 years to record mine production, and describe and interpret the mines and geology of the Kootenays. Take a look at the 1890's vintage map of the West Kootenay that shows the locations of towns, mines, and railways – it was a busy place even then.

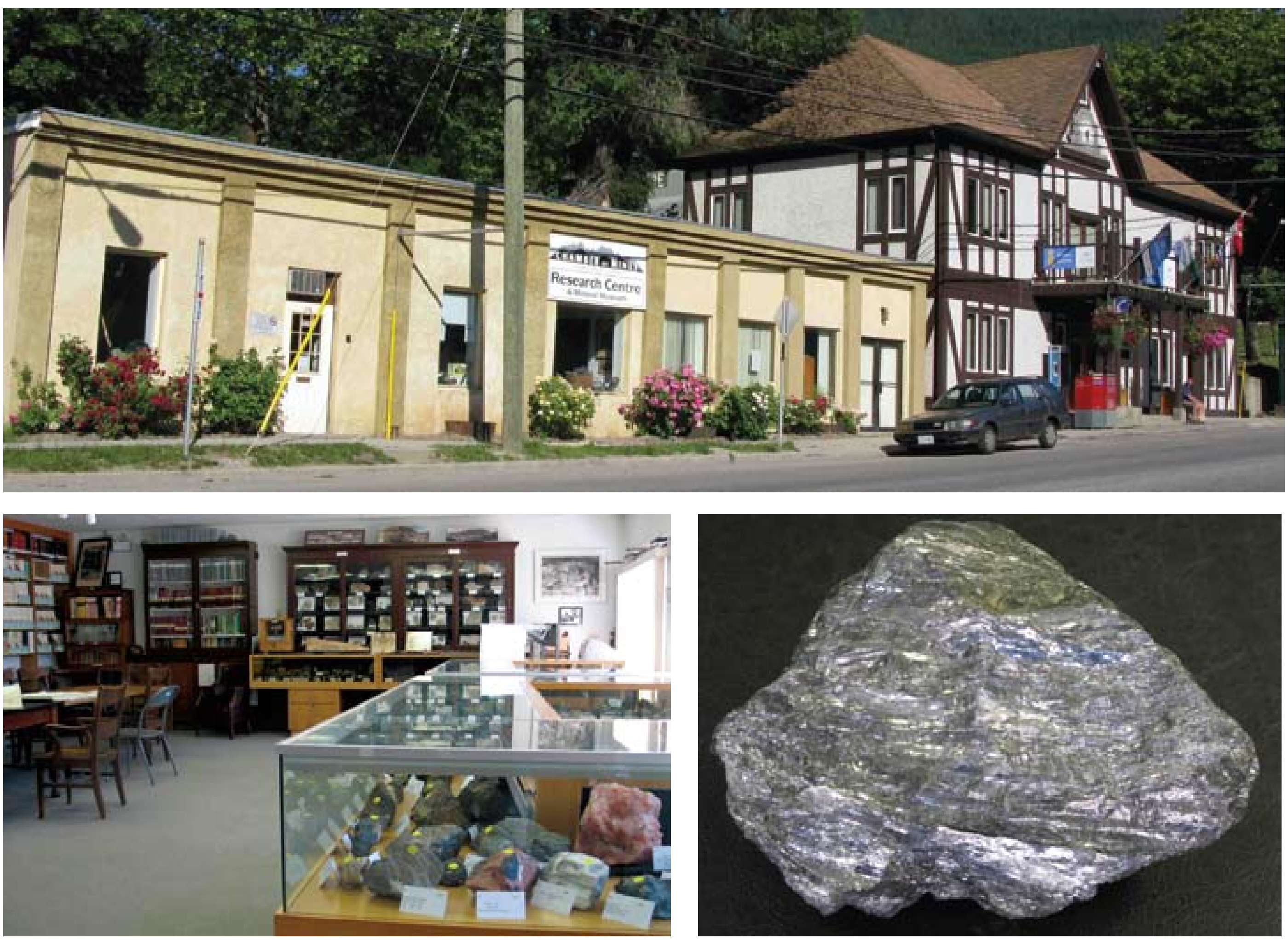


Figure 11. (Top) *The Chamber of Mines building (tan colour) is adjacent to the Chamber of Commerce Tourist Office on Hall Street.*
(Bottom, left) *The Chamber office contains a display of rocks and minerals, including silver-rich ore from local mines that made the region a famous silver-producer before World War I.* ***(Bottom, right)*** *Silver ores are heavy as they are commonly associated with the lead-bearing mineral galena.*

A photograph on the wall of the Chamber office notes that in the 1920s, 80% of the entire mineral wealth of British Columbia came from southeastern BC. The Chamber offices remain an important meeting place for the local mineral exploration community as mining and mineral exploration are active today in the region (e.g. Sites 6 and 12). Ask to see the specimens of gold and the Chamber's map of gold -bearing streams in the West Kootenay; you may be surprised by how many there are (e.g. Site 17).

*Figure 12. **(Top)** Post Office and Customs House building (Old City Hall) houses the Touchstone Museum. The stone in the lower story of the building is marble from a quarry near Kaslo. **(Bottom)** Museum displays feature the story of Nelson's early days, and its nearby mines.*

Touchstones Nelson Museum of Art and History

Head uphill and along Vernon Street to the Touchstones Nelson Museum of Art and History in the old Post Office and Customs House building (also known as the Old City Hall). The museum has excellent displays about local First Nations peoples, the history of mining near Nelson, and the early history of the Nelson community.

It was the Silver King mine that built Nelson and started the Slocan silver rush. The rich silver-copper-gold ores were discovered on Toad Mountain in 1886, and a nearby supply centre quickly developed on flats along Kootenay Lake created by Cottonwood Creek. Shops, outfitters, stables, and hotels sprung up on the slopes just above the lake. George Dawson of the Geological Survey of Canada visited in June of 1889 and remarked, "Nelson – a rough stumpy piece of ground named by courtesy a flat." Nelson grew over the 20 year life of the Silver King mine, with ore from the mine processed at a smelter in the upper part of town. The building of two railroads made Nelson a transportation hub for lake steamers that served the rich silver mining camps around Kootenay Lake (e.g. Site 5). The wealth of these mines flowed through Nelson and created the rich legacy of heritage buildings that we see today. Demand for power from the mines and city led to the development of the first electricity generating stations on the nearby Kootenay River.

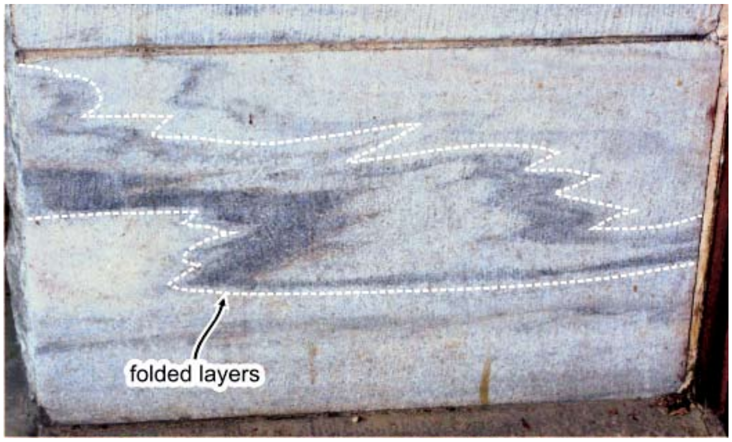


Figure 13. (Right) The Nelson Courthouse is built of marble blocks cut from a quarry north of Kaslo. White layers contain coarse grains of calcite up to 1 cm in diameter, while grey bands are finer grained. Marble is made of intergrown calcite grains that are strong yet easily cut by steel tools, and so are favoured as a building stone.
(Above) Blocks of marble adjacent to the front door, and windows above the door, display folds in the marble layers that formed deep in the Earth under conditions of intense heat and pressure during collision of ancient North America with oceanic islands (see also Site 4). Limestone is transformed to coarser-grained marble by heat and pressure

NELSON COURTHOUSE

Across the street from the museum is the Nelson Courthouse. Like the lower part of the museum building, it is built of blocks of pale-coloured local marble. Though marble has limited distribution in the bedrock of the West Kootenay, it has had a large influence on local life past and present. The marble hosts the important former silver mines at Riondel **(Site 5)**, a current dolomite mine at Crawford Bay **(Site 6)**, and the Cody Caves near Ainsworth **(Site 8)**.

CITY OF NELSON GAOL BUILDING

A number of heritage buildings in Nelson use local granite, often in combination with brick or marble. A few buildings are entirely built of granite blocks, such as the old City of Nelson Gaol building on Victoria Street. Granite is the dominant bedrock immediately around Nelson, and a quarry just east of Nelson provided much of this granite building stone. Granite bedrock forms cliffs along highway entrances to Nelson, the bluffs of Gyro Park and Pulpit Rock lookouts (Sites 2 and 2a), and the mountain slopes and the high peaks of Kokanee Glacier Provincial Park.

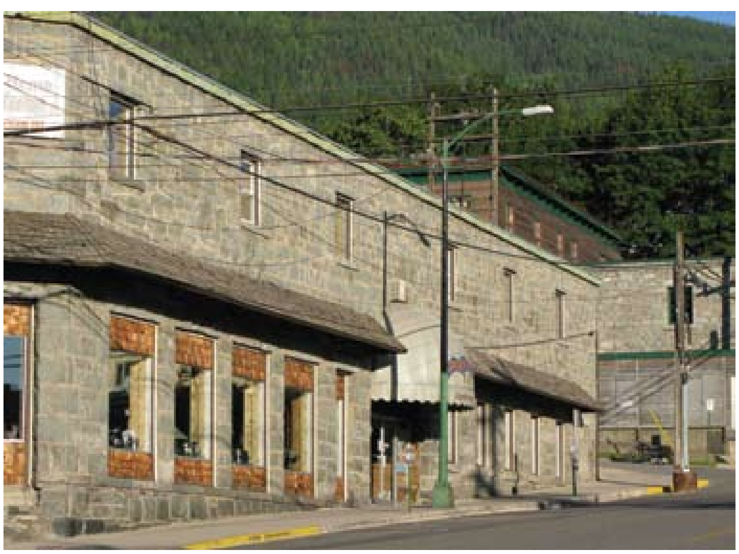


Figure 14. (Left) The City of Nelson Gaol building on Victoria Street is uphill from Baker Street. (Above) A close look at the granite reveals an intergrowth of black, grey, and white minerals. These minerals crystallized from a rock liquid deep in the earth. Later uplift and erosion exposed these rocks at the surface across the West Arm, where they were quarried.

(SITE 2) GYRO PARK VIEWPOINT OF NELSON: NELSON'S BIG PICTURE AND ROCK FOUNDATIONS

The lookout at Gyro Park has a panoramic view of Nelson and its surrounding geography. Rocks exposed at the lookout and nearby trails represent the two major rock types in the Nelson area: granite and volcanic rock. The highways to Castlegar and Salmo cut through granite cliffs on the edge of town, and granite forms the bluffs across the lake, and high peaks of the nearby Kokanee Glacier Provincial Park. Rich silver, copper, and gold ores were discovered within volcanic rocks on nearby Toad Mountain, leading to the founding of Nelson as a supply centre for the mines.

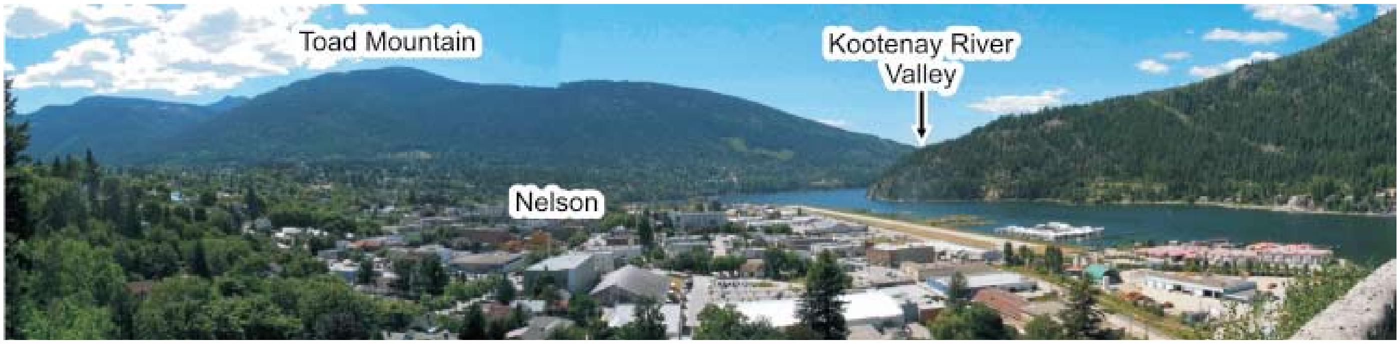


Figure 15. *The view from the lookout in Gyro Park across Nelson and the West Arm of Kootenay Lake. On the skyline from left to right are: Cottonwood Creek Valley, the highway and former railway route south to Salmo and the U.S.A; Toad Mountain, site of Silver King Mine that gave Nelson its start; the West Arm, the outlet for Kootenay Lake into the Kootenay River; and the granite ridge and bluffs across the lake, site of Pulpit Rock lookout (Site 2a). Nelson **(Site 1)** is built on sand and gravel deposits left by ancient streams flowing from the Cottonwood valley. Cottonwood Creek cut a ravine in these sediments and has deposited a flat of sand and gravel along the lake shore. Earth fill has been added to extend these flats into Kootenay Lake to accommodate airport and lakeshore development.*

Figure 16. *You can also look east along the West Arm of Kootenay Lake from the lookout in Gyro Park. Steep rock shorelines limit development on much of the west side of the lake. Fairview is located on the sloping surface of a fan-shaped deposit of sand and gravel deposited by Anderson Creek. The flat lands of Lakeside Park have been created by adding earth fill to shallow shoreline areas. The park is the site of a former smelter that processed ores from West Kootenay mines.*

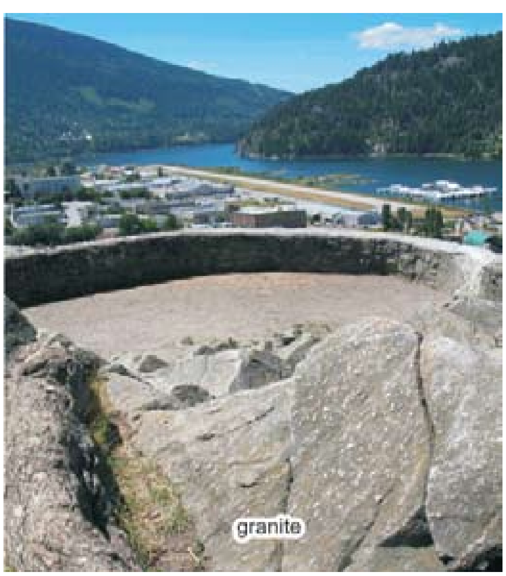


Figure 17. (Left) *Granite outcrop at the lookout in Gyro Park. Prominent white bumps are 1-2 cm crystals of feldspar that give the rock a spotted appearance. A grey coating of lichen on the rock surface obscures much of the granite texture. **(Above)** The granite contains rectangular feldspar crystals within a matrix of black minerals (e.g. amphibole, mica) and white minerals (e.g. feldspar, quartz). The large feldspar crystals weather more slowly than the finer-grained matrix and stand out in relief. Granite forms deep in the Earth when melted rock crystallizes slowly to a solid.*

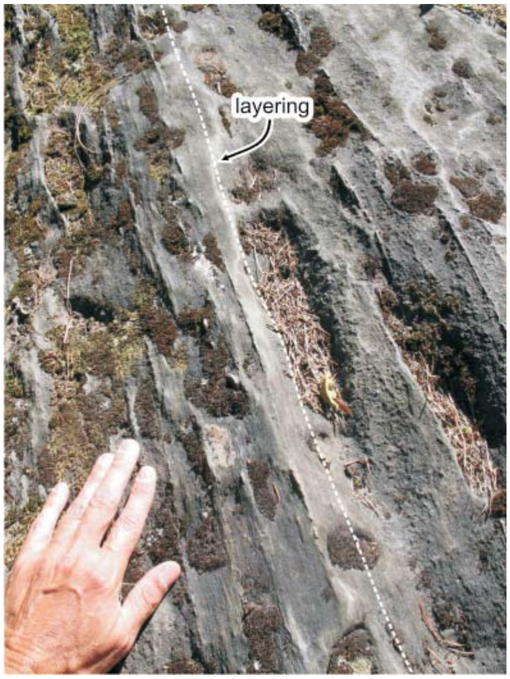


Figure 18. (Above) Rock exposed along the trail to the lookout in Gyro Park is a dark green layered volcanic rock. The rock contains thin layers of different compositions that weather at different rates. More resistant layers form ribs on the rock surface. This is a volcanic rock, altered to green minerals by elevated temperatures and pressures during burial deep in the earth.
***(Left)** Close up of volcanic rock. The layers may represent volcanic ash beds deposited near an ancient volcano.*

HOW TO GET TO GYRO PARK VIEWPOINT

From downtown Nelson, travel east along Victoria Street. Turn right and head up hill a half block on Park Street, and turn left on Gyro Park Road. From the parking lot in Gyro Park, take the short trail to the lookout.

(SITE 2A) PULPIT ROCK VIEWPOINT OF NELSON: NELSON'S REALLY BIG PICTURE

***Figure 19.** This is a view from Pulpit Rock of the West Arm of Kootenay Lake, Nelson, Cottonwood Creek valley, and the Selkirk Mountains. To the left, the gentle slopes of Fairview rise from the orange Nelson bridge to the mouth of Anderson Creek valley. This fan-shaped body is a thick pile of sand and gravel, eroded from the mountains and deposited by Anderson Creek. The position of Anderson Creek channel has shifted over the past 10,000 years, depositing sediment broadly to create the fan-shaped slopes of Fairview. The beach at Lakeside Park (just right of the orange bridge) is sand transported down Anderson Creek and spread along the shore by lake waves.*

Downtown Nelson is built on a slope of sand and gravel deposited by ancient Cottonwood Creek. Modern Cottonwood Creek, which flows out of the large valley behind Nelson, has cut a ravine in these sands and gravels, and constructed flat deposits of sand and gravel along the lakeshore. The rail yards are built on these flats. These natural flat lands have been extended by the addition of earth fill to create land for the airport and other lakeshore developments.

If you are up for a stiff but rewarding hike, the view of Nelson from Pulpit Rock lookout is spectacular. The larger features and patterns of many landscapes only reveal themselves from high above. The Pulpit sits on a granite bluff directly across and high above the West Arm from Nelson. From this vantage, it is obvious that steep rock slopes along the shores of Kootenay Lake have limited development in Nelson and Fairview to gentler sloping sediment fans (i.e. alluvial fans) built by mountain streams. Kaslo, New Denver, and Silverton (Site 11) are built on similar fan deposits.

HOW TO GET TO PULPIT ROCK VIEWPOINT. The trail to Pulpit Rock is across the West Arm from downtown Nelson. Follow Highway 3A over the Nelson bridge and turn left on Johnstone Road. Get directions from the Tourist Information Office in Nelson regarding the location of the trailhead and parking on Johnstone Road. The trail climbs about 350 metres through forest to the lookout. Allow 2 hours for the return hike and time at the lookout to savour the view.

(SITE 3) KOKANEE CREEK PROVINCIAL PARK: WHERE MOUNTAIN STREAM MEETS LAKE

Mountain streams create fan-like deposits of sand and gravel where they leave the confines of narrow mountain valleys and spread out on a valley floor or lake shore. Along the generally steep and rocky shorelines of Kootenay Lake, these gently sloping stream fans are important for wildlife habitat and human development. Communities such as Nelson and Kaslo have extensively modified their stream fans. Kokanee Creek Provincial Park protects a stream fan, largely in its natural state.

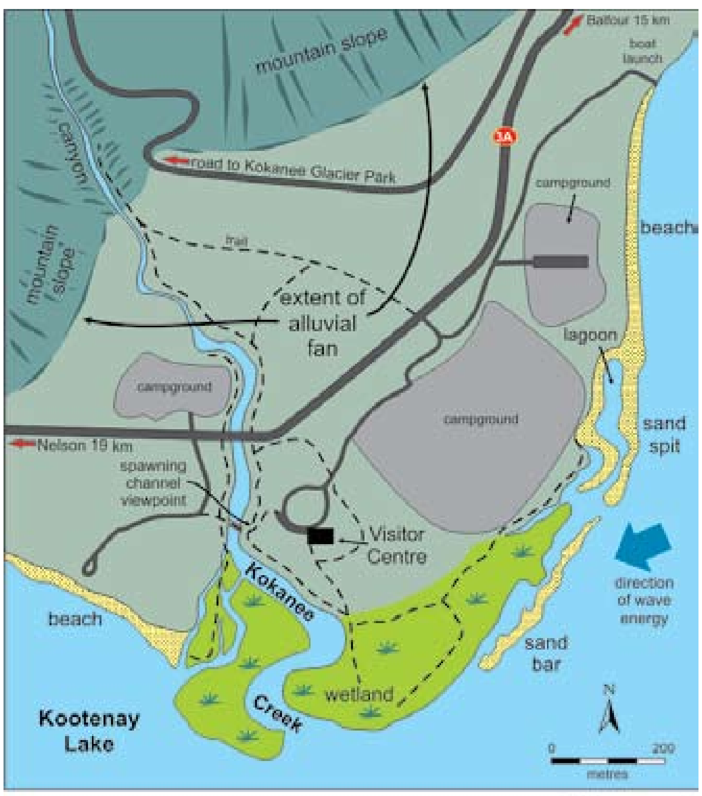


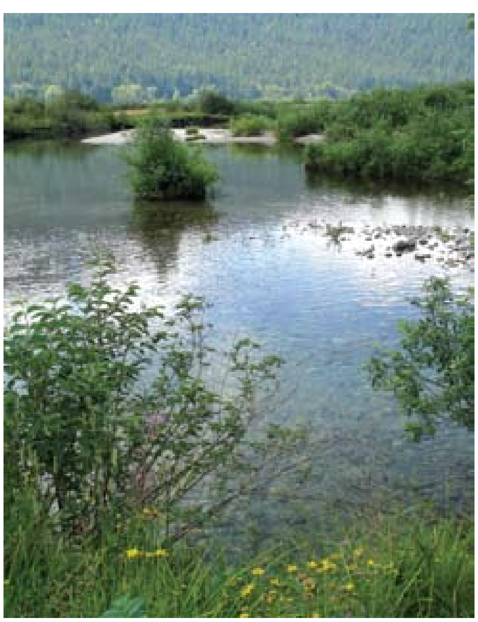
Figure 20. (Left) *A map of Kokanee Creek Provincial Park, showing the extent of the stream fan (also called alluvial fan) and its natural features. Gravel and sand is deposited in the stream channel. Over thousands of years, the channel has migrated back and forth, building a fan of sand and gravel. Sand is carried by the stream into the lake. Storm waves transport sand in shallow waters to form beaches and sand bars.*

Figure 21. (Right) *Kokanee Creek is filled with granite boulders eroded from the mountains and transported to the lake shore setting. The granite boulders have a distinctive pale grey colour. The photograph is taken during late summer during a period of lower stream flow.*

Kokanee Creek Provincial Park is a great place to explore. Start your tour at the visitor centre. The nearby spawning channel is an abandoned former channel of Kokanee Creek. The former channel has been modified into a stair-case of small pools and waterfalls, where kokanee salmon can dig nests for their eggs in fine gravel. From the foot bridge across Kokanee Creek, you will see that large boulders fill the channel. These boulders reflect the power of annual spring floods that occur as snows melt on high mountain slopes. Fine gravel, sand and mud are carried to the lake by floods and are largely absent in the channel below the foot bridge. Most boulders are a pale grey granite. Granite is the dominant bedrock of the high peaks of Kokanee Glacier Provincial Park, from which Kokanee Creek drains.

Figure 22. (Left) *This spawning channel has been constructed by fisheries engineers within an abandoned side channel of Kokanee Creek. Engineers use a particular size of gravel that is small enough for kokanee salmon to dig nests, but large enough for eggs to fit in the spaces between pebbles. A staircase of falls and pools encourages circulation of stream waters into the stream bed and back to the stream, carrying oxygen and nutrients to the eggs within the gravels.* ***(Top Right)*** *Kokanee salmon return each autumn to Kokanee Creek to lay eggs in the stream gravels (photo courtesy of BC Parks).* ***(Lower right)*** *Kokanee eggs in stream gravels (photo courtesy of BC Parks). The eggs live within stream gravels through the winter. Young salmon hatch in the spring and continue to live within the gravels until they are ready to emerge.*

Downstream, extensive wetlands that surround the mouth of the creek are fed by an abundance of small springs. These ground water springs are fed by stream waters that leak into the permeable gravel channel floor upstream, and flow downhill below the stream channel towards the lake (Figure 24). Gravel is deposited in the stream channel, while sand is carried by stream flow into the lake where it forms extensive sand flats. Storm waves on the lake pile this sand along the shore as sand beaches and sand spits.



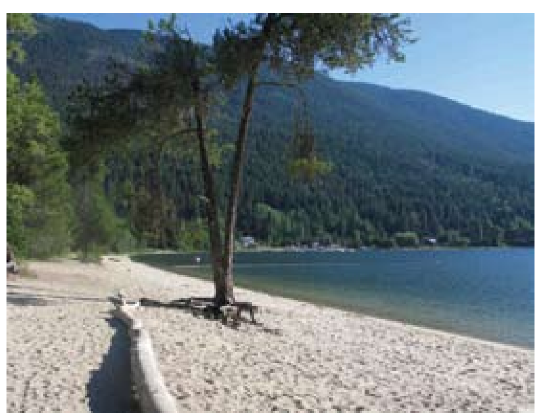


Figure 22. (Left) *Extensive marshlands grow on sand deposited along the shores of Kootenay Lake at the mouth of Kokanee Creek. These marshlands provide habitat for diverse animal species including juvenile kokanee salmon, song birds and wild fowl, amphibians, and mammals. The wetlands contain groundwater springs fed by waters from Kokanee Creek (see Figure 24).* ***(Right)*** *The park is famous for its sand beaches. Sand washed from the mountains by Kokanee Creek accumulates in Kootenay Lake as sandy shallows. Storm waves push the sand ashore, forming beaches and bars along the shore.*

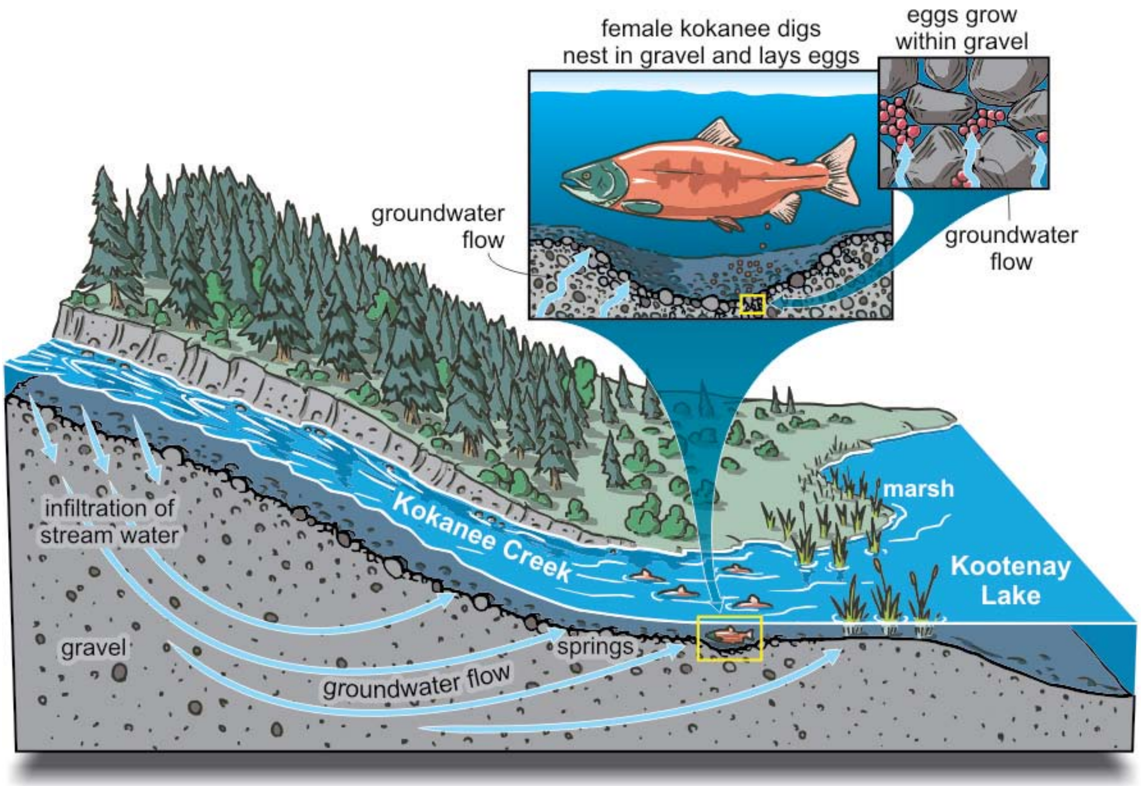


Figure 24. This schematic cut-away illustrates how stream waters infiltrate the stream bed and flow through the gravels to the stream mouth area, where they return to the surface as springs. Female kokanee salmon seek out springs in the stream gravels to dig their nests and lay their eggs. Throughout the winter, the eggs depend on the spring waters for oxygen, nutrients, and protection from freezing temperatures.

(Site 4) Kootenay Lake Ferry : An Ancient Suture Zone

Kootenay Lake, largest of the West Kootenay lakes, is an icon of the region. The lake is the backdrop for the major communities of Nelson and Kaslo, as well as a number of smaller lakeside villages. It extends 100 km from north to south and ranges in width from 3 to 5 km. Highways 3A and 31 follow its shores, providing vistas of its waters and shorelines. However, there is no better view than from the ferry that connects the west shore at Balfour with the east shore at Kootenay Bay.

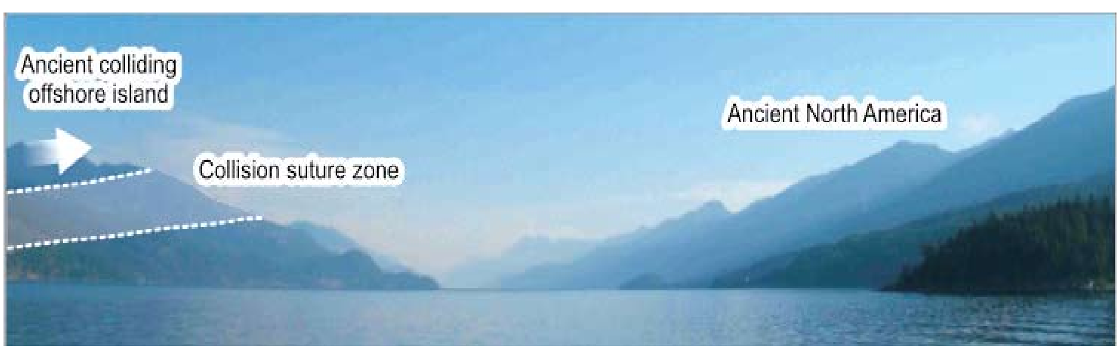


Figure 25. A view to the north up Kootenay Lake showing the location of the tectonic collision suture zone between rocks of ancient Pacific Ocean islands and rocks of the ancient margin of North America.

A view of a giant tectonic suture

Near Balfour ferry terminal, Highway 3A crosses a zone that marks a tectonic suture between ancient North America and ancient offshore volcanic islands that collided with North America 170 million years ago. This tectonic suture runs the length of British Columbia (Figure 7). Western British Columbia, indeed most of British Columbia, represents ancient volcanic islands that were welded to North America as the tectonic plate of North America moved westwards and collided with oceanic islands. From the ferry you can view the location of part of this suture zone (Figures 25 and 26). Though not obvious on the mountain slope due to extensive forest cover, this ancient suture zone runs along the Selkirk Mountains just west of the lake. The suture divides the West Kootenay, and follows a curved line from Nakusp to Kaslo, Balfour, and Salmo (Figure 5). Arrow Lakes, Slocan Lake, Castlegar, Nelson, Rossland, and Trail all sit on rocks of ancient islands; Creston, Kootenay Lake, Crawford Bay, and Riondel lie on ancient North America.

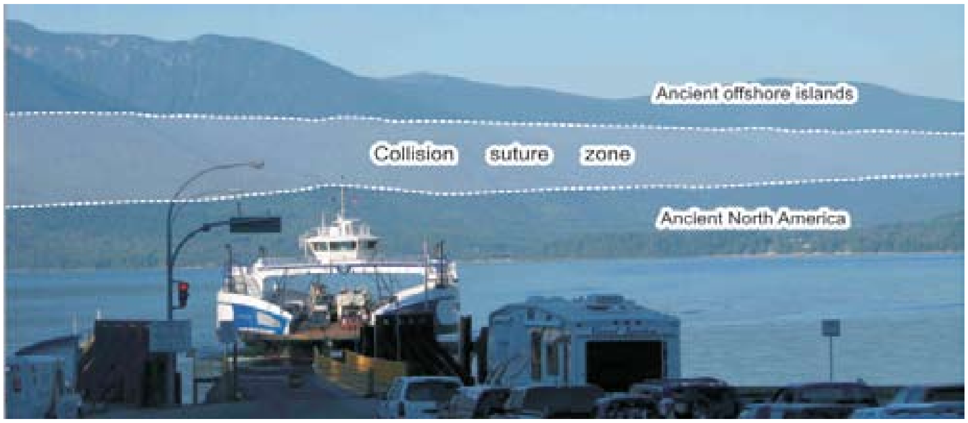


Figure 26. A view across Kootenay Lake from Kootenay Bay ferry terminal showing the location of the suture line between rocks of ancient Pacific Ocean islands and rocks of the ancient margin of North America.

Collision-zone rocks near Kootenay Bay

A good example of the geological damage created by this ancient collision lies along Highway 3A near Kootenay Bay. Rock cuts just up the hill from the ferry terminal expose layered gniesses cut by granitic dykes. These sheared and partly melted rocks were once sandstone, mudstone, and limestone. During the collision, these rocks were shoved deep in the earth, perhaps 10 km or more below the surface, as the edge of North America crumpled upon impact with the volcanic islands. Geologists have mapped the rocks in the Kootenay Bay and Crawford Bay area and determined that layers are contorted into a series of large folds that record this collision (Figure 27).

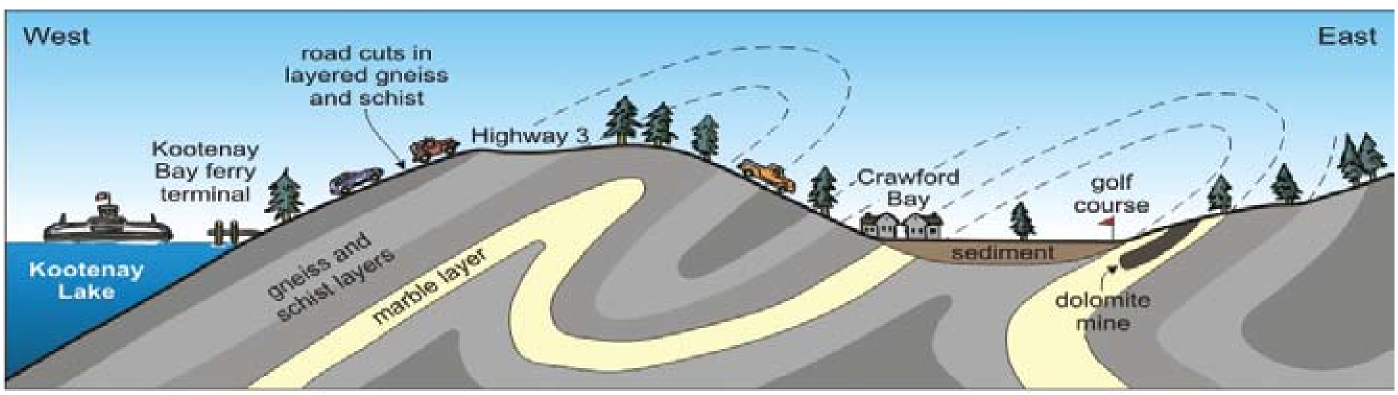


Figure 27. A schematic cross section of Highway 3A from Kootenay Bay to Crawford Bay showing the large scale folds of rock layers due to tectonic collision 170 million years ago.

How Kootenay Lake formed

The tectonic collision 170 million years ago crumpled and broke the rock, creating a series of faults in eastern BC that run north-south. Later faults tended to follow this earlier structural grain. Over millions of years, rivers carved north-south valleys along these weak zones of broken rock. During the Ice Ages, south-flowing glaciers (see Figure 9) scoured these river valleys, carving deep troughs that today contain Okanagan, Christina, Mabel, Arrow, Slocan, and Kootenay lakes. The southern and central part of Kootenay Lake lies above a deep crustal fault, and it is likely that rivers and later glacier erosion exploited the crushed rock in the fault zone, forming this deep valley. Near the end of the last Ice Age, the water level in the lake was about 150 metres higher than it is today, likely due to damming of its outlet by glacier ice. Following the Ice Age, the Kootenay River has filled the southern end of the lake with a delta of sand and mud, considerably reducing the size of the lake. The flood plains of this delta support rich wetlands and agricultural land in the Creston Valley.

How to Get There: The Balfour ferry terminal is on Highway 3A at the mouth of the West Arm 35 km east of Nelson. The ferry sails between Balfour (west side) and Kootenay Bay (east side). The sailing time is about 35 minutes and schedule information is available at 250-229-4215 or *www.th.gov.bc.ca/marine/ferry_schedules*. This ferry route was part of the main Crowsnest Highway route until 1963 when the Salmo-Creston highway route over Kootenay Pass was completed.

(SITE 5) RIONDEL:
A FAMOUS FORMER SILVER MINE WITH GUSHING HOT WATERS

Riondel is a small village of miners' cottages on the east shores of Kootenay Lake, a short drive north of the Kootenay Bay ferry terminal. Silver was discovered on this shore in the 1820's, and the discovery grew to become the Bluebell mine, which produced silver, lead, and zinc until it was shut down in 1972. The Bluebell mine at Riondel lays claim to the longest history of production in the province, an astonishing century and a half. Today the mine is closed, and an environmental clean up has removed much of this mining history. However, Riondel remains a great place to poke around. Take a walk to Galena Bay, a short trail that passes former mine tunnels and the mine mill site on the way to old wharf on Kootenay Lake.

Figure 28. The Purcell Mountains rise above former miner's cottages in Riondel.

Figure 29. Galena Bay on Kootenay Lake is the site of the former mine mill. All that remains is the old wharf (right). Galena, a lead mineral, was discovered on its shores. Galena often contains important amounts of silver, and was the major ore mineral in most West Kootenay silver mines.

LET'S TAKE A LOOK: END OF FOWLER STREET

In Riondel, drive to the end of Fowler Street and park in the large gravel parking area lined with large blocks of ore and marble. These blocks are good examples of the local marble and ore from the Bluebell mine. Look for a pale grey block; this is marble and similar to that used to build the Old Courthouse in Nelson (see Site 1). A thick layer of marble forms the bluff to the north of the parking area, and the shoreline cliffs to the south along Galena Bay. The marble layer extends tens of kilometers along the eastern shoreline of Kootenay Lake, and slopes to the west beneath Kootenay Lake. All the ore in the Bluebell mine at Riondel was found within this limestone layer, and the mine workings followed the marble layer hundreds of metres below Kootenay Lake (see figure 32).

Figure 30. A block of banded marble from Riondel. A thick layer of marble contained the ore bodies of the Bluebell mine. Note the similarity of this rock to marble blocks in heritage buildings in Nelson (see Site 1).

The marble was once a deposit of lime mud with abundant life on the seafloor off the coast of North America 500 million years ago (see Figure 6). The mud solidified to limestone as it became buried below other sediments that continued to accumulate on the seafloor. Three hundred and thirty million years later, during the tectonic collision of North America with offshore volcanic islands, the limestone layer and other coastal rocks were pushed deep into the Earth below the growing mountain belt. At great temperature and pressure, the tiny calcite crystals that made up the limestone grew into coarse crystals, destroying most of the fossils and converting the rock into marble.

Most of the large blocks that line the parking area are rusty ore from the Bluebell mine. The brown colour of the ore blocks is due to a coating of iron oxide rust from the weathering of pyrite, a common iron-bearing mineral. Other minerals in the ore, especially galena and sphalerite, contain the silver, lead and zinc.

Figure 31. A close up of quartz crystals within a cavity found in a block of ore from the Bluebell mine at the parking area on Fowler Street in Riondel.

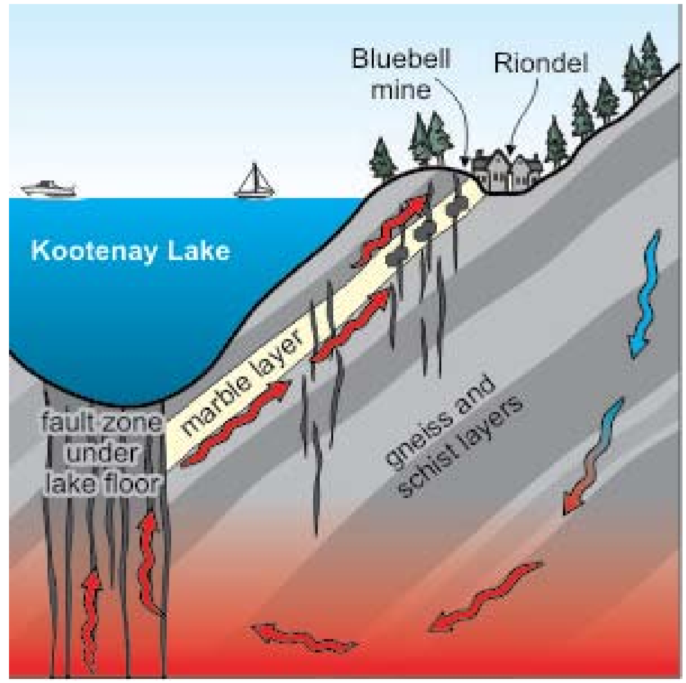


Figure 32. A schematic cross section showing the rock layering underlying the eastern shores of Kootenay Lake, and the marble layer that contains the silver-lead-zinc ores of the Bluebell mine. Ground waters warmed by Earth heat rise along faults and layers to enter the former mine workings.

Some of the rusty-weathering ore blocks contain cavities lined with quartz crystals. In the deep workings of the Bluebell mine, miners encountered hot waters up to 40°C flowing out of cracks and cavities. The hot waters are rich in calcium, magnesium, carbonate, and silica. To prevent the mine workings from flooding, pumps worked 24 hours a day. It is probable that these quartz crystals grew from these hot, silica-rich waters prior to mining. These geothermal waters likely relate to deep circulating ground waters that leak to the surface across the lake at Ainsworth hot springs (see Site 7). These hot waters leach silica from the rocks that they flow though, then precipitate silica as quartz crystals when the waters rise and cool near the surface.

Galena Bay trail: the mine, the marble, and the port

Follow the trail from the parking area to the south towards the open grasslands and Kootenay Lake. The trail passes the entrance of the old mine tunnel to the Bluebell mine. Adjacent to the portal are cliffs of marble, a part of the marble layer that contains the mine ores. The marble is white to grey in colour and varies from massive to thinly banded.

Figure 33. A relict mine tunnel portal at the Bluebell mine on the trail to Galena Bay. Marble cliffs surround the portal. This portal is sealed for safety reasons.

The trail continues across the grasslands to Galena Bay. The grasslands are the site of the former mill complex of the Bluebell mine. The mill site has been reclaimed and planted with grasses. On the west side of the bay is the wharf where supplies for the mine and community arrived on lake steamers, and from where mine output was shipped. In the early days from 1892 to 1896, Bluebell mine ores were shipped to the nearby smelter at Pilot Bay on Kootenay Lake just south of Kootenay Bay ferry terminal. A tall brick chimney and bright rusty orange soils remain from the lake shore smelter and are clearly visible from the ferry. Later, the mill at Riondel crushed and separated the ore, removing non-ore components, and the concentrate was shipped to the smelter in Trail.

Why are there so many Kootenay mines in the limestone-marble layer?

The marble layer at Riondel extends south through the Salmo River valley and into Washington State. This marble layer contains many other important lead-zinc-silver mines such as the HB-Jersey and Reeves-MacDonald near Salmo (Figure 5). The reason for this abundance is that marble or limestone act as a chemical trap for metals that circulate in hot groundwater deep in the earth. Marble and limestone react with acidic ground waters, just as they do with acidic rainwater that dissolve caves in limestone. When hot metal-rich waters encounter and dissolve limestone or marble, the chemistry of the waters changes. The chemical reaction causes the dissolved metals to precipitate, forming metal-bearing ores. So you might think of the limestone-marble layer as a giant chemical trap that has intercepted mineralizing solutions over geologic time, creating ore bodies.

(Site 6) Crawford Dolomite Mine : A Good Neighbour .... and Another Limestone Story

The marble layer that hosts silver-lead-zinc ore at Riondel continues south to Crawford Bay where it is mined for dolomite. At Crawford Bay, the marble (formerly a limestone) is rich in magnesium as well as calcium, and is referred to as dolomite marble. This underground mine, which has operated for decades, extracts dolomite rock from a sloping layer of dolomite marble. The mine workings extend underneath the golf course next door.

As you drive south towards Creston from Crawford Bay village, turn left onto Crawford Creek road. Along Crawford Creek road you will see a golf course on the west side and scattered homes on the east side. The entrance to the mine is marked by white dolomite outcrops on the east side of the road. Just north of the mine the road crosses a bridge over Crawford Creek, which has cut a narrow canyon through the dolomite layer.

Figure 34. *The entrance to the underground dolomite mine is at a former quarry on Crawford Bay Road. The blue doors control access to the mine tunnel. The quarry cliffs above the door are pale-coloured dolomite. Prior to underground mining, the dolomite was extracted from the surface quarry. The golf course is across Crawford Bay Road to the right.*

Figure 35. (Left) *Kokanee Springs Golf Resort is next door to the dolomite mine.* ***(Centre)*** *Dolomite has a massive sugary white appearance.* ***(Right)*** *An aerial view of the golf course and the dolomite mine entrance.*

Dolomite from the mine is hauled south along Highway 3A to Sirdar just north of Creston, where the dolomite is crushed and ground to sand or powder grains. Several characteristics make dolomite valuable. Dolomite is chemically reactive and consumes acid, and therefore the dolomite sand is used as a soil amendment that reduces natural soil acidity and promotes plant growth. Dolomite is rich in magnesium and so is fed to cattle as a magnesium supplement. The bright white colour of dolomite gives it value as landscaping stone, as white sand in stucco, and as white power in cement mortars and grouts.

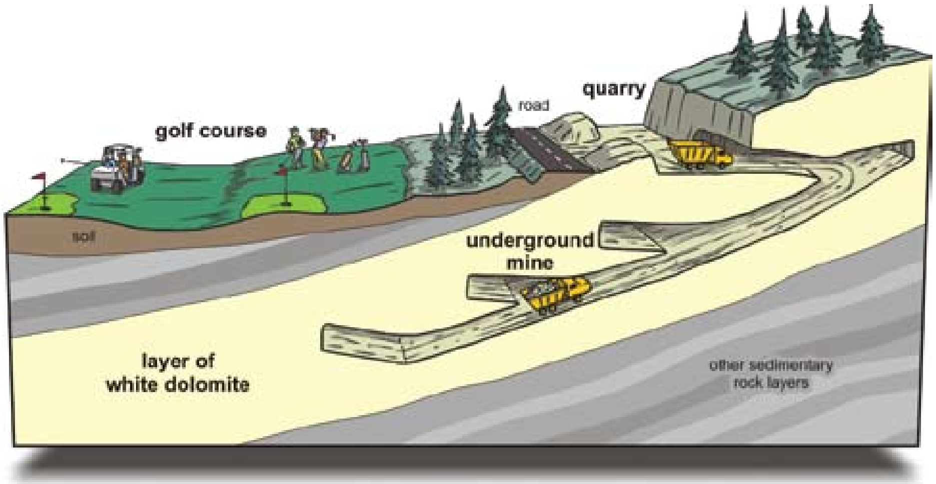


Figure 36. *A cartoon cross section of the dolomite mine within the sloping layer of dolomite. The simple geometry of the tilted dolomite layer hides the fact that the layer is part of a larger geological fold formed during mountain building (Figure 27).*

(SITE 7) AINSWORTH HOT SPRINGS :
DEEP EARTH HEAT AND PLUMBING

Ainsworth hot springs are northeast of Nelson along Highway 31 in the village of Ainsworth. The natural hot springs here were well known to the Ktunaxa people. In the early 1880's, silver was discovered nearby and Ainsworth became the first town to develop on Kootenay Lake. Ainsworth boasted as many as 3000 residents during the peak of mining activity from 1885 to 1893. As the mines dwindled, and the nearby centres of Nelson and Kaslo grew, Ainsworth began a steady decline. Today, only a few homes surround the hot springs resort.

Figure 37. *The hot springs pool has a beautiful view over Kootenay Lake and the Purcell Mountains.*

Figure 38. *Tan-coloured travertine is actively forming from hot spring waters that cascade down a cliff from the pool area to Highway 31.*

Figure 39. *Ainsworth on Highway 31 is part of BC Tourism's Hot Springs Circle Route through the west and east Kootenay.*

Ainsworth village and hot springs resort is perched on a steep slope above Kootenay lake. The entire resort area is built on deposits of travertine, a form of limestone that precipitates from hot springs. As the hot waters come to the surface, carbon dioxide dissolved in the waters bubbles away, causing calcium carbonate (travertine) to precipitate. Thousands of years of hot spring activity at Ainsworth has created thick deposits of travertine on the mountain slopes.

The resort pool offers a grand panorama of Kootenay Lake and the Purcell Mountains beyond. The pool waters are 35-38°C and flow from a cave where the waters are 40-42°C. The cave is a tunnel dug into cream-coloured deposits of ancient travertine that have accumulated over thousands of years. The slopes above the pool are partly vegetated travertine.

Take a look at the travertine just above the southern end of the resort parking lot. Excavation has exposed a layered, grey rock that breaks easily. To see travertine that is actively forming today, take a short walk north along Highway 31 from the parking lot access road. The highway passes a waterfall of hot spring waters that cascade over a colourful flowstone of modern travertine. The flowstone varies in colour from tan to cream; these colours reflect a surface coating of bacteria that oxidize iron dissolved within the geothermal waters. Look for plants coated with travertine to convince your self that this mineral continues to precipitate today. A ditch carries these waters to a culvert below the highway. From there, a stream flows to a cliff above Kootenay Lake where they cascade over another flowstone of travertine.

WHAT MAKES A SPRING HOT?

The Kootenays are famous for their hot springs. Best known are Radium and Fairmont hot springs in the East Kootenay, Ainsworth and Nakusp-area hot springs in the West Kootenay, and Canyon hot springs along the TransCanada east of Revelstoke. Hot springs in Canada are only found in the western mountains of British Columbia, Yukon, and the Northwest Territories. Hot springs require that hot waters found deep in the earth rise to the surface. What is the link between mountains and hot springs?

Chemical analysis indicates that hot spring waters originate as rain or snow melt. To gain heat, waters must circulate deep into the Earth, where it is hot. Most mountains are riddled with fractures that allow waters to descend. Rain and snow melt leak downwards into these fractures. The weight of water in this network of connected fractures pushes down on water deeper in the fracture network, pressurizing it. A steep, permeable fault can allow deep, pressurized waters to flow to the surface to form a hot spring. However, this only works if water infiltrates a mountain and springs back to the surface in a valley. To understand why this is so, imagine that you fill a garden hose with water and stand on top of your house holding both ends. A loop of hose dangles thirty feet below you. When you raise one end of the hose slightly above the other (i.e. the mountain), water flows out the lower end (i.e. in the valley). As long as one end is higher than the other, the length of the loop doesn't matter, it's just the relative height difference of the input and output ends.

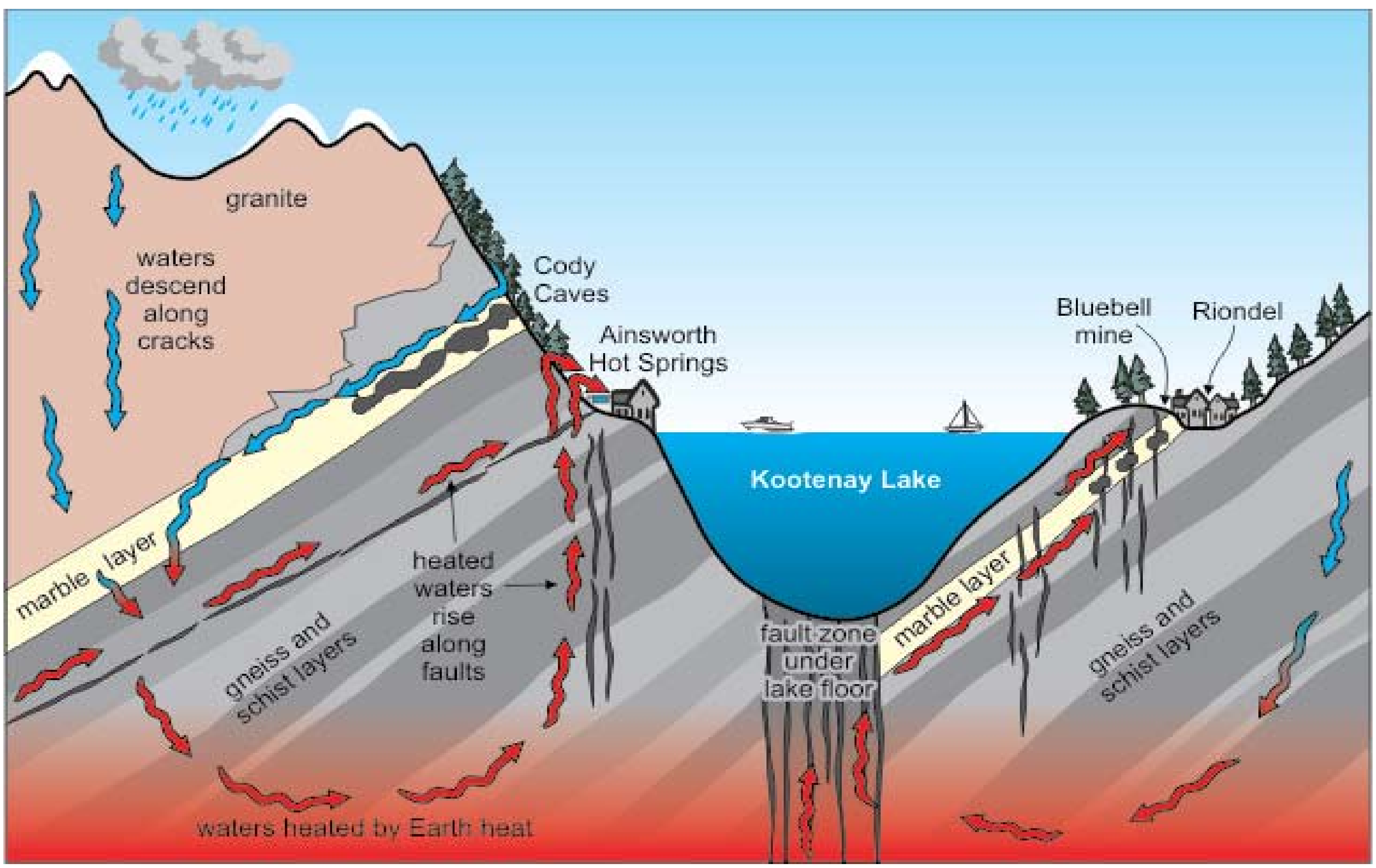


Figure 40. A cartoon cross section across Kootenay Lake near Ainsworth and Riondel, showing a possible configuration of the underground plumbing system that feeds Ainsworth hot springs.

Such a "loop" of deep Earth water is the plumbing system required for a hot spring to function. The temperature of a hot spring depends on how deep into the Earth the loop goes, and how much the heated waters cool as they rise back to the surface. Deep valleys underlain by permeable faults provide the easiest place to release this pressure. That is why most Kootenay hot springs such as Nakusp, Radium, Fairmont, and Lussier are in valleys.

At Ainsworth, water enters the mountain high above the village. Cody Caves lie directly above the hot springs on the mountain slope and may be an important entry point (Site 8). Geologists estimate that waters descend about five kilometers into the Earth, heating as they descend, before encountering the fault that allows them to flow to the surface in the valley at Ainsworth. This ancient fault runs below Ainsworth and northwards along the slopes above Kootenay Lake.

How to get to Ainsworth Hot Springs.

Ainsworth hot springs resort is in the village of Ainsworth on Highway 31, north of the Balfour ferry terminal. The village and resort are perched on a steep slope; look for the access lane to the resort parking lot above the highway.

(Site 8) Cody Caves Provincial Park
Dissolving Limestone and Subterranean Worlds

Cody Caves, just north and above Ainsworth, is another unique geological feature of the West Kootenay. Like most caves world wide, they occur in limestone (or marble), because these rocks are capable of slowly dissolving in water, a process that can create underground openings. Cody Caves occur in a thick limestone and marble layer that extends along the west side of Kootenay Lake from south of Ainsworth to Duncan Lake. Other marble layers extend along the east side of Kootenay Lake, passing below Riondel and Crawford Bay, and occur in the mountains east of Salmo. These limestone and marble layers, though limited in extent, are important to the West Kootenay in a number of ways. They are used as building stone (Site 1), host important silver-lead mines at Riondel (Site 5) and near Salmo, are quarried for dolomite at Crawford Bay (Site 6), and host the Cody Caves. The first recorded visit to Cody Caves was by the prospector Henry Cody during the silver boom in the 1890's. In 1966, Cody Caves became the first cave system in BC to become a provincial park. Approximately 2000 people take a guided tour of the caves each year.

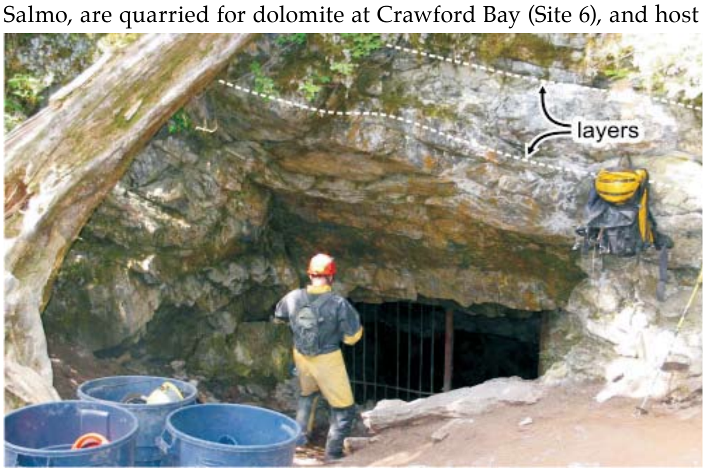
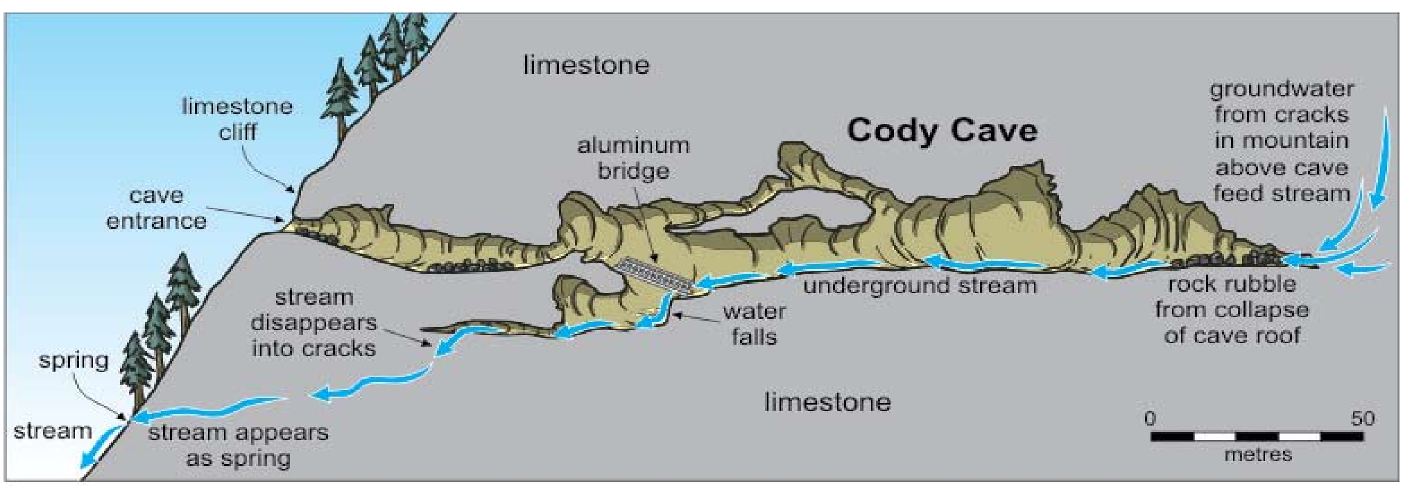


Figure 41. (Left) The entrance to the Cody Cave lies within a cliff of limestone. Layering of the limestone is evident on the cliff face. Guided tours start at the cave mouth. Underground temperature in the cave is steady at about 6°C.

Figure 42. (Below) A cross-section map of Cody Caves. Approximately 800 m of cave is accessible to explorers. An underground stream flows along the floor of the cave.



CAVES

Caves form by the underground erosion of rocks that dissolve in water such as limestone and marble (Figure 44). Rainwater, made acidic by carbon dioxide from the atmosphere and soil, slowly infiltrates cracks in limestone and marble, dissolving the rock and enlarging the openings. If these openings become large enough for humans to enter, we call them caves. Caves support unique ecosystems that include plants, bacteria, crickets, spiders, fish, and small mammals adapted to this dark, but little changing environment.

Figure 43*. Rock dripstone (stalactites) and columns (stalagmites) form by dripping waters from the roof of the cave. Note the broken stump of stalagmite on the floor of the cave that reveals tree-like rings that formed by coatings of limestone added over time by dripping waters. Photo by K. Stanway*

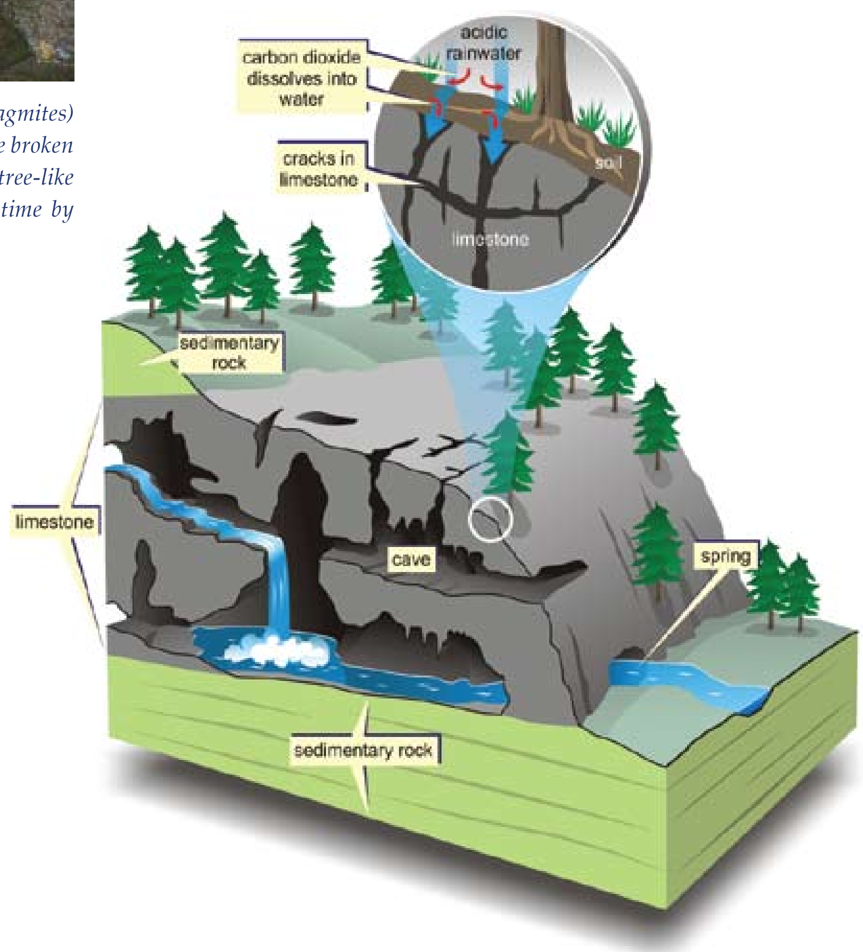


Figure 44. *A schematic illustration of a cave with an underground stream and spring.*

HOW TO GET THERE

Turn uphill on the forestry road three kilometers north of Ainsworth on Highway 31, at a large pullout on the west side. Follow the sometimes narrow, rough and steep gravel road for about 30 minutes (11 km) as it climbs the mountain. There is a parking lot and small building at the trail head. A fifteen minute trail leads uphill though the forest to the cave entrance (Figure 41). Just before the cave entrance, the trail crosses a stream that flows from a spring. The spring is fed by an underground stream within Cody Cave. Guided underground tours of the cave are available during July and August. Tours last for about one hour; longer tours can be arranged in advance. Call 250-353-7364 for current information regarding underground tours, or visit the web site at *www.codycaves.ca.*

(Site 9) SANDON GHOST TOWN:
BILLION DOLLAR BOOMTOWN AND THE SILVERY SLOCAN SILVER RUSH

Figure 45. A view of Sandon and the Carpenter Creek valley from the road to Idaho Peak lookout (Site 10). Sandon was the commercial centre for several dozen mines on nearby mountain slopes..

Sandon is a former mining town, set high in a narrow mountain valley, and rich in the ghosts of its former glory. Mines on the steep mountains around the town produced silver, lead, and zinc worth over a billion dollars and made Sandon the "soul of the Silvery Slocan". At its peak in the late 1890's, it boasted a population of 5000, two railroads, 24 hotels and 23 saloons. It was the first town in BC to be fully electrified, using power from a mountain stream and small hydroelectric plant. Sandon is sometimes referred to as "western Canada's most authentic ghost town". There is a walking tour of its scattered historic buildings and an excellent museum. The route to Idaho Peak lookout (Site 10) passes through Sandon, climbs the mountain slope above the ghost town, and provides panoramic views of Sandon and its setting (Figure 45).

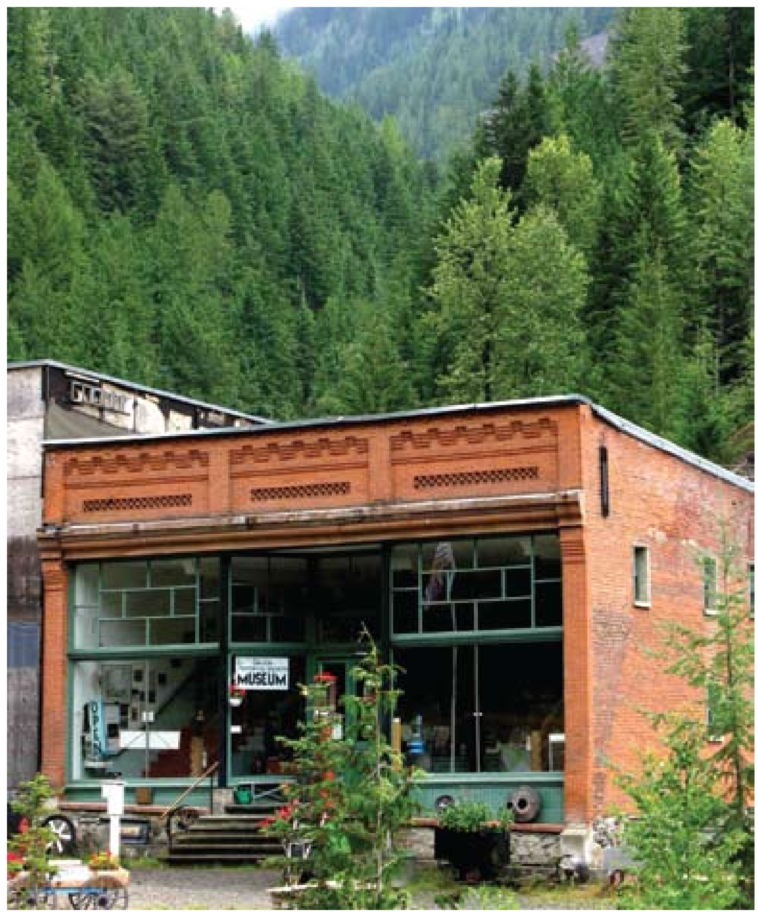


***Figure 46. (Above)** The Sandon Historical Society Museum and Interpretive Center is housed in the old general store building. The museum houses an excellent collection of old photographs and artifacts and tells the history of discovery, mine development, town life, railways, avalanches, and floods.*

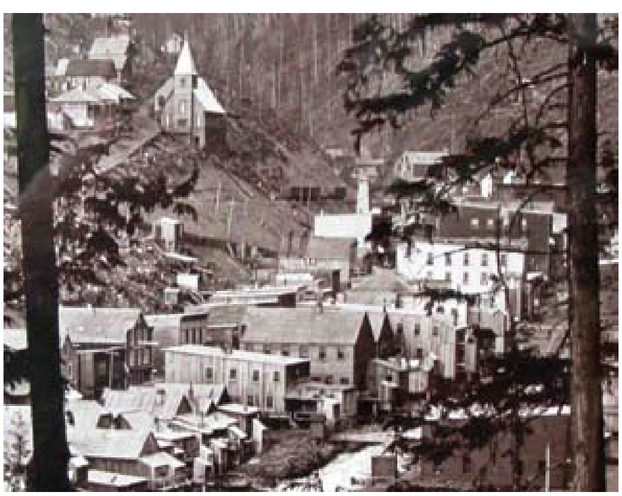


***Figure 47.**An early photo of downtown Sandon, precariously located between Carpenter Creek and steep mountain slopes. Throughout its history, the town was vulnerable to both floods and avalanches. Photo is courtesy of the Sandon Historical Society.*

Discovery of silver-rich veins

Prospectors knew good silver ore was usually associated with galena, a lead sulphide ore with a distinctive silver colour and cube-like fractures and crystals (Figure 48). Galena was discovered by two prospectors high on the mountainside above Sandon in 1891. The prospectors filed their claim and assayed the galena in Ainsworth; word got out that the galena contained very high silver values and the town of Ainsworth emptied out in a staking rush to the Sandon area. The wave of prospectors quickly discovered many other galena showings on nearby mountain ridges. The town of Sandon grew over night to serve these new workings. But the narrow valley bottom and Carpenter Creek forced the town to develop as a narrow strip. To create more land for the town site, the creek was redirected into a wood frame culvert that ran the length of town below a wooden main street. This narrow culvert was a "disaster waiting to happen" in the event that the culvert plugged and the stream was forced to flow in a new route through the town. Luckily for Sandon, such an event did not happen until 1955, but the flood in that year destroyed much of the town.

Figure 48. (Left) *An early photograph of a miner underground beside veins (white) containing silver ore. The veins of white calcite and quartz contained lead, zinc, and silver minerals. Note the candle in the miner's hand. Photo is courtesy of the Sandon Historical Society.*
(Centre) *Galena, a lead sulphide mineral, was the principle silver ore in Sandon-area mines and throughout the Slocan. Galena is easily recognized by its weight (it's lead!), its metallic sheen and silver colour, and its cube-like fracture.* ***(Right)*** *A painting in the museum of the famous 125 tonne "Big Boulder", discovered in Sandon Creek in 1892, that yielded 40 tonnes of ore. The discoverers staked the boulder, but other prospectors realized that it was a fragment of ore that had rolled down the mountain from its mother lode. They scoured the mountain slopes above and found the source of the boulder and a new mine.*

But the ore was heavy and the smelters far away

Mines high on mountain slopes quarried steep veins of carbonate minerals (calcium carbonate or calcite and iron carbonate or siderite) and quartz that contained pockets of silver-rich ore. The silver was contained in the lead sulphide mineral called galena. Early mining had to deal with the problem of how to get the heavy silver ore to smelters in Washington State. Very high grade ore could be sorted by hand and hauled by mule or horse team down to New Denver on Slocan Lake or to Kaslo on Kootenay Lake. There it was loaded on sternwheeler ships bound for the railways to the south. However the richness of Sandon's mines lured two railways to compete to haul Sandon's ore and both the Canadian Pacific Railway and Great Northern's Kaslo & Slocan lines were built to Sandon. The CPR line ran to New Denver while the Great Northern connected to Kaslo. Aerial tram lines carried ore from high mountainside mines to the railway. Some large mines above Silverton built trams that carried ore directly to Silverton. The larger mines decided to process lower grade ores and built mills that first crushed the ore and then separated ore from waste rock to create a concentrate. This avoided needless freight and handling costs. The concentrate was shipped by rail and lake steamer to smelters in Nelson or Trail where the ore was melted, yielding silver, lead, and zinc metals.

Figure 49. *The Klondike Silver Corporation mill is the last remaining mill in Sandon. The mill is on the outskirts of Sandon along the access road to Highway 31A.*

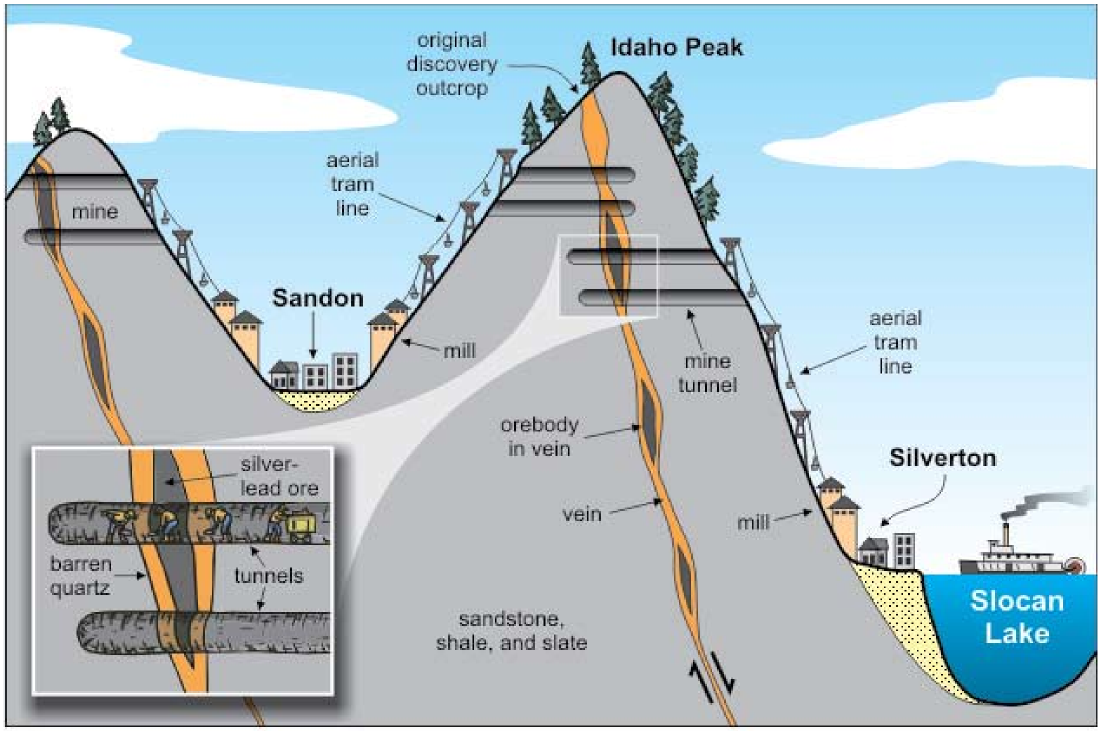


Figure 50. *A schematic cross section of Sandon, Idaho Peak, and Silverton on Slocan Lake showing the relationships between veins, orebodies, and mines. Veins (lodes) of calcite, siderite, and quartz contained pockets of silver-rich ore known as ore bodies (pay streaks and ore shoots). The ore was mined by horizontal tunnels and blasting of the ore bodies. Ore was carried by bucket on aerial tramlines down to mills in the valley, where waste rock was removed. The concentrated ore was loaded on trains bound for lakeside towns for transfer onto sternwheeler boats bound for smelters in Nelson or Trail.*

How do silver veins form?

The silver-rich veins that fuelled the silver rush at Sandon formed deep in the Earth. About 50 million years ago, tectonic forces stretched southern British Columbia, creating faults (see Figure 55). Hot rocks from deep in the Earth were elevated along these faults, causing vigorous circulation of heated ground waters along faults and fractures. These hot waters dissolved minute amounts of silver, lead, and zinc from rock as they flowed, creating metal-rich solutions. Silver-rich ore bodies formed where rising fluids cooled or depressurized, causing dissolved metals to crystallize. Over millions of years, rising mountains and continued erosion slowly brought these deep metal deposits closer to surface, where they were discovered and mined.

How to get to Sandon.

A gravel road links Sandon to Highway 31A near the highway summit between Kaslo and New Denver. The road passes a large mill building on the right, and enters the lower part of Sandon. Turn right across the bridge over Carpenter Creek to get to the store in the Old City Hall building and the Sandon Historical Society Museum and Interpretive Centre.

(Site 10) Idaho Peak Lookout : A Stunning View of Lake and Mountain

Idaho Peak lookout has a remarkable view accessible by a half hour walk from a forestry road. The view is sublime – Slocan Lake and the Valhalla Range in Valhalla Provincial Park to the west, Kokanee Glacier Provincial Park peaks to the south, and Goat Range Provincial Park peaks to the north. Far below on the shores of Slocan Lake lie New Denver and Silverton. Driving to the lookout from New Denver or Kaslo you traverse 3 biogeoclimatic zones: interior cedar-hemlock, engelmann spruce-subalpine fir, and alpine tundra.

Figure51. *The forestry access road to Idaho Peak lookout rises to a parking lot on a high subalpine ridge. A half-hour walk to the lookout follows a trail along the ridge to the forestry lookout on Idaho Peak with expansive views in all directions.*

Figure 52. View from Idaho Peak lookout to the northwest across Slocan Lake and the Valhalla Range. Note the village of New Denver is located on a gently sloping stream fan on Slocan Lake.

Figure 53. (Below) View to southwest across Slocan Lake to the Valhalla Range. The basin filled by Slocan Lake was eroded by rivers and glaciers along a major crustal fault. The common elevations of the highest peaks in the Valhalla Range reflect their erosion from a plateau elevated by movement on the fault.

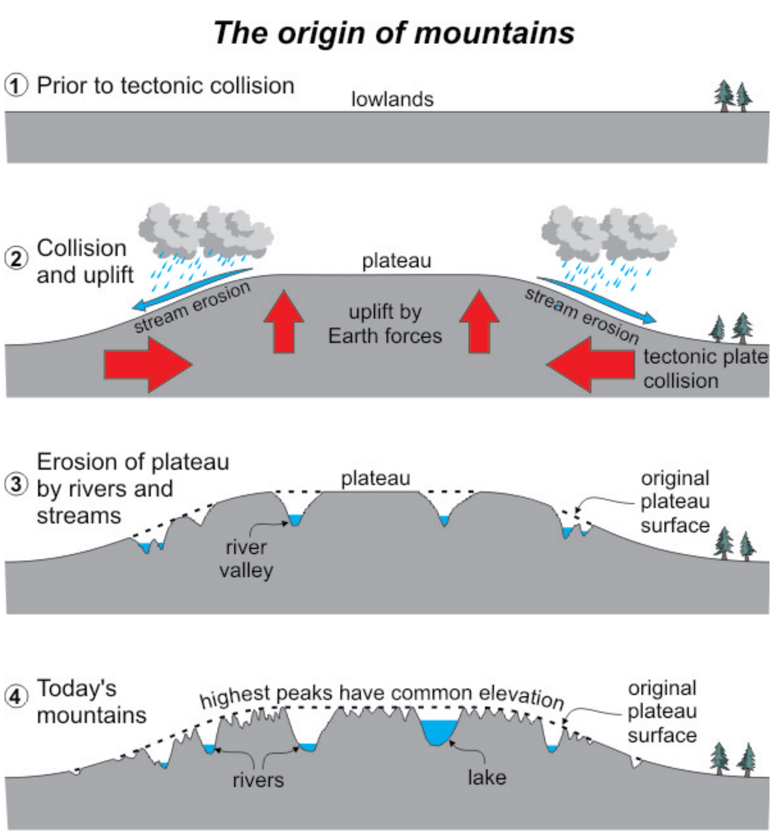


Figure 54. (Left) The origin of mountains during tectonic collision results in the uplift of lowlands. The rising plateau is carved by rivers, creating valleys. As the rivers continue to erode and expand the network of valleys, the flat surface of the plateau is reduced in area. Finally, almost all remnants of the plateau are lost, but the similar elevations of the highest peaks remain for a long period, a legacy of the original plateau.

First Plateau, then Valleys and Mountains

From the Idaho Peak lookout, you will note the somewhat surprising uniformity of the tops of the peaks in all directions. This is most obvious to the southwest in the Valhalla Range (Figure 53). What does this tell us about the origin of mountains?

Mountains occur when land is uplifted by tectonic forces. Rivers cut into this rising land, carving valleys. Tectonic uplift can exceed the capacity of rivers to erode the rising lands, resulting in an elevated plateau. The Tibetan plateau of China and the Altiplano of South

America are both examples of tectonically active plateaus (the climate of both of active plateaus is very dry, limiting the power of streams to erode).

Erosion is not even. Finely fractured rocks such as shale and slate erode more quickly than rocks that contain only widely spaced fractures such as granite and gneiss. Less resistant shale and slate near Sandon have eroded into rounded ridges and deep valleys, while more resistant granite and gneiss form the high and craggy peaks of Kokanee Glacier Provincial Park and the Valhalla Range respectively. Stream erosion is also focused along zones of weakness such intensely fractured rock in faults. Such accelerated erosion often creates large and deep valleys along fault zones. Erosion along the Slocan Lake fault is an example of this process.

TWO DIFFERENT WORLDS SEPARATED BY A FAULT

Slocan Lake follows a major fault that juxtaposes very different rocks. West of Slocan Lake, rock in the Valhalla Range is gneiss, a rock that formed 20 km deep in the Earth. East of Slocan Lake and north of Silverton is sandstone and shale that formed in an ancient ocean. The gneisses have been elevated at least 20 km to their present position in the Valhalla Range, while sandstone and shale east of the lake have been raised no more than several kilometers. The Slocan Lake fault accommodated this relative movement during a period of stretching of the Earth's crust 50 million years ago (Figures 55).

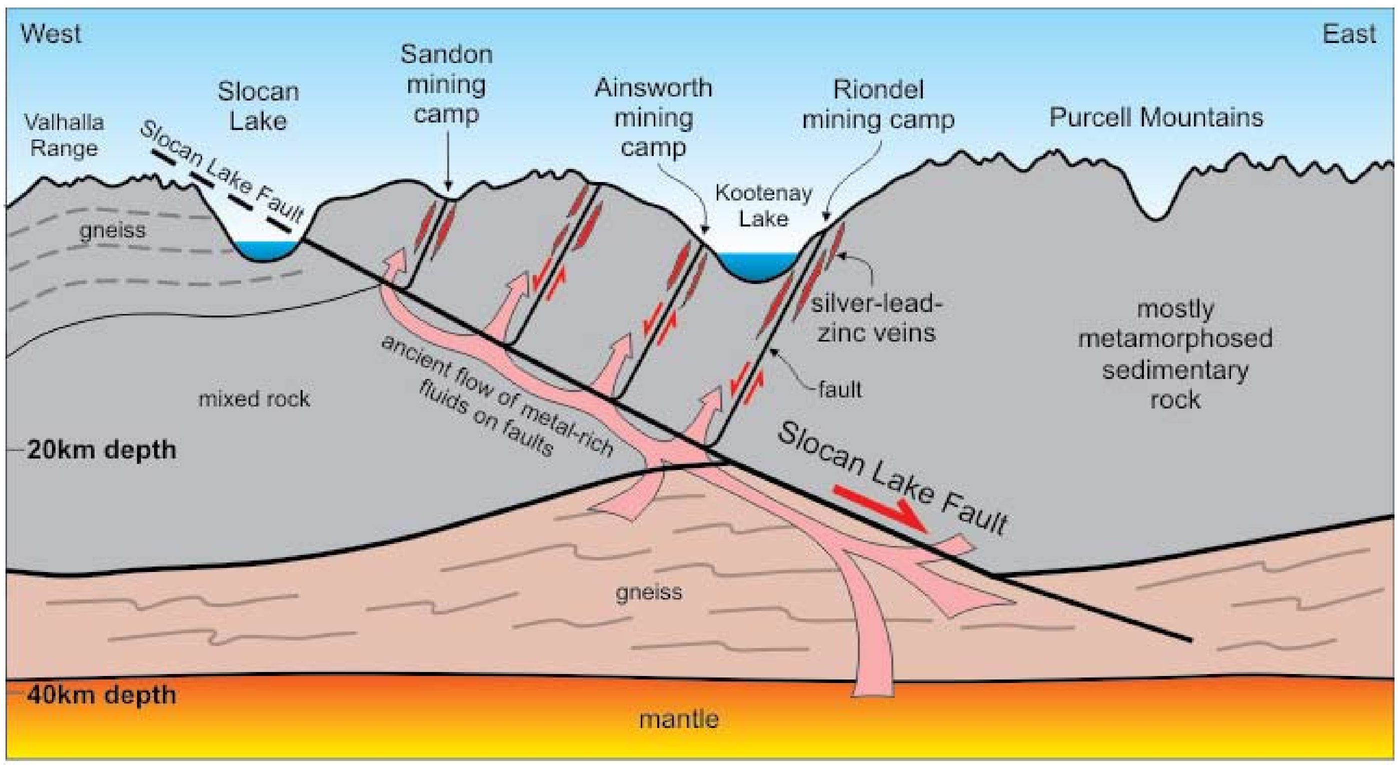


Figure 55. A cartoon cross section of the Earth's crust below the West Kootenay region. The Slocan Lake fault cuts the Earth's crust almost to the mantle. Fifty million years ago, movement on this fault lifted hot rock to shallow depths, driving vigourous circulation of hot metal-bearing ground waters along faults and fractures. These hot waters formed many veins of ore that later became the mining camps of Ainsworth (Site 4) and Sandon (Site 9)

HOW TO GET THERE Check in Sandon for current road conditions to Idaho Peak. The road is unsurfaced, steep, and narrow, but is usually okay for cars (not RVs and trailers). The 11 km road begins behind the museum in Sandon and climbs the steep forested slopes of the Carpenter Creek valley. The road passes several former mines marked by dumps of waste rock from tunnel development. There is an excellent view of Sandon and Carpenter Creek valley near kilometer 8 (Figure 45). After kilometer 9, the road enters subalpine meadows and then climbs across a bowl of alpine grasses and wildflower meadows to the parking lot and trail head on the ridge line. The parking lot is cut into the ridge, revealing layers of brown sandstone and black shale. A half hour walk follows the ridge to the lookout on Idaho Peak.

(SITE 11) NEW DENVER AND SILVERTON: TWIN TOWNS, MINING HERITAGE, AND BEACH GEOLOGY

Figure 56. ***(Left)*** *Downtown Silverton and* ***(Right)*** *New Denver.*

New Denver and Silverton are picturesque towns on the shores of Slocan Lake founded during the heyday of the Silvery Slocan mining boom in the latest 1800's. Both villages have interesting heritage buildings and mining-era museums, are built on gently sloping fans built by mountain streams, and have dramatic views of the lake and Valhalla Range. All of these provide for interesting geological stories that deserve your time.

MINING ERA MUSEUMS

Figure 57. *Silverton Historical Society's interpretive centre in Silverton displays equipment rescued from local Silvery Slocan era mines. A pamphlet available at the interpretive centre allows a self-guided tour of ore rail cars, rock drills, a hoist for lifting men and ore up a shaft, a stamp mill for crushing ore, air compressors for forcing air through the mines for ventilation or for powering equipment, and more. A reconstructed aerial tramway with ore buckets demonstrates how ore was carried down steep mountain slopes from the mines to the mills in Silverton.*

Figure 58. *The Silvery Slocan Museum in New Denver is located in the old Bank of Montreal building near the foot of Main Street. During the 1890's silver rush, ore from Sandon (Site 9) was transferred to sternwheeler ships at New Denver for transport down Slocan lake to the railway at Slocan City.*

Reading the Geology of the Hills at Silverton Creek

__Figure 59.__ Silverton Creek has built a gently-sloping gravel fan into Slocan Lake that contrasts with the more widespread steep rock shorelines. The gravel has been eroded from the mountains drained by Silverton Creek.

__Figure 60.__ Viewed from above, the Silverton Creek fan has a semicircular shape created as gravel was deposited by Silverton Creek into Slocan Lake over 10,000 years. The view is looking down from Idaho Peak __(Site 10)__.

At the bottom of 4th Street in Silverton is a small park where Silverton Creek enters Slocan Lake. A short walk leads to the lakeshore beach and mouth of the creek. Boulders on the beach and at the creek mouth are dominantly two types: granite, and layered sandstone-shale. This suggests that these two rock types dominate the mountains drained by Silverton Creek. The geological map of the West Kootenay in Figure 5 confirms this to be true.

Note that most of the boulders (>25 cm) on the beach are granite, while pebbles (~2-10 cm) are mostly sandstone and shale. This difference reflects how each rock tends to erode. Granite typically has widely-spaced fractures and therefore breaks into large blocks. Granite blocks are often tough enough to survive the bouncing and grinding of stream travel with just a rounding of corners to show for it. Sandstone and shale on the other hand contain many fractures and tend to break into small pieces. During stream transport, these small fragments round into pebbles.

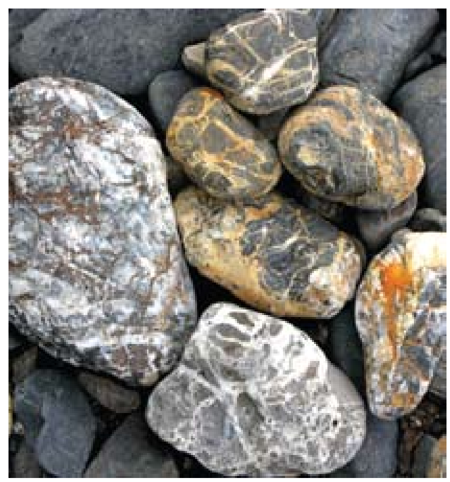


__Figure 60. (Left)__ Granite pebbles from Silverton beach have a distinctive salt-and-pepper texture, while __(Centre)__ sandstone and shale are identified by a characteristic layering. __(Right)__ Some pebbles on Silverton beach contain fractures filled with white and rusty minerals. These are eroded from veins. The white mineral is quartz and the rust is an iron oxide derived from the weathering of iron-bearing minerals. Iron minerals such as pyrite and siderite are often associated with silver ore, and these pebbles of vein material would have interested early silver prospectors who happened on Silverton Creek.

It might surprise you but prospectors weren't just looking for gold in their pans. They were also looking for silver. Silver ore wasn't valuable enough in the earliest days when a prospector had to carry his gains by foot. However, interest in silver blossomed once a network of pack horse trails was established, and there were rumours that railways and paddle wheelers were coming. The major silver ore is the lead-silver mineral galena. Like gold, galena is heavy. Unlike gold, it is not very durable, so it breaks down faster in streams. But enough galena survives the trip downstream to make it useful to prospectors. Using their pans, they traced the galena upstream and this was the best way to find bedrock silver lodes.

(SITE 12) MAX MOLYBDENUM MINE, TROUT LAKE: A BRAND NEW MINE

The new MAX molybdenum mine is near the remote Kootenay community of Trout Lake (Figure 2). Opened in 2007, the mine is an example of how modern mines must develop within a strict environmental regulatory framework. The mining operation blasts and hauls ore from underground workings to a mill building where the broken rock is crushed and ground to fine particles, and the molybdenum minerals separated. A truck load of molybdenum concentrate leaves the mine once or twice a week, bound for refining in England via rail and ship.

Figure 62. (Left) The mill at the MAX mine. (Right) MAX mine buildings viewed from the valley floor near Trout Lake.

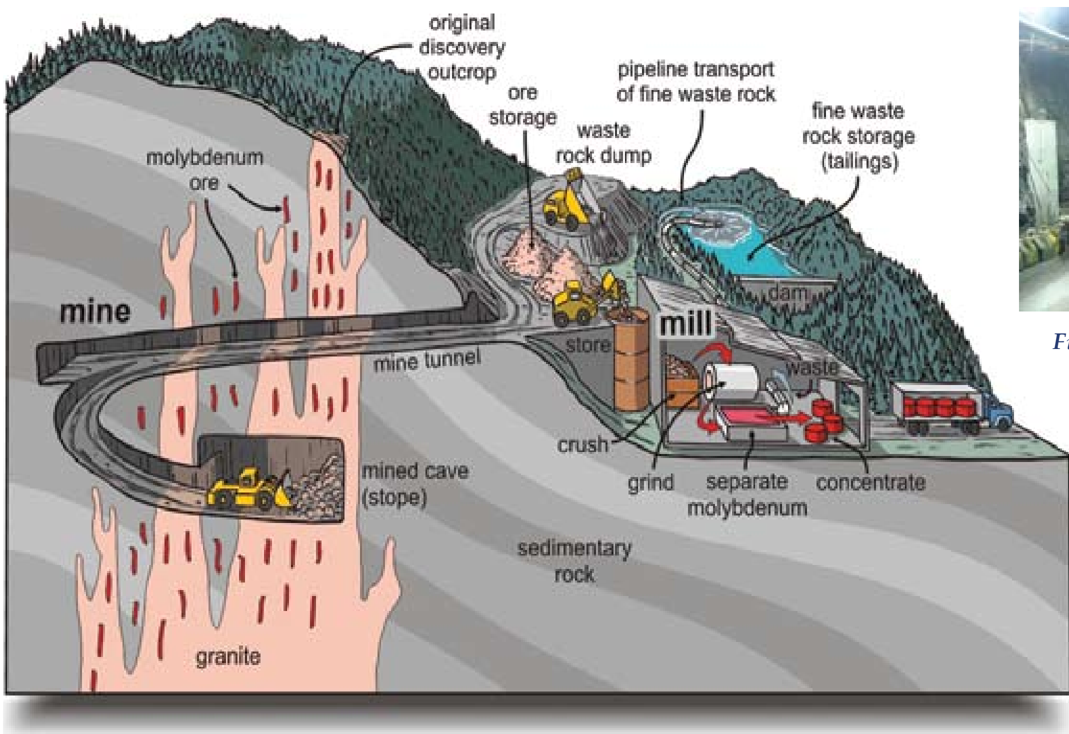


Figure 64. Underground tractor for scooping and hauling blasted ore.

Figure 63. This cartoon diagram illustrates the components of the MAX mine. The ore lies within the mountain, associated with a granite intrusion. The mine was found by prospectors who discovered molybdenum ore exposed on surface, high on the mountain. Follow up drilling from surface near the original discovery outcrop indicated a large buried ore body. A tunnel was excavated into the mountain to access the ore body. The mining process starts with blasting of the ore, and transfer of the broken ore to the mill. In the mill, rock is crushed and ground to a fine sand. Molybdenum sand is separated from waste rock sand, creating a molybdenum concentrate that is shipped by truck to a railway for transfer to a smelter. Waste sand is carried as a slurry in a pipeline to a nearby storage pond where it is permanently stored.

Figure 65. *MAX mine.* ***(Left)*** *The entrance to the mine. A small train carries ore out of the mine. Large fans draw air into pipes that take fresh air into all parts of the mine.* ***(Centre)*** *White quartz veins contain abundant grains of molybdenum.* ***(Right)*** *A close-up of molybdenum ore: abundant grains of molybdenite (molybdenum sulphide; dark grey), pyrite (brass colour), and quartz (white).*

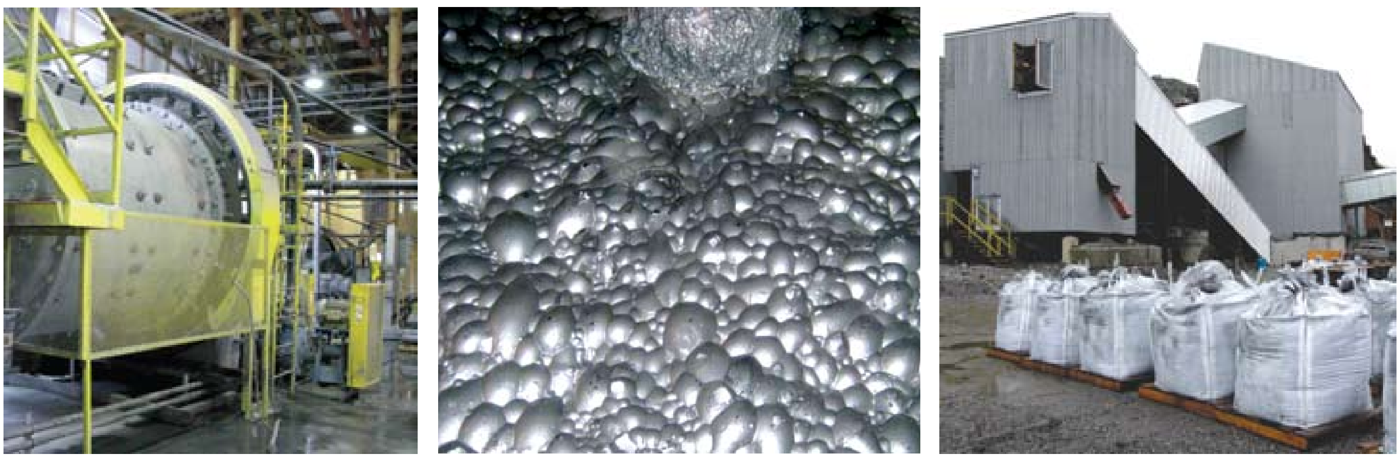
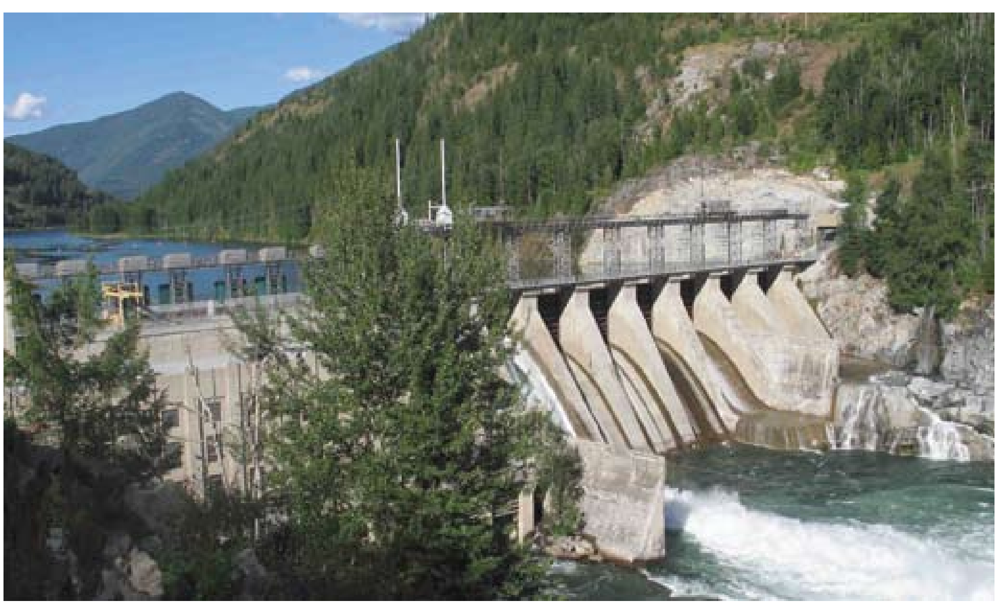


Figure 66. *Mill building at the MAX mine.* ***(Left)*** *A rotating ball grinder reduces rock fragments to fine sand-size fragments.* ***(Centre)*** *A close-up of the froth of concentrated molybdenum rich fines in the flotation process (Photo courtesy of Roca Mines). Molybdenum is separated from waste material in this flotation process.* ***(Right)*** *Bags of dried concentrate awaiting shipment.*

(Site 13) KOOTENAY RIVER HYDROPOWER PLANTS: POWERING THE KOOTENAYS BECAUSE OF AN ANCIENT DIVERSION



Kootenay Lake drains into the Columbia River through a short stretch of Kootenay River between Nelson and Castlegar. Highway 3A follows the Kootenay River as it drops 120 m between Nelson and Castlegar. A series of dams and associated hydroelectric power plants harness this great weight of falling water.

Figure 67. *The Brilliant dam and hydroelectric power plant on the Kootenay River from a viewpoint along Highway 3A.*

Early mining and smelting in the West Kootenay created a great demand for power. The first hydroelectric plant was built in 1897 at Bonnington Falls to provide power to the mines in Rossland, 50 km away. The transmission line carried 22,000 volts and, at that time, was the longest and highest voltage transmission line in the world. Additional dams allowed the development of the giant smelter at Trail, and the Sullivan mine at Kimberley. Today, eight power plants on the Kootenay River produce 1100 megawatts of electricity, enough to power 500,000 homes.

An ancient diversion of the Kootenay River?

The Kootenay River between Nelson and Castlegar is curious. For a big river, it has a narrow valley with many rapids and falls. The steep gradient has been exploited for its hydroelectric potential, and this reach of the Kootenay has a remarkable concentration of hydroelectric power stations. The narrow valley and steep gradient is distinctly unlike the Kootenay River upstream of Kootenay Lake, where the big river flows with a gentle gradient down a large valley.

Geologists have puzzled over the route of the Kootenay River. The river flows south down the Rocky Mountain Trench in the East Kootenay, then reverses course in the U.S.A to flow back into Canada near Creston and into Kootenay Lake. Kootenay Lake then drains through the narrow valley of West Arm past Nelson to tumble down a canyon to the Columbia River at Castlegar. To explain this curious routing, geologists offer the following explanation. Waters in both the Rocky Mountain Trench and Kootenay Lake valley once flowed south into an ancient Columbia River. About 10 million years ago, the eruption of extensive lava flows throughout eastern Washington State blocked this southward flow (Figure 6), backing up the waters as an ancient Kootenay Lake until they spilled over a low divide in the West Arm valley. This new Kootenay River was able to cut down along a fractured fault zone that underlies the West Arm valley, forming a narrow canyon. During the Ice Age, south flowing ice scoured and deepened the north-south trending valleys of the Kootenay and Columbia Rivers, but had little impact on the west-oriented West Arm, and so this valley remained narrow and steep. As the glacier ice was melting, a glacial lake filled the southern arm of Kootenay Lake and drained to the south, while the northern and western parts of Kootenay Lake were still filled by glacier ice. Once all the ice had gone, the Kootenay River resumed its flow from the West Arm down the narrow canyon to the Columbia River at Castlegar.

Figure 68. *Upper Bonnington falls and power station on the Kootenay River.*

How to get There. North-bound traffic on Highway 3A has access to several pull outs that provide viewpoints of hydroelectric facilities. The southernmost is the Brilliant Dam pullout, about 2 km north of the Brilliant Bridge over the Kootenay River. The Brilliant Dam was constructed during WWII to provide additional power to the Trail smelter. In the early 2000's, an additional power plant was installed to gain energy from water normally spilled over the dam.

Highway 3A bridge at Brilliant. A short stretch of untamed Kootenay River can be viewed from the Highway 3A bridge across the Kootenay River on the outskirts of Castlegar. At the bridge, the Kootenay River flows out of a narrow granite walled canyon and into the open Columbia River valley, where the river broadens with gravel bars and back channels. Grohman Narrows Provincial Park, near Nelson, also provides views of the untamed Kootenay River.

(SITE 14) COLUMBIA RIVER LOOKOUT AT CASTLEGAR: TERRACE TOWN ON A GIANT RIVER

Figure 69. View of Columbia River valley at Castlegar from the viewpoint on Highway 3. Castlegar is built on a staircase of terraces, ancient river plains of the Columbia River abandoned as the river cut downwards.

The entire West Kootenay region is drained by the Columbia River and its tributaries. A viewpoint near Castlegar provides a grand view of this giant river and its valley. The Columbia is the largest river flowing from the Americas into the Pacific Ocean. The Columbia River is ancient. Its flow was interrupted during the Ice Age when the entire region was covered with 2 km of glacier ice. Once the climate began to warm about 12,000 years ago huge plugs of ice blocked the major valleys. Glacier melt-water streams flowed between the ice and the valley wall, and deposited vast quantities of sand and gravel that now form the highest terraces in these valleys. These terraces make excellent sites for golf courses at New Denver, Nelson and Castlegar. As the ice continued to melt, temporary glacial lakes developed and silt was deposited as well as delta sands and gravels. Eventually the Columbia and Kootenay Rivers resumed flow and began to cut through the silt, sand and gravel deposits. Over time, this downward cutting stranded former river plains. Today, Castlegar is built on a staircase of flat terraces or benches, each representing a former valley floor, and reflecting the progressive down cutting of the Columbia River. The Castlegar airport is built on one of the uppermost of these ancient river plains, a flat bench high above the current level of the river (Figure 71). Gravel pits in these benches exploit the sand and gravels laid down by ancient flows of the Columbia River.

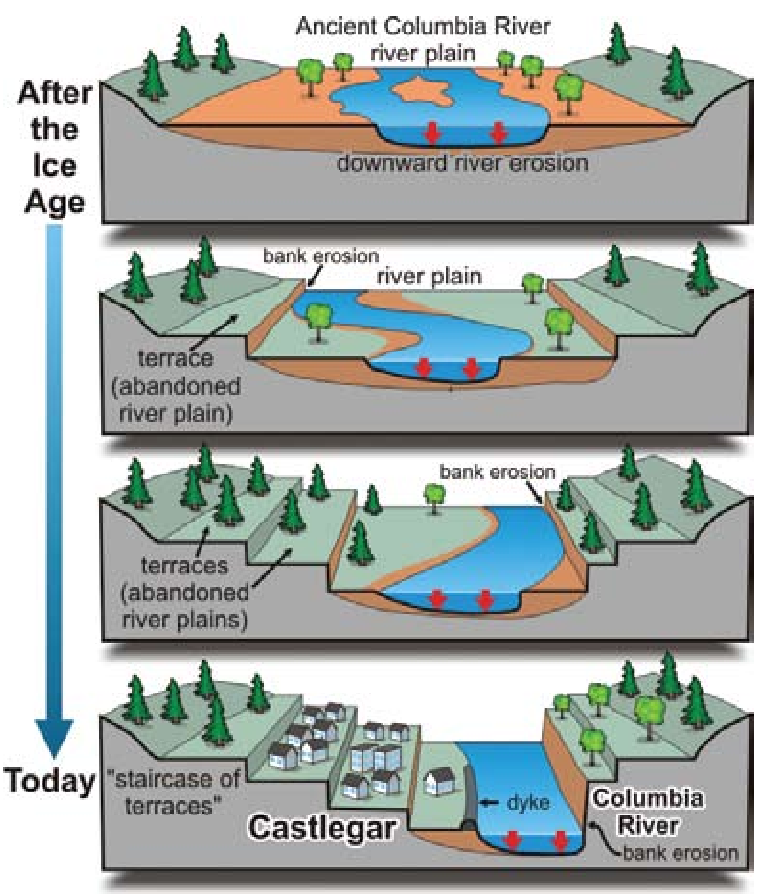


Figure 70. A schematic illustration of how the Columbia River has created a staircase of terraces over time.

__Figure 71.__ A view of Castlegar Airport from Highway 3. The airport sits on a former river plain of the Columbia River high above the present level of the river.

How to Get to There: The rest site and viewpoint is on Highway 3 towards Salmo about 6 km southeast of Castlegar, and near the top of a long grade that climbs out of the Columbia River valley. An access road cuts through a ridge of rock to a parking lot. At the north end of the parking lot is an information sign and a view north towards Castlegar. There is a short and pleasant walk up a forested ridge to two additional viewpoints. Rock throughout the lookout area has a 'stretched' granite look – it is a granite rock that has been deformed under high temperature and pressure.

(Site 15) TRAIL SMELTER VIEWPOINT & INTERPRETIVE CENTRE: INDUSTRIAL GIANT AND A STORY OF ENVIRONMENTAL RECOVERY

The Columbia River valley at Trail combines a dramatic natural landscape and intensive industrial use. The valley is narrow and deep, with great rock cliffs on the eastern valley wall. The valley floor is a striking staircase of flat benches that extend from river level to 200 meters elevation. The large metallurgical complex sits on a high bench overlooking the city of Trail. The fertilizer operation that utilizes sulphur from metal ores is situated on a higher bench to the east at Warfield. In addition to the benches, the landscape has a curious aspect. The valley slopes lack the conifer forests typical of the West Kootenay; instead there are expanded areas of exposed rock and much of the forested area is dominated by small broadleaf trees. On close inspection, bedrock exposures commonly have a brown to black mineral coating that gives the rock a drab look. What's up?

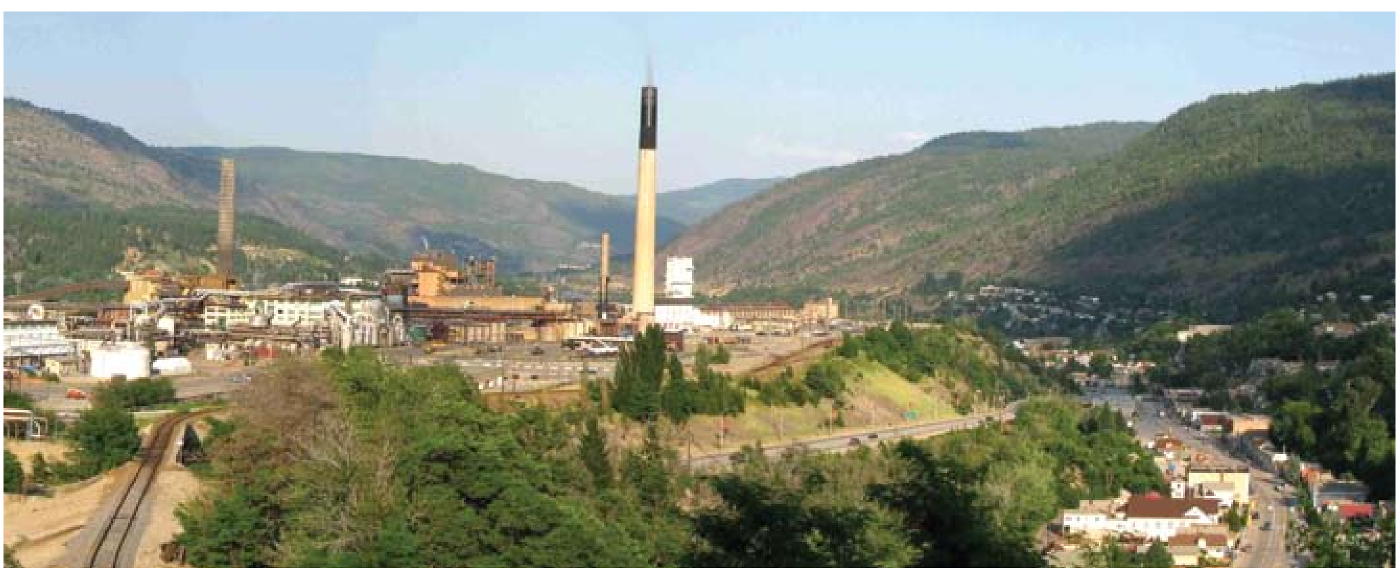


__Figure 72.__ A view of the Teck Resources Limited smelter complex and the City of Trail in the Columbia River valley from the viewpoint on Warfield Hill Road. The smelter sits on a flat terrace, the eroded remnant of a former river plain of the Columbia River. The Columbia River has since cut downwards to its current level (see __Site 14__ for explanation).

A LONG HISTORY OF MINING AND SMELTING

In 1896, a copper furnace was built at Fritz Heinze's BC Smelting and Refining Company at Trail Creek Landing to treat the copper and gold ores from the nearby Rossland mines (Site 16). He also built a railroad from Rossland to Trail, then west to the Boundary country to serve the mineral industry in the Grand Forks and Greenwood areas. The Canadian Pacific Railway bought the railroad and smelter in 1898, forming the subsidiary, the Canadian Smelting Works. That same year, the first hydroelectric power plant of the West Kootenay Power and Light Company was completed at Lower Bonnington falls on the Kootenay River (Site 13), supplying power to the smelter and mines.

The small smelter began processing lead-silver ores from the Slocan area near Nelson in 1899, and, by 1902, the world's first electrolytic lead refinery began operation at Trail. In 1906, the Canadian Smelting Works merged with several of the Rossland mines to form The Consolidated Mining and Smelting Company of Canada Limited (CM&S), later to be known as Cominco.

In 1916, CM&S developed a method of producing zinc by electrolysis, particularly for World War I needs. The company thus began to make use of the huge zinc content of the Sullivan mine at Kimberley in the East Kootenay. To ensure the large electric power requirement for the metal production of the future, CM&S acquired control of the West Kootenay Power and Light Company that same year. By 1920, engineers had developed a differential flotation process that made possible the separation of lead, zinc and iron minerals as high grade concentrate and, thus, unleashed the great value of the giant resources of the Sullivan mine, which operated for 92 years.

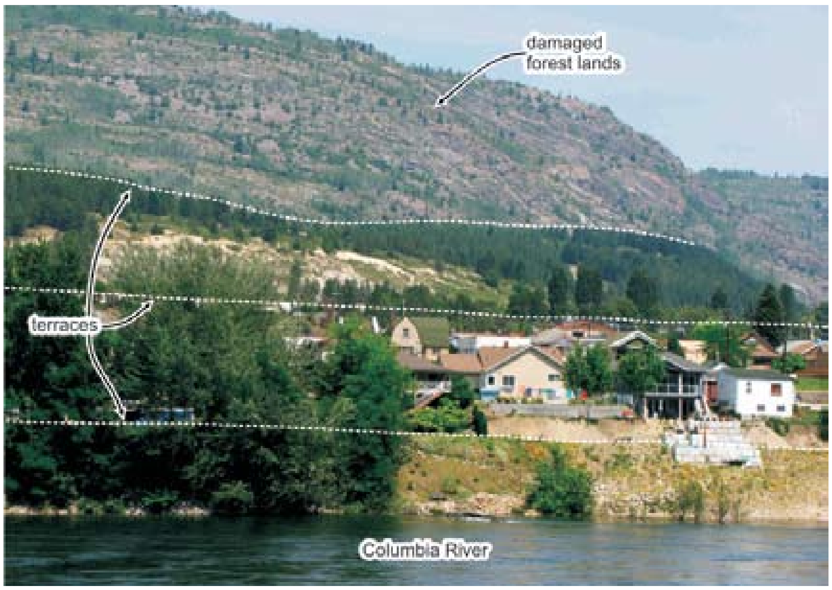


Figure 73. Barren rocky slopes rise above a staircase of gravel and sand terraces in the Columbia River valley at Trail. Broadleaf and conifer forests are re-establishing on the rocky upper slopes of the Columbia River valley after environmental damage caused by sulphur dioxide emissions from early smelter operations.

ENVIRONMENTAL IMPACTS

Up until the early 1970s, environmental practices at the smelter were rudimentary by today's standards, though in keeping with the technology of the day. Today, broadleaf and conifer forests are re-establishing on the rocky upper slopes of the Columbia River valley after decades of plant and soil damage caused by sulphur dioxide and acid rain from the smelter operation.

Over $1 billion has been invested in technological and environmental modernization since the late 1970s. A new lead furnace came on line in 1997 that has greatly reduced air and water emissions of sulphur dioxide and metals. This has accelerated the recovery of natural vegetation and the growth of millions of trees planted by the company and community groups since the 1940s.

Teck Trail Operations conducted a comprehensive ecological risk assessment from 2000 to 2008 to identify

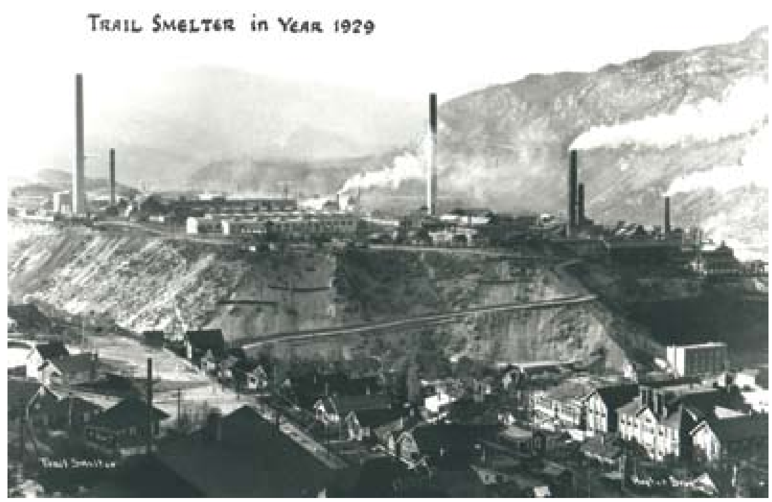


Figure 74. A view of the smelter complex at Trail in 1929. This smelter treated ores from important Kootenay mines at Kimberley, Rossland, Riondell, and elsewhere. Environmental damage to local forests and waterways from smelter emissions occurred during these early years. Note that the smelter is built on a high bench, a relict of a former valley floor left stranded by downward erosion by the Columbia River and tributary streams. Photo is courtesy of the Teck Cominco Metals Ltd.

impacts on vegetation from past emissions. The company is developing an ecosystem management plan for the area around the smelter jointly with government, industry and other stakeholders to remediate, enhance, and protect impacted and other habitats nearby. A two-year, $6 million restoration of the riverbank below the Trail smelter was completed in 2008.

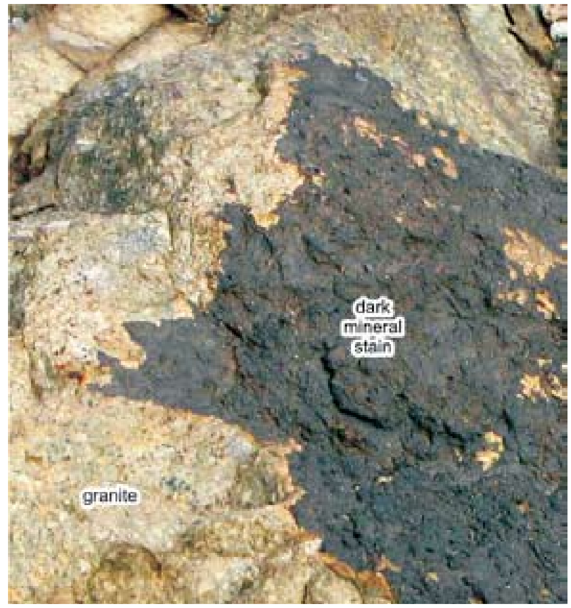


***Figure 75.** . **(Left)** Barren roadside rock along Highway 3B on the southern outskirts of Trail reflects damage caused by smelter emissions on nearby forests and soils. Loss of forests led to erosion of soils, and acid leaching of the rock has resulted in a brown coating of iron oxide. **(Right)** Close-up of a dark stain on pale-coloured granitic rock.*

The Teck Trail Operations Interpretive Centre

The Teck Trail Operations Interpretive Centre, located within the Trail & District Chamber of Commerce, is a small science centre that presents the smelting and refining process and features a variety of hands-on exhibits. Exhibits profile the many uses of metals in everyday life, exploring for mines, and the story of historic environmental impacts and recent improvements in the Trail area. Tours of the Electrolytic and Melting Plant begin at the Interpretive Centre at 10 am weekdays. Reservations can be made through the Chamber of Commerce at 250-368-3144. The colourful story of Cominco history is told at the Rossland Museum (Site 16).

***Figure 76**. There are excellent displays in the Teck-Trail Operations Interpretive Centre.*

How to get There.

To view the smelter complex, turn off Highway 22 north of Trail at Warfield Hill Road opposite the entrance to the smelter complex. A short drive uphill leads to a parking lot with a small park, table and viewpoint. The Teck Trail Operations Interpretive Centre is located within the Trail Chamber of Commerce at 1199 Bay Avenue.

(SITE 16) LE ROI GOLD MINE, ROSSLAND : GOING UNDERGROUND INTO A HISTORIC MINE

Early mining in the West Kootenay created a wealth that led to the development of major towns with affluent architectures, rail lines, and hydroelectric generating stations. Rich West Kootenay mines made Nelson, Rossland, and Trail progressive communities with some of the earliest electrification in BC. The West Kootenay would be a very different place today had not forestry, agriculture, and tourism built on infrastructure developed by mining.

Figure 77. A restored head frame and other historical mine equipment complement the museum and mine tour at the Le Roi mine.

ROSSLAND'S MINING HISTORY

Gold-copper ores were discovered in 1890 on Red Mountain. The town of Rossland sprang up nearby to service the mines. In the earliest days, ore was packed by horse down the steep route along Trail Creek to Trail on the Columbia River, where it was taken by paddle wheeler to smelters in the United States. In 1896, a smelter started in Trail to process Rossland's gold and copper ores (Site 15). Later, a rail line hauled Rossland ores to Trail, descending the steepest rail grade in Canada. Over a period of three decades, Rossland mines produced about three million ounces of gold, making it the second largest gold-producing area in British Columbia history. Only the Bralorne camp near Lillooet exceeded its gold production.

The Le Roi mine in Rossland was a major gold and copper producer from 1895 to 1927. This mine was the birth place of Cominco, a major corporation in the history of Canadian mining. Cominco began as the consolidation of several Rossland mines into a combined operation. The mine tour and museum opened in 1967 and today is a National Historic Site. It provides an excellent view of mining life at the turn of the century. Tours are available throughout the summer months.

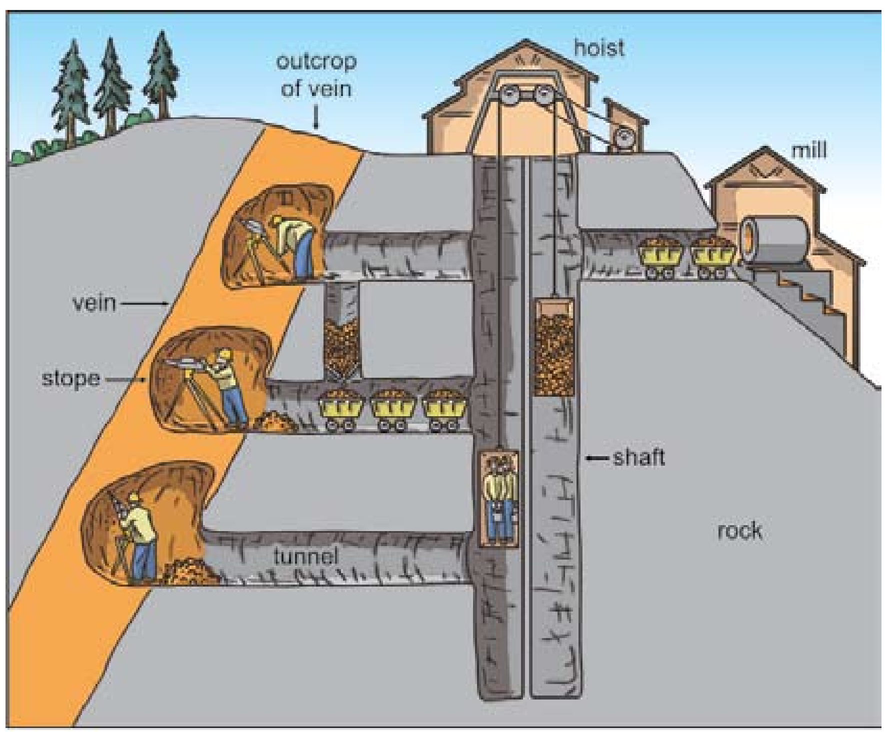
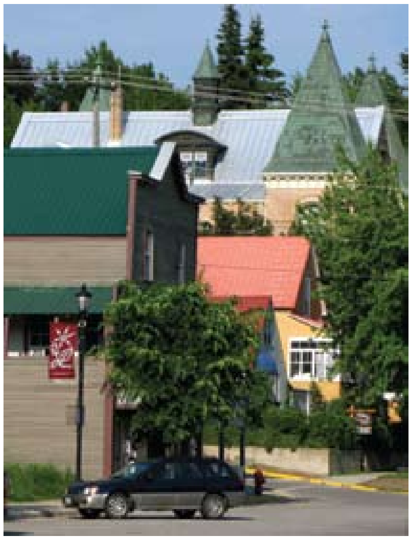


Figure 78. A schematic diagram of an underground vein mine. A shaft provided access to a series of mine tunnels at different levels, each leading to a working area (stope) where ore was mined. Ore was transferred by ore cart and hoist to a mill, where the ore was crushed to sand and ore particles were separated from waste rock particles.

WHAT DO YOU SEE?

The mine is just west and uphill of Rossland on Highway 22 at the junction with Highway 3B.

Outdoor and indoor displays near the mine entrance include a head frame, air compressor, aerial ore tram, and a rock garden displaying a variety of different rock types. An interesting 45 minute guided mine tour is available in the summer and follows a route through the old mine workings, passing underground workings where ore was removed (stopes), ore chutes, and displays of historic drilling and blasting techniques.



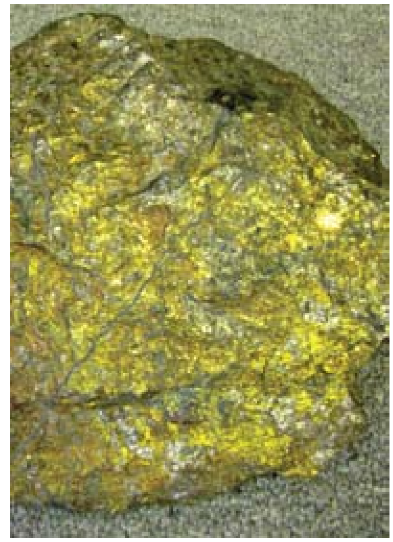


Figure 79. (Top Left) *Heritage buildings in Rossland date from the gold mining era.* ***(Top, middle)*** *On the underground tour at the Le Roi mine.* ***(Top, right)*** *Copper-rich gold ore from the Le Roi mine.* ***(Left)*** *Ammonite fossils found in rocks near Salmo indicate Salmo and Rossland area rocks formed below an ancient sea.*

What is the Geology of the Le Roi Mine?

Gold and copper were mined from large steeply sloping veins in the Le Roi mine. The veins contained quartz and calcite along with iron and copper minerals, and tiny grains of gold scattered throughout the ore. The veins cut through ancient volcanic rocks. Geologists interpret these volcanic rocks to be 190 million years old and believe that they formed as volcanic islands in an ancient sea. Similar rocks near Salmo contain ammonite fossils that lived in this ancient sea. Within this volcano, the Earth's forces created large faults that were pathways for hot mineral-bearing fluids circulated by volcanic heat. The Le Roi vein was one such fracture zone, and quartz along with gold, copper minerals, and pyrite precipitated in the fractures, filling it with a multimillion dollar bonanza. Over millions of years, these rocks were subjected to burial and later deformation during mountain building. Millions of years of uplift by the Earth's forces coupled with ongoing erosion exposed them at surface. And then one day a prospector came along.

(Site 17) Downtown Salmo :
Stone Murals of 540 Million Year Old Rock

Salmo is a small village with old fashioned wooden buildings and a long history of mining. Salmo also has some of the best rock art in the Kootenays. Artists have created stone murals with local flagstone depicting a variety of scenes including prospectors and wildlife. The flagstone is quarried in the nearby mountains from layers of hard quartz sandstone or quartzite. The quartzite is naturally white in colour, but rusting of iron-bearing minerals such as pyrite can stain the rock brown, tan, yellow or cream.

Figure 80*. A stone mural of a prospector panning for gold adorns a wall in Salmo*

***Figure 81**. **(Left)** Close-up of quartzite in stone murals. Natural iron oxide pigments stain the white quartzite rock a variety of colours.*

***(Right)** Flagstone quartzite is sorted and loaded on palettes for shipping at a works yard along Highway 3 south of Salmo. The flagstone is dug from shallow quarries less than 5-10 m deep. Shallowly buried quartzite is naturally fractured along its layering by water that freezes and thaws due to temperature variations. More deeply buried rock that doesn't undergo seasonal temperature changes, isn't naturally fractured, and therefore won't split easily.*

The quartzite formed about 540 million years ago, after sands deposited by rivers along the coastline of ancient North America consolidated. This was a time before land plants and animals, and only rudimentary fishes swam the seas. A few million years later, further north at a location now along the TransCanada highway at Field, the famous fossils of the Burgess Shale accumulated in seafloor mud. The rest of today's British Columbia, had yet to form! So when you gaze at the murals, you are looking at history as well as art.

Gold mining history in Salmo

Salmo is an old mining town in the Salmo River valley. Prospectors found gold in gravel at the confluence of the Pend Oreille and Columbia Rivers downstream from Trail. Panning their way upstream, they found more gold in the Salmo River, and followed it upstream to gold-bearing outcroppings in the mountains near Salmo. During the 1880's and 1890's, a number of gold mines went into production, blasting shafts and tunnels along quartz veins that contained scattered grains of gold. Ymir, 10 km up the valley from Salmo, became a town of 1000 people with 13 hotels and rooming houses. Later, nearby mines produced silver, lead, zinc, and tungsten until the 1970's worth billions of dollars. The broad flat-topped terrace of mine tailings along Highway 3/6 south of Salmo was produced by the HB-Jersey lead-zinc mine that closed in the 1970's (Figure 5). This mine alone produced about $1 billion dollars worth of ore, and employed over 300 miners for more than 40 years.

***Figure 82**. An early prospector finds placer gold that leads to the discovery of hard rock gold mines near Salmo. The mines were found by tracing the placer gold upstream to its source.*

Gold panning: stream ore versus mother lode bedrock ore

Streams naturally contain eroded bits of all the geology from the areas that they drain. Prospectors followed rivers upstream, panning the mouth of each tributary. If there was gold in their pan, they followed the tributary upstream. If there was nothing of interest in their pans, they continued up the river to the mouth of the next tributary. Heavy materials such as magnetite (black sand), galena, silver ores, and garnet would be found along with gold in the concentrate at the bottom of a pan.

The earliest prospectors were looking almost exclusively for gold, because it was the only thing valuable enough to carry back to civilization on foot. Placer gold was the best type of gold; it was found free as nuggets in the stream, and only required a pan or small equipment to recover. Some prospectors followed the gold upstream to the mother lode in bedrock, but bedrock gold is more difficult to mine and requires blasting and significant labour.

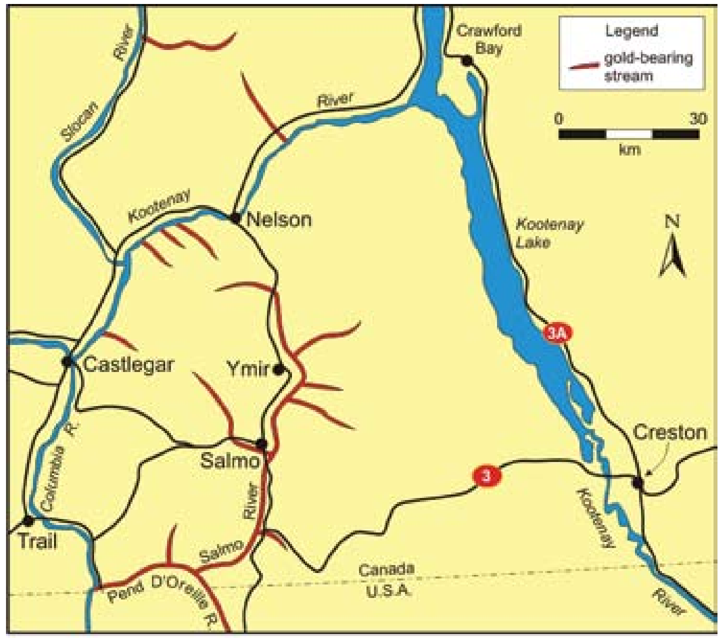


Figure 83. *Map of gold bearing streams in the West Kootenay. Most are in the drainage of the Salmo River*

SOME OTHER POPULAR READINGS OF LOCAL INTEREST

Edward L. Affleck, 2001, *High Grade & Hot Springs, A History of the Ainsworth Camp*, Ainsworth Hot Springs Historical Society.

Joan Donaldson-Yarmey, 1996, *Back roads southern Interior British Columbia*, Lone Pine Publishing, Edmonton
(Includes descriptions of sites along several highways in the West Kootenay).

Don Gayton, 2002, Kokanee – *The Redfish and the Kootenay Bioregion*, Transmontus/New Star Books.
(Discussions of late Ice Age and modern lakes and rivers, and historic impacts of human activities in the Kootenay on Kokanee salmon).

Larry Jacobsen, 2008, *Jewel of the Kootenays: The Emerald Mine*, Salmo Arts and Museum Society
(The mine, its history, and its many personalities written by a former miner).

Bill Mathews and Jim Monger, 2005, *Roadside Geology of southern British Columbia*, Mountain Press Publishing Company
(Roadside geology of some Kootenay highways including Castlegar Lookout and Salmo stone murals and a comprehensive discussion of geologic history of southern British Columbia).

J.D. McDonald, 1995, *The Story in the Rocks: The Geology of Rossland*, *BC*, Rossland Historical Museum Association.
(An introduction to the geologic history of Rossland and its ore deposits).

John Norris, 1985, *Old Silverton, British Columbia*, *1891 – 1930*, Silverton Historical Society
(A local historian brings Silverton alive with the lives of the miners and entrepreneurs who founded this picturesque mining community).

Veronika Pellowski, 1992, *Silver, Lead and Hell: The Story of Sandon*, Prospector's Pick Publishing, Sandon.
(A lively account of Sandon and its mining history).

Eugene (Pelle) Peterson, 1993, *Window in the Rock*, Ye Galleon Press.
(A fascinating story written by a Sandon prospector and miner).

Terry Turner, 1997 & 2000, *Bluebell Memories: A Pictorial History of the Bluebell Mine, Riondel, BC*, Riondel & Area Historical Society.
(Written by a retired geologist, this pictorial history shares the experiences of residents as they reflect on this legendary mine).

Terry Turner and Susan Hulland, 2002, *Impressions of the Past, The Early History of the Communities of Crawford Bay, Gray Creek, Kootenay Bay, Pilot Bay and Riondel, on the East Shore of Kootenay Lake, British Columbia*, Riondel & Area Historical Society.

Eileen Van der Flier-Keller, 2006, *A Field Guide to the Identification of Pebbles*, Harbour Publishing
(A handy fold-out pamphlet that identifies over 28 different types or rocks and minerals, with the aid of 80 beautiful photographs of pebbles from beaches and rivers).

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