Blåfjell

Teacher's Sheet

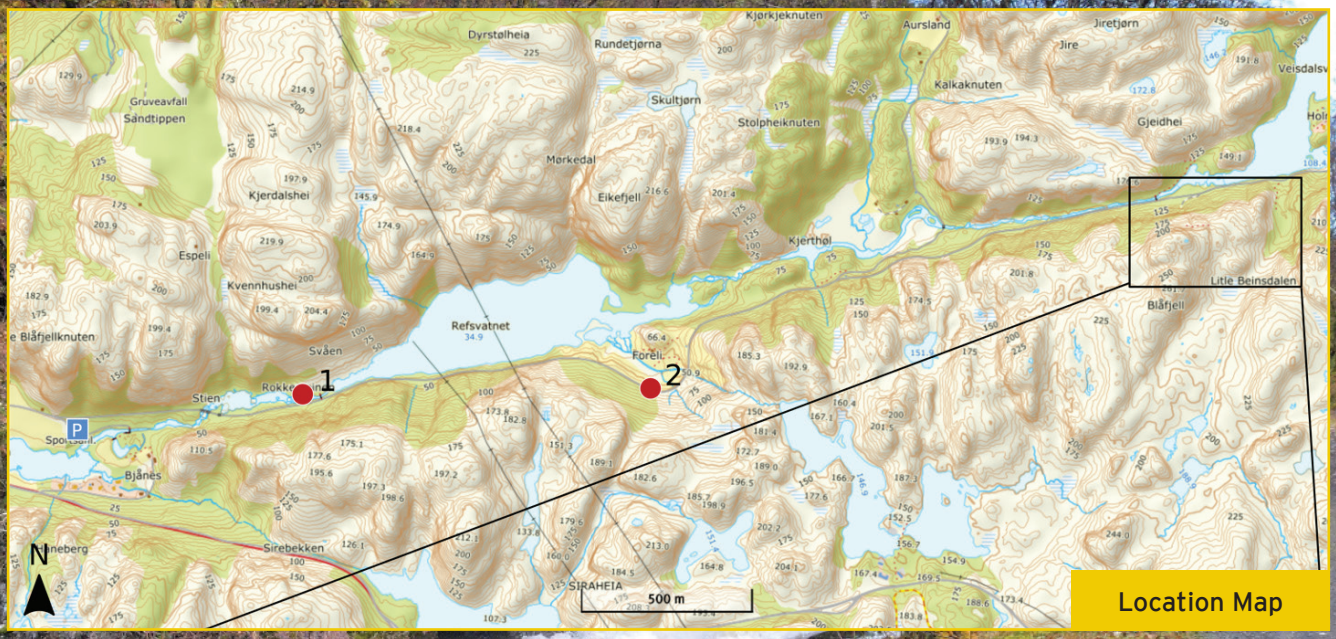


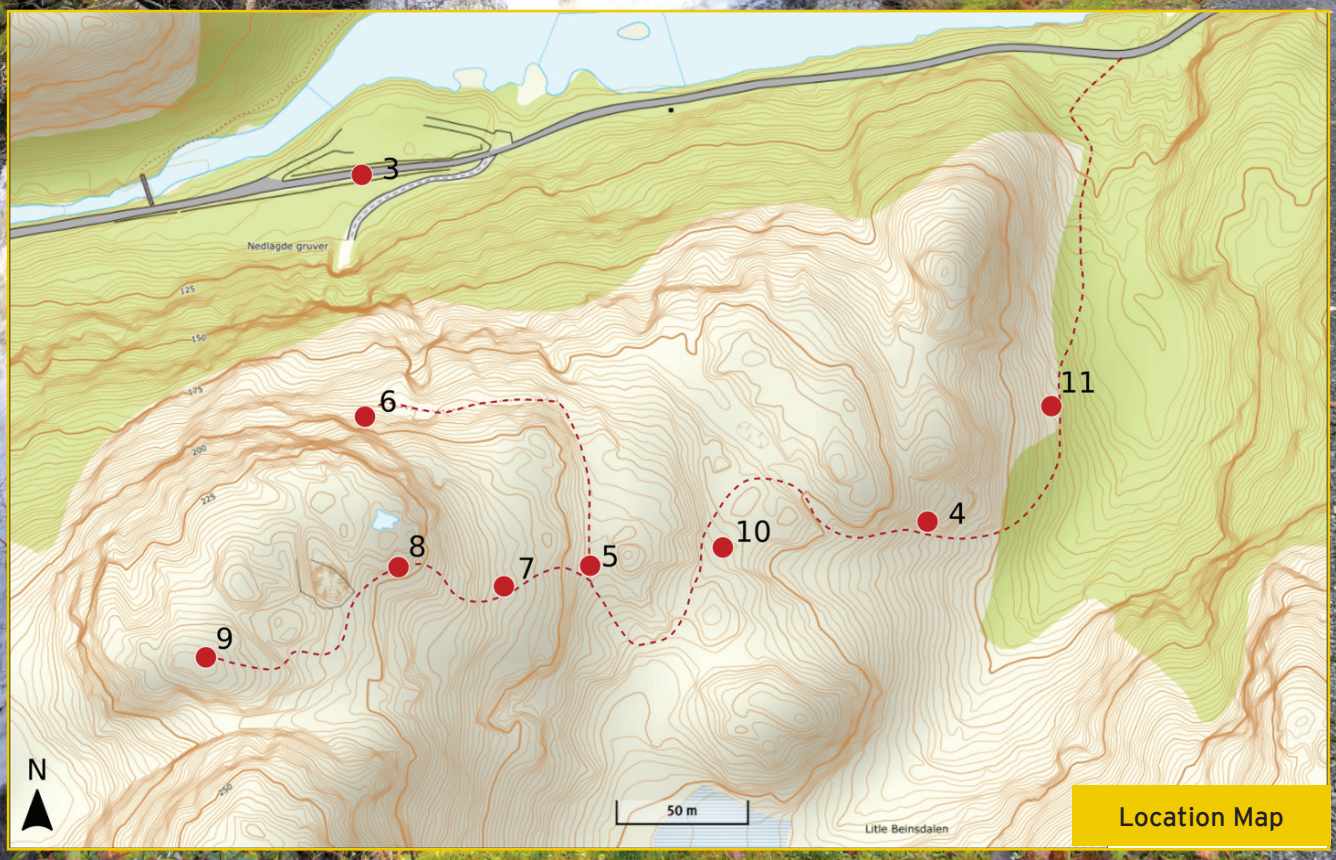
Parking at Linepollen (P on map) will give the pupils a 3,6 km walk to the mines, which in normal walking pace will take about 1 hour. Possibilities to meet cars on the road.

Arriving at the mines (3 on map) there is possibilities to park cars. From here the pupils will walk by foot. The lower mines lay with an altitude of about 110 meters above sea level while the top of the mountain to hike have an altitude of about 250 meters. The path is good but not marked.

Note that entering the mines is on your own risk.

This is also a popular route to bike.





Teacher's Notes

SUGGESTED STOPS	POINTS TO NOTE
Access:	Parking is available for cars and buses at Linepollen (N58.34851, E006.33141), follow sign. A 3.4 km walk will take you to the Blåfjell mines. This road follows the old railway from the mines to the ocean and is nice for biking. Smaller cars and busses can drive all the way up to the mines and park there (N58.35823, E006.38467).
1	**The rocking rock** (N58.35037, E006.34332). The rocking rock was protected by law already in 1923 and was the first geological phenomenon to be so in Norway. It is estimated to weigh about 74 tons and can be easily moved by human power due to balancing on two points on the subsurface. The boulder is a rockfall from the surrounding steep mountains, meaning the rock consists of Anorthosite.
2	**The Blåfjell railway** (N58.35144, E006.35997). There is no exercise for this location. From the Blåfjell mines to the export harbour in Rekefjord there ran a 8,5 km railway that was used to transport the ore. Work on this railway started early in 1864. When the line was finally completed in 1870, it was among the very first railways in Western Norway. After suspension of operations the track was dismantled and removed, most of the equipment in all probability going back to England. Today we can still clearly see a well-preserved 3,5 km section of the right-of-way between Blåfjell and Åmodt. 200 men were employed on this railway construction in 1865. The maximum workforce at the mines was about 150 in 1870 when almost all the iron ore exported from Norway came from Blåfjell. At first the railway line only went as far as the western end of lake Refsvannet. Horses and carts loaded with ore travelled down the valley from the mines to the lake. Barges were used to cross the water, or sledges in winter when the ice was strong enough. The ore was transferred to railway wagons that travelled down to Rekefjord under the influence of gravity. The final part of the journey to the coast was also by horse and cart. The empty wagons were pulled back uphill by horses.
3	**The mines** (N58.35823, E006.38467) There is no exercise on this location. Location to tell about the mining industry. There is a long history of mining in Magma Geopark, most importantly for ilmenite. Mining of ilmenite in Rogaland started in 1785 near Koldal, c.6 km east of Egersund. This was to extract the iron, but activity soon ceased because there were smelting problems caused by too much titanium, and the distance to the smelter at Moss was too great. 12 years of mining: 1863-1875 The mining traditions in Sokndal go back to the 1860s, when The Titanic Iron Ore Company Ltd, an English enterprise with its head office in Leeds, in 1863 purchased the mining rights for ore deposits in Sokndal. Quarry operations started that same year. Up to 50 miners worked here in 8 mines at this time. After more than a decade of varying production, the company's activities in Norway were suspended in 1876. Almost 100,000 tons of titanic iron ore had been mined and shipped to England for smelting. Today the traces of this activity are widespread, with impressive stone walls, mining shafts, and building foundations all in evidence.
4	N58.35734, E006.38863 The rocks in the area includes Anorthosite and Norite. The ore ilmenite is found in relation to the Norite. At this location, the Norite containing ilmenite has "fallen apart" and can be seen in the terrain as a pile of gravel, still within the boundaries of the dyke. The rocks falles apart like this for several reasons. One might be that the rock was earlier crushed during events of movement in the bedrock. Another contributing factor is that minerals in the Norite weathers more quickly than the surrounding Anorthosite. This specific area might have contained more of the minerals that weather easily making the rock "dissolve" into gravel.

5	**Ilmenite** (N58.35706, E006.38656) The ilmenite ore at Blåfjell is associated with very coarse-grained Norite that extends as far south as lake Måkevatnet. Very coarse-grained rocks are called pegmatites. The rock type Norite (named after Norway) consists mainly of two minerals – plagioclase (a light coloured feldspar mineral; density of c. 2.7 g/cm3 i.e. 2.7 times the density of water) and orthopyroxene (a dark silicate mineral containing iron and magnesium; density c. 3.6 g/cm3). This coarse-grained norite also contains ilmenite (a black metallic mineral; density c. 4.75 g/cm3). So the correct full name for the ore-bearing rock at Blåfjell is Ilmenite Norite pegmatite. The ilmenite can easily be seen with the black to dark grey, almost blueish colour, and the metallic luster. Some places it can be seen as a massive layer, other places as grains in the Norite. The Blåfjell-Måkevatnet body was formed when molten rock was injected into older rocks about 920 million years ago. These were anorthosite, a rock consisting mostly of plagioclase. The pegmatite has a very irregular shape and extends ~5 km from north to south. Ilmenite is very unevenly distributed and economic concentrations occur in layers and lenses that cannot be followed very far.
6	**The top mine** (N58.35732, E006.38481) Entry is not allowed, but these mines can be studied from the outside looking in. Toppgruve (Top mine) is the most instructive to visit. The ore here is extremely rich; it locally reaches 100 ilmenite. This ore-body has a relatively simple, sheet-like form that dips north with a thickness of 2-6 m. There are several entrances at c. 200 m and excavations extend inwards and upwards for c. 55 m where they reach the surface. When the sheet of ore was excavated, two columns were left to support the roof. Much very high-quality ore remains at Blåfjell, but in too small concentrations to make it economic today.
7	**Norite dyke** (N58.35693, E006.38600) The norite intruded into the anorthosite about 10 million years after the anorthosite had crystallized. It has a different mineralogical composition containing plagioclase and pyroxene, whereas anorthosite only contains plagioclase. It is coarser grained (pegmatite) than the anorthosite, giving it a very different appearance compared to the anorthosite. In some cases, it might be more resistant to weathering than the surrounding anorthosite causing it to "pop up" from the anorthosite.
8	**Study the outcrop** (N58.35697, E006.38534) The rock looks different, but it can still be a challenge to separate them looking at them in field. Some outcrops are more suitable for this than others. This outcrop contains large surfaces of anorthosite where the crystal shapes and sizes can be seen – plagioclase occur as both mega crystals and finer grained crystals in the matrix. At the location there is also a sharp and distinct boundary to the ilmenite.

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Resources (N58.35660, E006.38424)

From the top of Blåfjell several windmills can be seen. In the distance, traces of the mining industry at Tellenes can be seen.

At Tellenes they extract the ore ilmenite on a large scale in an open pit mine. This is one of the largest industries in the area creating jobs for the local community. It is also one of the largest open pit mines in Norway and leaves a great impact on the environment.

The production of titanium from ilmenite leaves a large amount of gangue and other waste products. Earlier some of these were dumped in Jøssingfjord but is today stored in a large landfill site. Recently the discussion has reappeared on what to do with new gangue as the landfill gets full.

Around the open pit mine, Norway's largest windmill park has been built (as of November 2017).

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Traces of glacial activity (N58.35716, E006.38741)

In Quaternary time glaciers dominated in the area. Several glacial events were followed by interglacial periods. The last ice age, called Weichsel, started about 120 000 years ago and ended just about 10 000 years ago. The glaciers eroded and changed the landscape and left and abundant of traces which can be seen in the landscape today – some of them being fjords and valleys, striations, glacial erratic and moraines. These are all landforms that was shaped by the erosive powers of the glaciers and the abilities the glaciers had to transport material from one place to another.

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Moraines (N58.35779, E006.38935)

Moraines are glacial deposits and most the moraines in Norway is created during the last Ice Age – Weichsel.

Moraines are characterized by being poorly sorted, little rounded and varying in grain size from clay to boulders. Moraines are deposited all over, some as ground moraines, end moraines and lateral moraines.

Moraines create good soils for plant to grow and in an area as Magma Geopark characterized with little fertile bedrock, the moraines create green patch around in the landscape.