

Geology of Iceland

University of New Brunswick (UNB) Department of Earth Sciences

International Hale Trip

May 12-24th 2025



In association with the UNB Bailey Geological Society and Geological Engineering Society

Contents

Acknowledgements	3
Summary	4
Itinerary	5
Daily Recaps	6
Day 1 – Western Reykjanes Peninsula	6
Day 2 – Reykjavik Region	7
Day 3 – Grindavik area	8
Day 4 – The Golden Circle	9
Day 5 – Laugervatn area	10
Day 6 – Westmann Islands	11
Day 7 – South Central Coast	13
Day 8 – Horgsland area	14
Day 9 – East Coast	15
Day 10 – Northwest Iceland	16



Acknowledgements

This opportunity would not be possible without the support from our sponsors. The 2025 Hale Committee would like to extend our gratitude to everyone who helped us make this trip possible. Funding was received from the University of New Brunswick (UNB) Department of Earth Sciences and several generous industry and local sponsors. We would like to acknowledge the **Prospectors and Developers Association of Canada (PDAC)** for their support through field trip funding.

In alphabetical order, we extend our appreciation to: **Association of Professional Engineers & Geoscientists (APEGNB)**, **Atlantic Geoscience Society (AGS)**, **Bayview Credit Union**, **BGC Engineering Inc.**, **Black & McDonald Limited**, **Dillon Consulting Limited**, **GeoVector Management Inc.**, **Killam Apartment REIT**, **Magna Terra Minerals Inc.**, **Sequoia Environmental Consulting**, **Ski Cape Smokey**, **Terrane Geoscience**, and the **UNB Student Union**. Thank you!



Summary

In the Department of Earth Sciences at the University of New Brunswick, 3rd and 4th year Earth Science and Geological Engineering students have the opportunity to plan, visit, and learn about sites of exceptional geological and/or geotechnical significance. This trip aims to solidify our understanding of geology and is financially supported by the late professor W.E Hale through the Hale Fund, established by the friends and colleagues of the late Dr. W.E. Hale, a professor, and former Chair of the Department of Earth Sciences. This year, 12 students, assembled as the Hale Committee, chose Iceland as their destination with the guidance of UNB professors Dr. Cliff Shaw and Dr. Allison Enright as well as industry professional, Robin Adair. For 12 days, May 12th to 24th, we travelled around the country of Iceland in a counterclockwise fashion.

The primary objective of this trip was to expose undergraduates to multiple types of geological and geotechnical features. This allowed us to get a greater understanding of geology and geological engineering in general through seeing igneous deposits, sedimentary deposits, volcanoes, seismicity, tectonism, etc. and how they co-exist in a geologically active area. This trip offered the opportunity for the students to experience the vast range of geological features in Iceland and immerse in Icelandic culture through exploring cities such as Reykjavík and historic sites.

While in Iceland, we saw both new and old dynamic volcanism as well as important tectonic settings such as spreading ridges and rift valleys. Magmatic deposits and tectonics are crucial in understanding the formation of resources, ore deposits, and mineralization of rare earth element and sulfide deposits. This gave the students insight on how mineral deposits can be produced and demonstrated in situ examples of geology that we have been learning about during our studies at UNB. Overall, this field trip was very successful and gave students enriching experiences both culturally and academically.



Itinerary

May 12th: Travel day (Fredericton to Toronto to Keflavik)

Day 1 (May 13th): Western Reykjanes Peninsula

Day 2 (May 14th): Reykjavík region

Day 3 (May 15th): Grindavík area

Day 4 (May 16th): The Golden Circle

Day 5 (May 17th): Laugarvatn area

Day 6 (May 18th): Westmann Islands

Day 7 (May 19th): South Central Coast

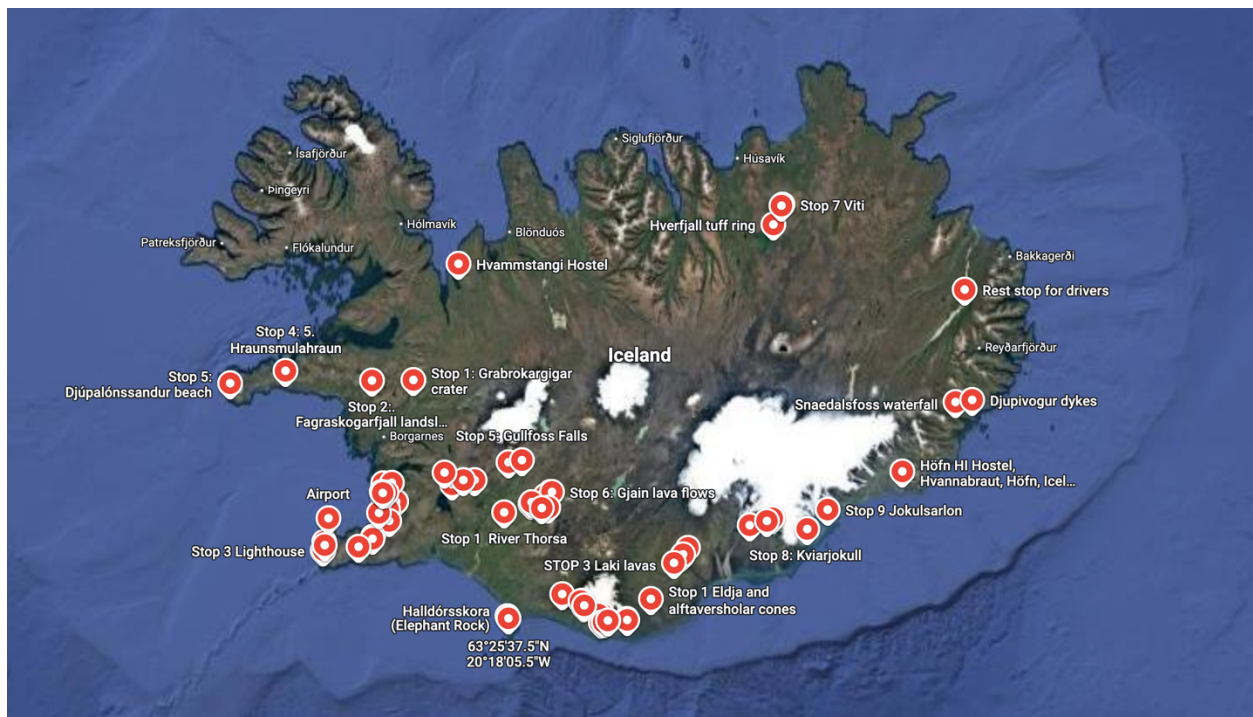
Day 8 (May 20th): Horgsland area

Day 9 (May 21st): East Coast

Day 10 (May 22nd): Northwest Iceland

May 23rd: Travel day (return to Reykjavik, flight to Toronto)

May 24th: Travel day (return to Fredericton)



Daily Recaps

Day 1 – Western Reykjanes Peninsula

Upon arrival in Keflavik, we headed directly to our planned stops starting with the bridge between continents at Sandvik. This site is a part of a series of fissures that are the on-land extension to the Mid-Atlantic Ridge. The lavas here are 13.6 ka and erupted just after the end of the last Pleistocene glaciation. While looking at the contact between flows, students were able to see how flows formed and whether or not there might have been a time gaps between eruptions.

Next up was the Stampar craters, this site gave students the opportunity to reflect on the geometry, orientation, and distribution of the cones with respect to the fracture at bridge between continents. After this site we visited the Reykjanes lighthouse, the second lighthouse to be built on this site after the original, built in 1878, was damaged by earthquakes and erosion. The closest land is 5300km away – the island of Sal in the Cape Verde islands.

Stop 4 of the day was the Gunnuvher geothermal field, a saltwater hot spring named after a ghost who is said to be trapped in the hot springs. Close by was stop 5; Reykjanesviti. The cliffs we saw were hyaloclastites that formed sub-glacially. This was an interesting stop to reflect on the influence of glaciation on volcanic eruptions. The final stops of the day included Seltangar: a demonstration of two sequences of lava, Graenvatn: a maar deposit, and the Seltun geothermal area. The latter was fascinating as it demonstrated harsh environments where only the strongest of bacteria can thrive. We also saw a significant amount of sulfur that precipitated out of the solution.



Figure 1: The Reykjanes lighthouse and lava fields.



Figure 2: The Reykjanes peninsula coast.

Day 2 – Reykjavik Region

The first stop of the day was the Fossvogur sediments, these are some of the only sedimentary rocks that formed in Iceland. The sediments are between 12.8 and 15 ka and were deposited during a warm inter-glacial period. They show a cyclical climatic change beginning with a tillite followed by deposition of fossil-bearing marine sediments.

Following this, we visited Raudholar which translates to “red mounds” – this rootless cone field is stained red from iron oxidation through eruptions that once occurred over a swamp. Similar textures to that in St. Andrew’s, New Brunswick, peperite, was produced at this location. This process also allowed for the formation of sulfides on the basalt at this site, an exceptional example of how mineralization can occur through eruptions. The last site was the Burfell volcano park, one of our favourite stops. We hiked up the volcano channel, seeing lava tubes (cave like structures) along the way as we reached the crater at the peak. This volcano is 8100 years old and followed mainly to the NW where the lava entered the sea around Hafnarfjörður. For the students this was an amazing experience, our first time being on top of a volcano was truly exciting.

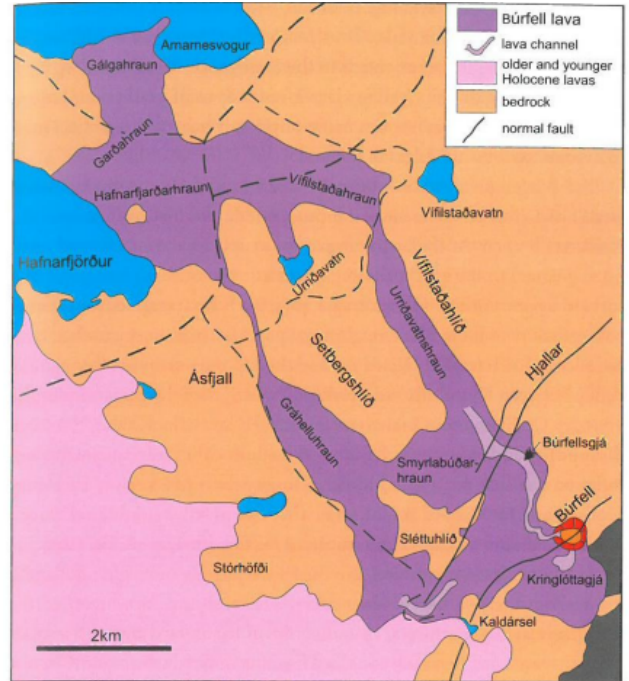


Figure 3: Burfell spatter cone and lava flow showing key structure and distribution.



Figure 5: Raudholar rootless cone field.



Figure 4: The top of Burfell volcano.

Day 3 – Grindavík area

On day 3 we saw rocks younger than ourselves. We visited the April 2024 lava flow over Road 43. These basaltic flows were a great demonstration of a'a flow texture as well as what recently cooled lava looks like. In this same region there are engineering berms that were built to protect the geothermal power plant at Svartsengi at the town of Grindavík. We saw how these berms interacted with the flowing lava, for the most part they restricted the flows, but some lava was still able to pass through. This demonstrated to the engineering students of the group especially, the importance and hazards involved in geological engineering. Despite the excitement we had while seeing these new flows, it was also upsetting to reflect on the damage and loss that the residences of Grindavík faced. A small lava flow threatened the northern part of Grindavík in January 2024 and earthquakes did significant damage to the homes and businesses of the village. As we drove through Grindavík it was apparent that everyone abandoned their homes and have not re-situated in the village. This day was a reflection on the reality of volcanic eruptions.



Figure 7: April 2024 flows over road 43.



Figure 6: April 2024 flows interacting with pre-existing solidified flows.

Day 4 – The Golden Circle

We started the day by visiting Thingvellir national park which is also the site of old Icelandic parliament. These meeting began in 930 and involved people from all over the country.

Thingvellir is also a great site to see a few waterfalls and a rifting zone. Following this stop we visited Midfell for a deposit of porphyritic basalts. This area had many beautiful samples with large plagioclase, olivine, and diopside crystals. Stop 3 was at Laugarvatnshellir, where we saw pillow lavas exposed in a ravine.

The last two stops of the day were well-known tourist locations – Geysir and Gullfoss. The geothermal activity at Geysir is driven by intrusions in the roots of an extinct central volcano. The residual heat gives a thermal reservoir of 200-250°C. This heat is then transferred to groundwater at 1-2km which then rises to the surface. The water erupted here is alkaline and plots in the bicarbonate field on a Cl-SO₄-HCO₃ diagram. However, the water is composed of chloride and sulphate as well as it approaches those fields in the diagram. The geysers are also surrounded by siliceous sinters. At Gullfoss we saw a large waterfall at the head of the Hvita river gorge, with most of the water melting off the Langjökull glacier. The canyon wall features sedimentary rock overlain with caps of lava which are much more resistant to erosion than the sediments. Erosion at this site is estimated to be around 25cm per year.



Figure 10: Thingvellir National Park.



Figure 9: Geysir geothermal eruption.



Figure 8: Gullfoss waterfall.

Day 5 – Laugervatn area

The first stop was to visit the Þjórsá river – this is the longest river in Iceland (230km) sourced from the Hofsjökull glacier. There are 6 hydroelectricity plants running off this river that produce 1040 MW of power. 3 more stations are in various stages of planning and construction.

Sultartangi features a human-made ravine that diverts the river for 3.5km through a tunnel from a higher dam in the diver and through the power station. This was an exciting stop for the Geological Engineering students as it highlighted the importance of geology in earth's processes in engineering.

At stop 2, we visited a lookout point on route 32 called Gaukshofdi for a view of Hekla, a shield volcano. Nearby was stop 3, another rare sighting of sedimentary material in an igneous dominated country. At Bringa, we saw fluvial conglomerates with well developed cross bedding. After this we visited stop 4, Thorsardalur, a small cone field similar to Raudholar. These features are similar to those featured on Mars – they have been suggested to have a similar origin to those that we visited in Iceland. Our final stops of the day were to visit the Strong archeological site and Gjain lava flows. Strong was excavated in 1939 and abandoned after the 1104 Hekla eruption which deposited 10-30cm of tephra. Nearby at Gjain, there is a series of lava flows that display variations of columnar jointing.



Figure 11: Sedimentary cliff at stop 3.



Figure 12: River Thjorsa with the view of Hekla.

Day 6 – Westmann Islands

Visting the Westmann Islands was one of the group's favourite days on the trip. We took the ferry to Heimaey, the largest of the Westmann islands, and spent the afternoon exploring the island. Everyone split up into smaller groups to explore the geological features at their own pace. Some of the sites seen this day were the following:

Nordurklettur: On the north side of the Harbour as we arrived in Heimaey we passed the Nordurklettur. The northern cliffs are the result of at least 7 eruptions that occurred during the end of the Weichselian glaciation about 13-15 kya. At that time the cliffs were two separate islands, since then they have been eroded with some deposition between them.

Hain: This is a section through a vent. It shows the outer rim of a tuff cone and an inner scoria cone that shows the products of subaqueous and subaerial eruptions.

Storhofthi: For those who visited this stop, it took about 1.5 hours to walk to the furthest south part of the island to see this outcrop. There is an added bonus after the walk, since there is also a puffin lookout at this location. On the south side of the island at Storhofdi another island was produced around 6.5 to 7 kya. Storhofdi is a typical emergent volcano. It has a small lava shield of pahoehoe lava that caps the tuff cone. This volcano is very similar to modern Surtsey – it started with hydrovolcanic eruptions that were very explosive as the volcano emerged from the sea. Once it was exposed the eruptions became effusive. During the explosive activity the northerly winds deflected the tephra to the south and built a north facing half cone that forced the effusive lava to flow to the north.

Saefell: Walking along the southeastern shore for about 1 km and then looking to the east, we saw the island of Saefell. It lies in approximately the centre of a tuff cone. The top part of the conduit is a diatreme.

Helgafell: This is a spatter – scoria cone that formed in an eruption 5900 years ago. It is the first completely magmatic (strombolian to effusive) eruption on the island. The eruption joined the earlier formed islands. On a clear day you can get a good view of the entire island and a good part of the Westmann island chain. The summit was formerly a look out post after the invasion of the Algerian pirates in 1627. There are some remains of the old shelter still preserved.

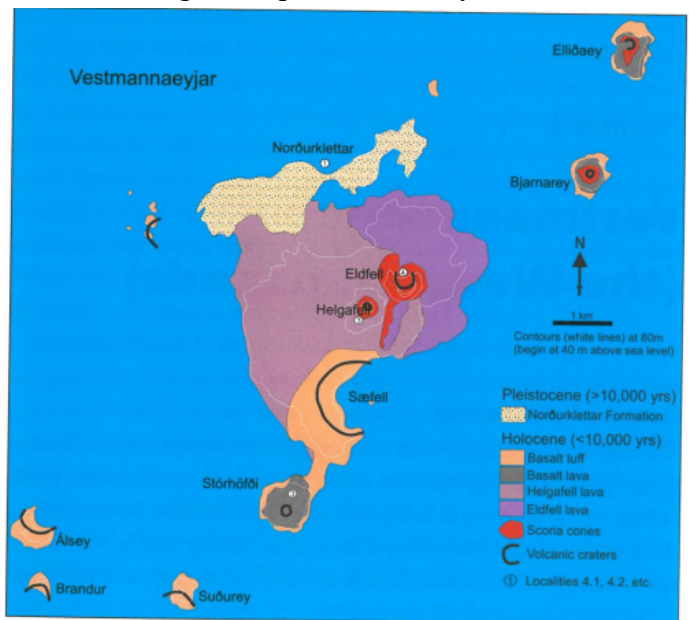


Figure 13: Geological map of Heimaey and other islands in the Vestmannaeyjar archipelago.

Eldfell: Most of the groups opted to hike up this volcano as it was slightly less steep. The mountain of fire (Eldfell) is the most recent part of the island – it formed in 1973. The eruption began with very little warning. A few small earthquakes occurred around 10 pm on January 22nd and a larger one at 1:40 am on January 23rd.

At this time there were only three seismometers in southern Iceland, so it was not possible to tell if the epicentre was on Heimaey or in the Torfajokull volcano. The seismologists thought that Torfajokull was the more likely source of the quakes. On Monday night January 22nd, the fishing fleet was confined to the harbour by a storm. Just before 2am a farmer called the police to tell them that an eruption had started 200 – 300 m east of the farm Kirkjubaer. This was a fissure eruption, and the fissure extended from Kirkjubaer to the harbour mouth in the north and to the sea in Stakkabot to the south.

The eruption began in earnest on January 23rd at 1:55am and formed a continuous curtain of fire (lava fountains) along the length of the fissure. Within three days the activity was focused on one vent which built up the Eldfell cone. Initially lava advanced downslope from the fissure (to the east and northeast). The emergency services realized that the fissure could extend to the north and block the harbour or to the south and damage the airport. The mainland civil defense, and NATO forces in Keflavik helped to airlift 300 people to the capital. The rest of the population headed for the harbour and were evacuated in a steady stream of fishing boats. In the first 12 hours of the eruption more than 30 million tons of tephra and lava erupted.

The eruption lasted for five months and ended on July 3rd, 1973. It covered most of the town with tephra and about a quarter of the town was engulfed in lava. The locals and civil defense set up pipes and pumps to spray the lava with seawater to slow its advance and redirect it. Even with these efforts, some parts of the town could not be saved, and 417 houses were buried under lava. This was another example of engineering efforts to tackle an eruption with some success. With the impact of the history of this volcano it was an amazing site to visit.



Figure 15: The view of another island within the Westmann Islands from the top of Eldfell.



Figure 14: The town of Heimaey with Helgafell in the distance.

Day 7 – South Central Coast

The first stop of the day was to visit Solheimajokull. We followed a trail through a valley that took us to overlook the glacier with a well-defined end-moraine. This end moraine formed, then a lobe of the glacier was thick enough to cover the adjacent ridge (this was in around 1904). Around 1860 most of the ridge was ice covered! Many of the deposits are a result of stream flow, just south of the overlook is a small round hill a few meters high that is likely a kame.

Stop 2 was to the Solheimar ignimbrite Park. This is an ignimbrite from the Katla volcano (the one under the ice of Myrdalsjokull). This volcano has a 700 m deep, 14 km wide caldera. It has erupted at least 21 times in recorded history – it last erupted in 1918. Katla is a bimodal volcano that erupts mildly alkaline basalt and rhyolite. Fissures from this volcano extend to the NW as the Eldja system. The ignimbrite is ~ 5 metres thick with pumice clasts in an ash matrix. We looked carefully at the pumice clasts and there were at least two types!

Stop 3 on day 7 we visited Dyrhólaey, these isolated “islands” in a sea of sand are emergent structures of submarine volcanoes. The main part of Dyrhólaey is made of tuff formed by water – magma explosions and it represents the remnants of a tuff cone. On the east side the tuff is capped by compound pahoehoe lava which has cubic jointing interpreted to be due to water enhanced cooling of the flow. The flows are subaerial, but parts flowed into the sea (making the cube jointed parts). The rocks off the coast are known as the Reynisdrangar, are the basalt sea stacks situated under the mountain Reynisfjall. According to legend, the Reynisdrangar needles were formed when two trolls were trying to drag a three-masted ship to land. When daylight broke, they turned to stone. The Needles can be seen clearly from the village of Vík and are 66 meters above sea level at their highest. In one of the many caves here – there is a local legend about a monster having lived here for many centuries. The monster seems to have disappeared after a landslide over 100 years ago. Sites like this gave the students appreciation for culture and Icelandic heritage in addition to the geology.

The last few stops were to Reynisfjall beach, a black cobble beach with spectacular columns in a basaltic sill, followed by Vikurfjara black sand beach, and last but not least, the Yoda Cave; a cave shaped like Yoda from Star Wars.



Figure 16: Group picture at Solheimajokull.



Figure 17: Dr. Shaw discussing the geology of Iceland.

Day 8 – Horgsland area

The first stop of the day was to visit the Eldgja eruption and alfaversholar cones. The cones are just southeast of the stop to see Eldgja – these are rootless cones formed when the Eldgja lavas overran wet sediments. The Eldgja flows are the largest known historical lava eruption, with a volume of 20km^3 along with an additional 6km^3 erupted between 934 and 940. After this stop we visited the Sitha formation at Keldunupurpark. These cliffs are dominated by hyaloclastite breccia that has been intruded by cube jointed basalt. The base of the hyaloclastite breccia lies on diamictite, and the cliff is topped by bedded hyaloclastite and another unit of cube jointed basalt. The same formation was visible from our third stop, Lomagnupur, which is the tallest cliff face in Iceland (600m). At least 5 of the depositional units of the Sitha formation are exposed here.

Our next stop was to Skeitharsandur, the largest glacial outwash plain on earth. At this stop we saw a piedmont glacier – Skeitharsjokull, an outlet glacier of Vatnajokull. This plain was the last to be crossed by route 1 (1974). Major Jokulhlaups such as in 1996 and 2011 have caused damage to the road and bridges. The 1996 jokulhlaup had a peak discharge of $45000\text{ m}^3/\text{second}$. We then saw the damage of the 1996 jokulhlaup at stop 5 – the remains of the Route 1 bridge.

Our final stop of the day was to Svinafellsjokull park, where we saw Kviarjokull - an outlet glacier of Oeraefajokull. We parked in a terminal moraine complex that marks the extent of the glacier during the late Holocene. The system is defined by ridges on the north and south. We also saw a proglacial lake with bergs from Breitharmerkurjokull at this site. This day introduced us to many glacial features and allowed the engineering students to reflect on the strength of geological phenomenon with respect to human-made structures.



Figure 18: Route 1 bridge destroyed by the 1996 jokulhlaup.

Day 9 – East Coast

Day 9 was a long day of driving as we had to reach the northeast of the island along Route 1. We broke the day up into a few stops to allow the drivers to rest before continuing. There were not many stops focused on geology this day, but the scenery was incredible.

The first geological stop was to see the Djupivogur dykes. They are 3-6 metres wide and part of a large dyke swarm that is ~ 9 km wide and extends around 40 km to the NNE-SSW. These dykes are associated with the 10-12 Ma Altafjordur central volcano that is SW of this location. The dykes were emplaced at ~ 1.5 km below the original surface. They likely fed fissure flows like the ones we saw on the Reykjanes peninsula at the start of the trip. Following this we visited the Krafla fires. We parked in the middle of the Krafla caldera which is 9.5 km E-W and ~ 7 km N-S. The hiking trail to the west crosses early post-glacial lavas with a thick soil cover. As we continued down the trail, we crossed a 2650-year-old flow that is closely associated to the Hverfjall event. The trail continued to the south where we saw a lava lobe from the 1724-1729 Myvatn fires and then a geothermally active area. Following the trail to the north on to Leirhnjúkshraun - a flow from the 1975-1984 Krafla fires event. This was a great stop to stretch our legs from driving and see a variety of different volcanics. The last stop before we reached our accommodations for the night was Viti Lake. This is a 320 m diameter crater formed by a phreatic eruption in May of 1724.



Figure 19: Viti Lake.

Day 10 – Northwest Iceland

As we were approaching the end of the trip on day 10, we were heading back to Reykjavik to spend our last night in the capital before heading to the airport. We only made a few stops this day including a visit to the Grabrokargigar crater, protected land that hosts three scoria cones within 1 km on a NW-SE trend. Evidence of glaciation can be found within this landscape as the craters are post glacial. This stop included a short hike to the top of one of the craters. Following this stop we made our final geological site visit to see the 2 the Fagraskogarfjall landslide - a large landslide that occurred on July 7, 2018, on the mountain Fagraskogarfjall. Debris reached up to 2.3 km from the top of the scarp on Fagraskogarfjall. The debris partially dammed the river Hitara. The land before the slide was unsuitable for farming so there was no loss of life or property damage. The volume of debris is around 10 – 20 cubic metres. This was an interesting stop to see the extent of the mass movement.

After these two stops we continued on our way to Reykjavík, passing through a 5.7km long underwater tunnel through the west fjords. This was truly exciting for the engineering students in the group! Once we returned in Reykjavik, we spent the evening exploring the city in smaller groups. The afternoon of May 23rd, we travelled to Keflavik to catch our flight to Toronto. And then departed for Fredericton the morning of May 24th.



Figure 20: Grabrokargigar craters.