A tour of the Geoscience Garden

The Geoscience Garden contains about 80 rocks, arranged to simulate rock outcrops that tell the story of the Earth's crust in western Canada. This tour visits about 25 of them, and illustrates many of the most abundant rock types in the Earth's crust, as well as some unusual ones.

Rocks are commonly classified into three categories:

- ***Igneous***: rocks formed from molten magma which has solidified
- ***Sedimentary***: rocks deposited on the Earth's surface through the action of water, air, or living things.
- ***Metamorphic***: rocks that have been changed (while solid) by heat, pressure, and tectonic movements within the Earth.

In practice, there are rocks that combine the characteristics of more than one group. For example some of the igneous and sedimentary rocks in the garden have been slightly metamorphosed, but many of their original characteristics may still be visible. There may be more than one right answer to the question "what kind of rock is this?"

Most of the rocks in the Garden are marked by plaques, set in the ground. Each rock is marked by a number (top right corner) and a link to the web site http://gg.eas.ualberta.ca where you can find more information.

Start at the sign marked by a tall basalt column at the east end of the Garden. On this sign you will find information about the eastern part of the Garden, which represents the **Canadian Shield**, a vast area of very old rocks extending from Labrador in the East to Alberta and the Northwest Territories in the west.

From the sign, travel west to see...

69 **(Meta-) Basalt.** Basalt is one of the most common types of rock in the Earth's crust. It is an igneous rock that forms from lava originating by melting in the Earth's mantle. Basalt forms most of the Earth's ocean floor. It also occurs widely in the Canadian Shield. The rocks in this area come from near Yellowknife, and record volcanic activity that occurred about 2.7 billion years ago. This basalt has been slightly metamorphosed by heat and pressure during its long history, so is more properly called metabasalt or greenstone. Although this has produced some new minerals in the rock, its general appearance is still typical of basalt.

Walk west to...

62, 65 **Granite.** Granite is another very common type of igneous rock. Granite magma forms mainly by melting within the Earth's continental crust, caused by heat from below. Granite is an intrusive rock, meaning that the magma cooled slowly while it was still underground. This caused it to crystallize into large mineral grains. You may be able to see grey, glassy-looking ***quartz***, two different kinds of ***feldspar*** (paler grey and pink), and small shiny grains of ***mica***.

Travel SE to see some much more unusual rocks:

25-32 **Nepheline Syenite Gneiss.** Occasionally, melting in the crust or the mantle can produce magma with unusually large amounts of sodium or potassium. Rocks derived from such magma are known as "alkaline rocks". They are much rarer than the igneous rocks at the previous two stops. At this stop you can see a syenite containing the sodium-rich minerals ***nepheline*** (grey), ***cancrinite*** (orange) and ***sodalite*** (blue). These rocks have been somewhat deformed, giving them a foliation.

33 **Carbonatite.** Most igneous rocks are composed mainly of minerals that contain groups of silicon and oxygen atoms (*silicate* minerals). Much more rarely, igneous rocks are found that contain minerals with groups of carbon and oxygen atoms (***carbonate*** minerals). Such igneous rocks are called carbonatites. This example is mostly made of a yellowish carbonate mineral called ***dolomite***, together with small amounts of the black silicate mineral ***richterite.*** Carbonatites are often found together with alkaline rocks in the Earth's crust.

Walk west, passing many other igneous and metamorphic rocks and look at...

02 **Gneiss.** Large parts of the Canadian Shield are composed of rocks that were originally sedimentary or igneous, but which are now so highly metamorphosed that their original features cannot be recognized. Often these rocks show light and dark bands of different minerals, formed during plastic flow within the Earth. Such "high-grade" metamorphic rocks are known as gneiss (pronounced "nice"). This boulder stood for many years outside the Earth Science Building and was seen by generations of geology students. After 2000 it was moved to a location near the Faculty of Agriculture, Life, and Environmental Sciences. During the construction of the Geoscience Garden it was "repatriated" to its present location.

Keep walking west, and you will come to a very different type of rock.

44 (no plaque) (Meta-)**Conglomerate.** This rock, unlike all those you have seen so far, is composed of fragments of previously eroded rock that are resting against one another. It is clearly a sedimentary rock that was deposited on the old eroded surface of the Canadian Shield. Although it is not exposed, you have clearly crossed an ***unconformity:*** an ancient erosion surface marking a gap in the record of geologic time in this part of the world. At this boundary, you leave the Canadian Shield and enter the ***Western Canada Sedimentary Basin.***

41 **Quartzite**. This is another sedimentary rock, but this time the grains are of sand: much smaller fragments than in the last example. In this rock, both the sand grains and the mineral cement are made of quartz, making the rock a quartzite. You can see very fine layering, called ***lamination***, and in places the layers cross one another forming ***cross-bedding.*** These features indicate that the sand was deposited by currents that built wave-like dunes on the sea-floor. Notice that the layers slope downwards (or ***dip***) to the west.

The originally horizontal layers have been tilted. As you walk west, you will cross onto successively younger and younger layers.

To the northwest you will find...

83 **Dolomite and Magnesite.** The large grey and white rock contains two rock-types. At the base, grey dolostone is a carbonate rock originally formed on a tropical sea floor during the Cambrian Period, about 500 million years ago. Dolostone contains the calcium-magnesium carbonate mineral ***dolomite***. In the upper part of the rock, this has been replaced by a magnesium carbonate mineral, ***magnesite***. It is likely that magnesium was concentrated by hot groundwater passing through the rock, to form this mineral deposit.

Walk northwest across the road (watch out for traffic) to....

80 **Limestone**. This sedimentary rock comes from a unit called the Cairn Formation, of Devonian age (about 380 million years old). It was formed in a tropical sea that covered what is now Alberta. In the sea there grew reefs similar to modern coral reefs, but built mainly by sponge-like organisms called ***stromatoporoids***. Numerous spaces occur within and between the fossil skeletons of these organisms. In the subsurface (where this unit is known as the Leduc Formation) these spaces are filled with water, oil, or natural gas. Rock like this was formed the oil reservoir that was tapped by the Leduc #1 discovery south of Edmonton in 1947. More information about the Western Canada Sedimentary Basin and the Leduc #1 discovery is available in the signs.

From here, cross the access road to the west side (watch out for traffic again) and walk north, until you reach....

16 **Limestone.** This is one of several outcrops of limestone from the Mount Head Formation, of Mississippian (or Early Carboniferous) age, formed on a tropical continental shelf about 340 million years ago. This limestone contains patches of harder ***chert***, where the original limestone has been replaced by fine-grained silica (silicon dioxide).

North-northwest of rock 16 is a smaller limestone outcrop that has a conspicuous white surface..

9 **Fault in Limestone**. In this limestone, there are several whiter ***veins*** that formed from cracks within the rock. These cracks were formed by tectonic movements, and filled by mineral material deposited from hot groundwater flowing through the cracks. The white, south-facing surface has streaks or ***slickenlines***, indicating that the cracks formed along a ***fault***, where one block of crust moved relative to another. If you look to the southwest, towards the brown Biological Sciences Building, you will see from the layout of the rocks that there is an offset in the layers, showing that the fault continues in this direction.

Walk towards the northeast, towards Saskatchewan Drive, until you come to...

24 **Skarn.** When hot magma comes into contact with limestones, many chemical reactions occur. The resulting rocks, known as skarn, often contain minerals produced by these reactions. In this example, the green mineral is a silicate rich in Calcium called ***epidote***.

In addition, there are sulphide minerals, including ***chalcopyrite***, a copper and iron sulphide.

Just to the north you will not be surprised to see an igneous intrusion...

04 **Tonalite.** This rock superficially resembles granite. However, it is a little darker than a typical granite, and when examined in the laboratory it turns out to have less potassium and more sodium than a typical granite. A dyke of paler rock with coarse grains of feldspar cuts through the tonalite.

To the east is the largest rock in the garden, at nearly 16 metric tonnes.

21 **Magnetite.** This black rock is composed almost entirely of the mineral ***magnetite,*** an iron oxide that is attracted to a magnet. If you are navigating with a compass you may find that it points in the wrong direction when held close to this rock.

Head back west to...

10 **Limestone**. One of the largest rock installations - this one includes several reef-building and solitary coral fossils. See if you can find them.

Just to the west of the belt of limestone is a belt of contrasting sedimentary rocks

13 **Siltstone**. Rocks 11-15 are all sedimentary rocks from the ***Spray River Group*** of Triassic age (about 250-200 million years old). These rocks are clearly layered and show a roughly constant dip, sloping down to the west at about 20 degrees. The rocks display a variety of sedimentary structures that indicate deposition by currents on the sea floor. These include ***ripple marks*** and ***cross-lamination***. There are also rare fossils. The belt of siltstone is offset, presumably by the fault you saw at **9.**

As you continue westward you walk in the direction of dip of the layers, which takes you onto higher and therefore younger layers. The next unit you arrive on is....

48 **Conglomerate.** This rock is composed of large fragments of older rocks and is therefore also clearly sedimentary. However, the grains are much larger than the previous example, indicating a much higher energy environment. Although there is no direct evidence of age in these rocks, they come from the ***Cadomin Formation*** of Alberta, which is thought to be Early Cretaceous, deposited about 125 million years ago.

Lying above the conglomerate is...

58 **Sandstone.** This rock is composed of sand-size grains, and represents a moderate-energy environment. There are fragments of fossil wood that suggest this is a non-marine sedimentary rock, probably deposited in a river channel. This rock comes from the ***Blairmore Group***, of Early Cretaceous age (about

51 **Volcaniclastic rock.** This is the youngest unit in the portion of the Western Canada Sedimentary Basin in the Geoscience Garden. It's a rare rock of volcanic origin amongst the sedimentary strata. It consists of fragments produced in an explosive volcanic eruption. If you look carefully you may see small crystals of ***garnet*** indicating that the magma originated at great depth.

Continuing to the west, you will find yourself back on...

54 **Sandstone** of the Early Cretaceous Blairmore Group (about 115 million years old). This time, the layers in the rock are almost vertical, showing that we have crossed a fold into the ***Rocky Mountain Foothills***. Structures in this rock include ***cross-bedding*** indicating that currents created dunes on the bed of the river in which this sandstone was deposited.

Travel SE to find the next indication that you have entered the Rocky Mountains...

42 **Slate.** You have crossed a boundary into rocks that are metamorphic: that is, they have been altered by heat, pressure, or deformation within the Earth's crust. These are low-grade metamorphic rocks, in which features of the original rock (or ***protolith***) can still be discerened. In this case, you can see bands of light and dark material that are nearly vertical. These are the original sedimentary layers or beds, that have been tilted during the building of the mountains. However, there is another structure in the rock - it now splits along closely spaced planes that slope steeply to the west. This characteristic, known as ***cleavage*** was produced by the tectonic squeezing that affected the rock, which re-aligned all the mineral grains within the rock so that it splits in a new direction.

46 **Slate**. This rock is similar to the last but you can see that the sedimentary layers are bent through the hinge of a large fold.

35 **Slate.** In this westernmost outcrop of slate the sedimentary layers dip to the west. You have now crossed the large fold that extends across all outcrops of slate. When making a geologic map, geologists try to deduce the presence of large structures like this, by making observations at separate outcrops and tying them together.

75 **Sign about Cordillera.** For the last few outcrops you have been seeing the effects of deformation - tilting, folding, faulting, cleavage development - that produced the Cordilleran mountain belt of western Canada. In this sign you can find more information about the Canadian Cordillera.

Immediately west of the sign is an outcrop of

85 **Mylonite.** Mylonite is an intensely sheared rock produced by extreme deformation. This rock, which could also be called a ***schist*** contains several different types of 'grain' or ***fabric*** indicating that it has been deformed in a shear zone where one large mass of rocks slid over another during mountain-building.

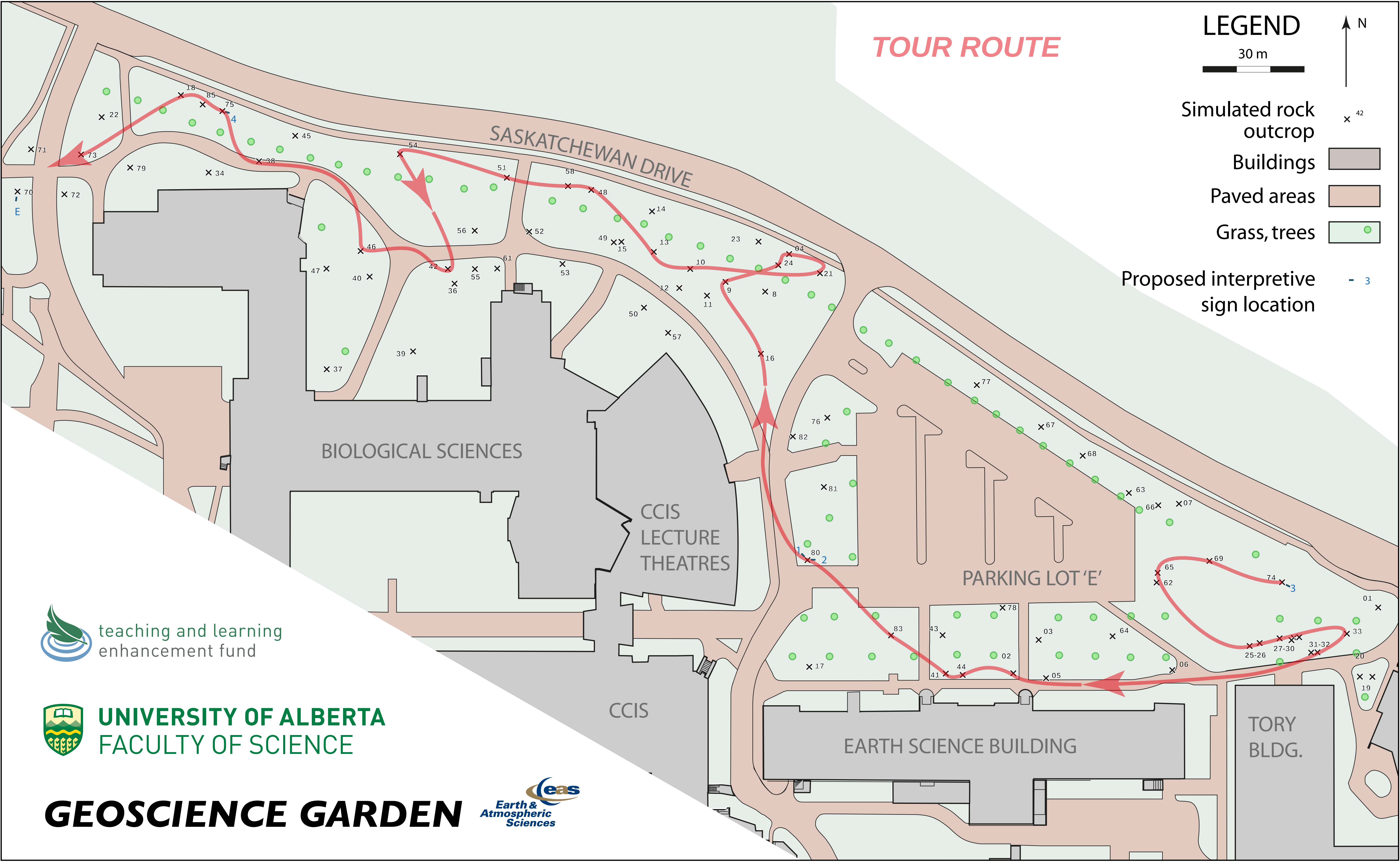
Just to the west is a higher-grade metamorphic rock

18 **Garnet amphibolite.** This rock may have started life as a basalt lava similar to one of the first rocks you saw. However, it was buried and 'cooked', probably at over 500°C, within the core of the mountains, where chemical reactions produced new minerals ***garnet*** (red) and ***amphibole*** (greenish black).

Travel west to the youngest rocks in the garden.

72 **Pumice** is a product of recent volcanic activity. This is lava that was frothy, full of gas bubbles, which has solidified to form a rock that actually floats on water.

We hope you have enjoyed your tour. For more information on all aspects of the Geoscience Garden may be found at *http://gg.eas.ualberta.ca*



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