

# The Geology of Greenside & Blea Cove, Glenridding

Cumberland Geol Soc Excursion
20th August 2023

Leader

Edward G McGowan

# Logistics

Meet at 10 am outside the Visitor Centre in the Glenridding Car Park. Parking costs £8.50 for a full day ticket. If the car park is full, there are others at the Patterdale Cricket Grounds, and Patterdale Hotel.

The day will entail a roughly 6 km walk. The route from the carpark to the Greenside Mine is a very easy road track. Following the circuit route over a foot bridge, the route will diverge from the path to observe exposures that crisscross up to a disused slate quarry. This part of the excursion will involve walking over inclined, uneven ground and step over a very small stream. This late into the summer, bracken may need to be trampled. Once the geological discussions have concluded, we shall rejoin the footpath and return to the carpark. Depending on weather/enthusiasm etc the trip will last 4-6 hours.



# Introduction

The geology observed during this excursion forms a part of the leader's ongoing PhD research project entitled "*Eruption source vents and subsidence patterns in exhumed caldera volcanoes, English Lake District*", conducted at the University of Leicester. The first phase of the project aimed to geochemically characterize major silicic pyroclastic deposits throughout the Upper Borrowdale Volcanic Group (BVG) and establish correlations between units across wide areas. Once units had been characterized and correlations established, targeted pyroclastic deposits can be traced back to potential source vents. This second phase relies on the combination of further geochemical analysis, stratigraphical relationships, and field observations of characteristic caldera-forming facies (e.g. thickest localities for the ignimbrite, rheomorphic folds related to active volcanotectonic faults, mesobreccias, and heavily disturbed lacustrine sediment deposits (Lipman, 1984; Branney & Acocella, 2015).

At the time of writing, samples of the Birker Fell Formation lavas and Thirlmere Member ignimbrite have been collected at Blea Cove and are awaiting geochemical analysis. However, field observations support the notion of Blea Cove potentially being close to a caldera margin.

Within the literature, the area of Blea Cove is poorly documented. Loughlin's (2002) technical report on the 1:10,000 scale maps NY31NE and NY41NW (of which Blea Cove resides in the former), gives a little information on the local formations. The text is brief and largely compares the formations to other localities described in different reports. Text regarding the parataxitic Thirlmere Member is extremely limited. The concluding remakes state that the Thirlmere Member was likely emplaced rapidly by low-fountaining eruptions that ponded proximal to source (agreeing with Woodhall (1998)), and the Esk Pike Formation comprises coarse sediments deposits in a fluvio-lacustrine environment (similar to the Seathwaite Fells Formation) via mass flows, traction and suspension (agreeing with McConnell (1993) and Woodhall (1998)).

The source vents for the Lincomb Tarns Formation, including the Thirlmere Member are unknown (Woodhall, 1998). However, due to similar caldera-forming characteristics seen in the Airy's Bridge Formation of Scafell Caldera, caldera formation is implicit for the emplacement of the Thirlmere Member (Woodhall, 1998; Millward, 2004). Millward (2004) provides a probable caldera margin that extends far beyond Blea Cove, to encompass deposits found on Watson's Dodd, where the Thirlmere Member is estimated to be over 300 m thick. However, this correlation has been tentatively made, based upon "fragments in the soil, scattered blocks on the rounded grassy slopes and some very degraded small exposures", as well as similar geochemical compositions and presence of garnets (Millward, 1998). The latter two justifications are fairly weak, as the Airy's Bridge Formation to the west and Whelter Knotts Formation to the east also share these traits. Therefore, it is entirely possible the caldera margin could be located further south, with the Birkhouse Moor Fault forming the northern margin.

Although the Greenside Mine is not accessible to the public, and its geology is not directly related to caldera volcanism, it is still a site worth visiting. Firstly, the full overview of Blea Cove is best seen from the road north of Glenridding Beck, which leads to the mine. Secondly, the geology and history of the mine is fascinating. And thirdly, it is so close that visiting does not add too much to the excursion.

# Regional Context

The area around Greenside and Blea Cove see a sudden change from lower BVG andesitic lavas in the north, to some of the youngest volcanic deposits of the upper BVG to the south. This change is marked by the Birkhouse Moor Fault. It is typically stated that the lower BVG is dominated by effusive lava eruptions, whilst the upper BVG is dominated by explosive caldera-forming volcanism (Millward, 2004), both of which are well demonstrated here.

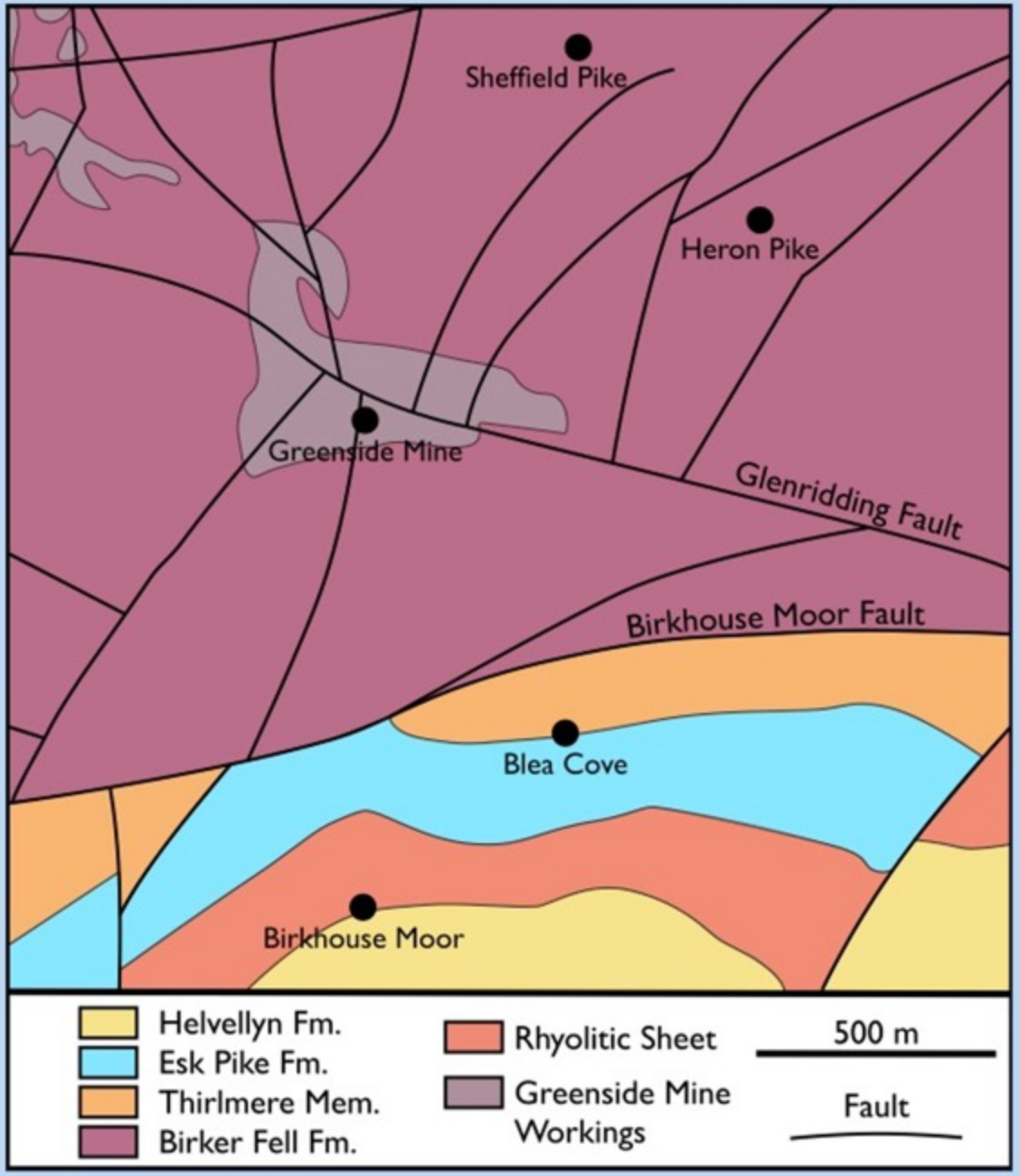
The lowest exposed deposit of the upper BVG is the Thirlmere Member – one of the basal members of the Lincomb Tarns Formation. A high-grade rhyolitic parataxitic ignimbrite.

Overlying the ignimbrite is a thick succession of mud- to sandstones laid down in a fluvio lacustrine environment. These deposits comprise the Esk Pike Formation.

The Esk Pike Formation is then succeeded by a rhyolitic sheet of unknown origin. It has been tentatively correlated with the Middle Dodd Dacite lava domes some 7 km to the south.

The final and youngest unit in the area is the Helvellyn Formation, a dacitic massive eutaxitic lapilli tuff that is rich in plagioclase phenocrysts.

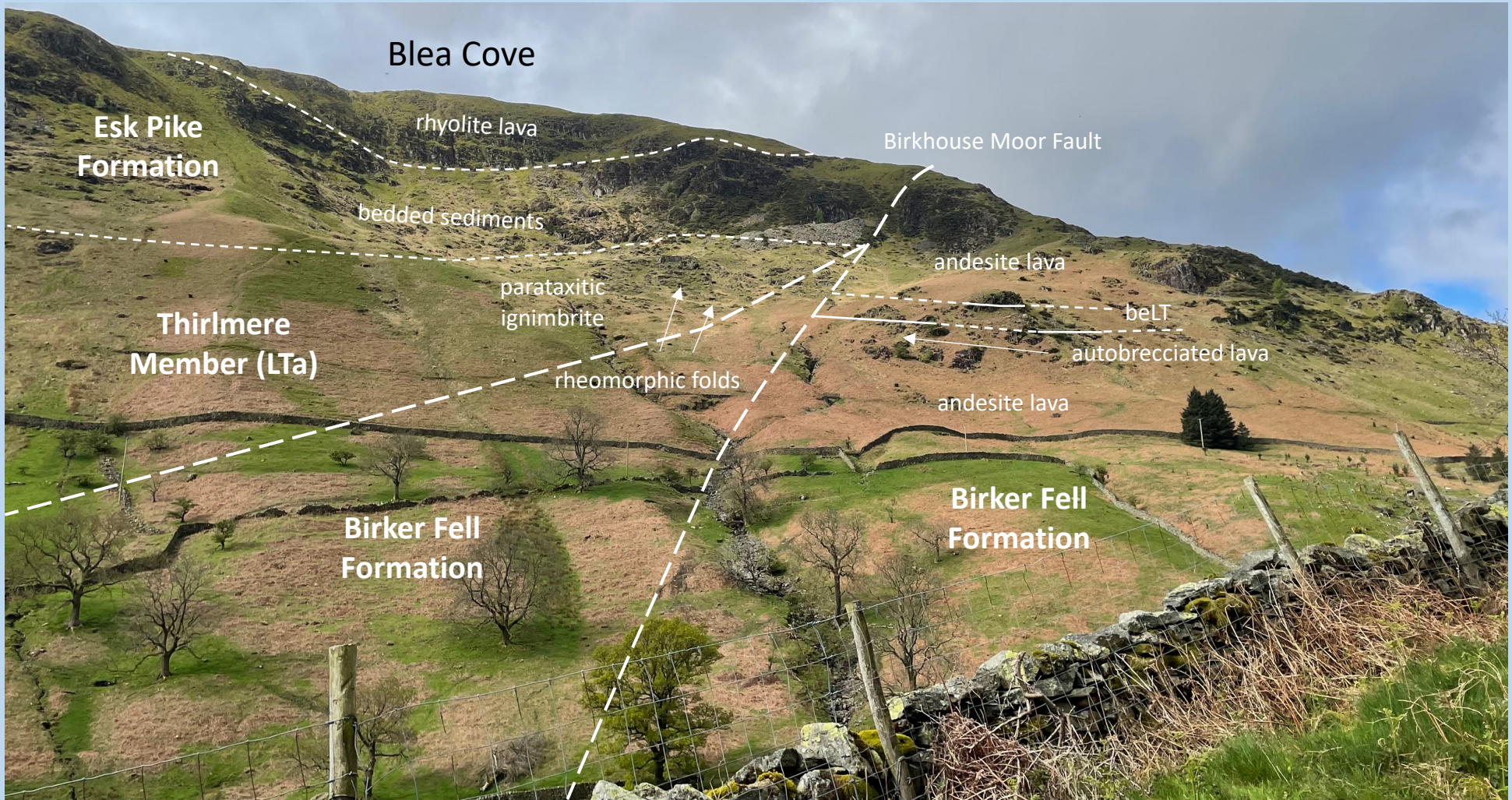
Throughout the succession there are numerous features related to active volcanotectonic movement and caldera-forming activity.




**A simplified geological map of the Greenside and Blea Cove area, showing the sudden change in geology across the Birkhouse Moor Fault.**

# Regional Overview

The view of Blea Cove can be best seen in its entirety from Greenside Road. The outcrops on the right largely comprise of andesitic lavas of the Birker Fell Formation, with a thin pyroclastic deposits (bedded eutaxitic lapilli tuff - beLT) overlying one of the lavas. These lavas are separated from the geology to the left by a fault that runs from the righthand edge of the Blea Cove crags, diagonally down to Glenridding Beck. On the left of the fault, the lowest outcrops comprise parataxitic ignimbrite of the Thirlmere Member. The main crags of Blea Cove comprise fine to coarse-grained sediments of the Esk Pike Formation, which overly the ignimbrite. Higher up the crags (and out of reach for this excursion) is a rhyolitic lava, emplaced upon the sediments.



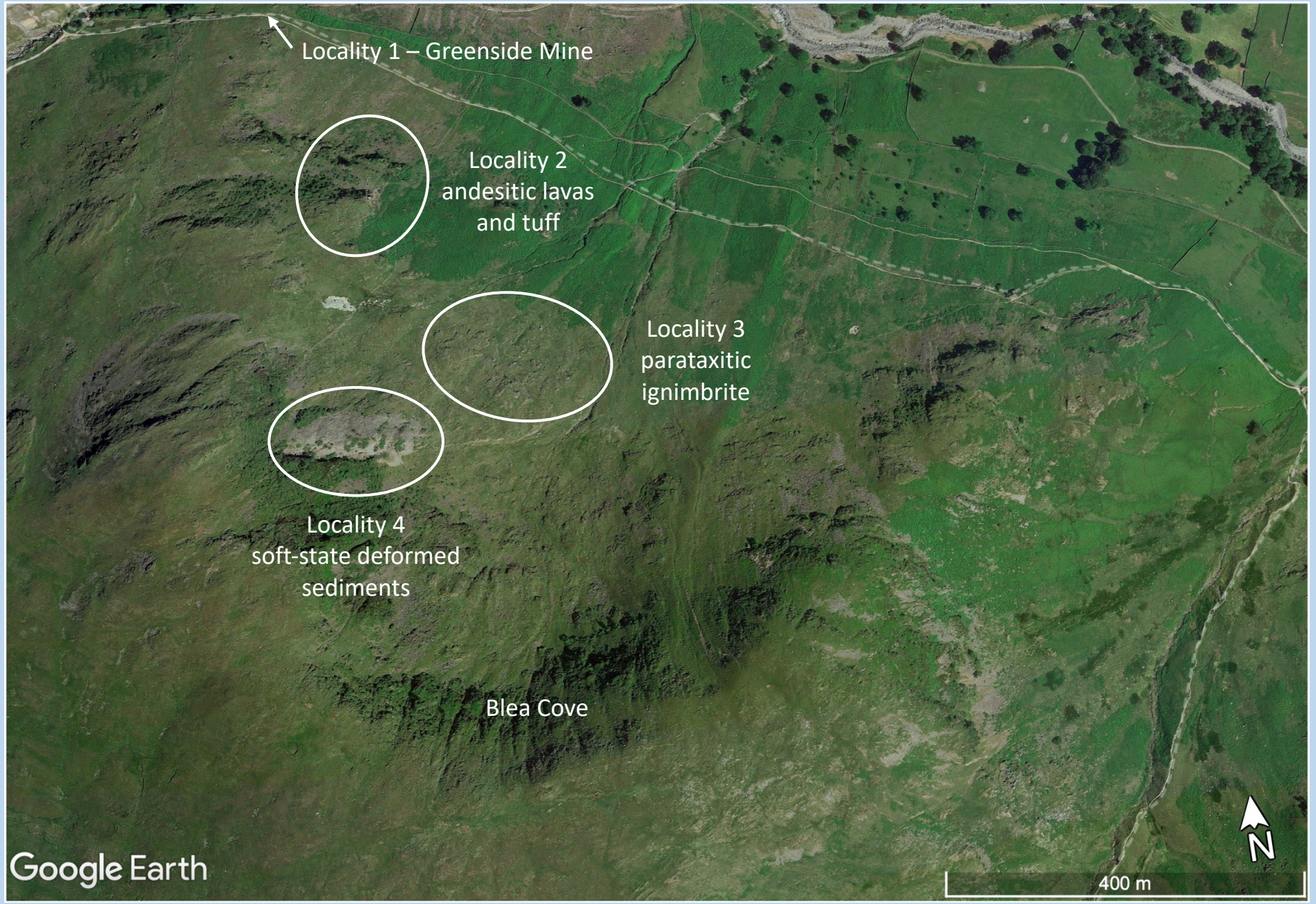
# Itinerary

The walk shall begin by heading to the Greenside Mine. From the road to the mine the entirety of Blea Cove can be well seen.

Due to closure of the mine, a discussion about the local geology and history of the mine shall be had outside.

Following this, the excursion shall cross the Glenridding Beck and head to Blea Cove. The first locality at this site shall begin with Birker Fell Formation lavas and a small tuff. The geology then drastically changes over a tiny stream, shifting to extremely welded and rheomorphically folded ignimbrites. The final locality will once again see a geological shift as slates in a disused quarry display beautiful soft-state deformation.

The shifting geology is believed to represent a caldera margin, fill deposit and post-caldera lake sequence.



# Locality 1 – Greenside Mine

The site is believed to have been first worked by the Romans. However, it was not until 1784 that the first official documents of mining at Greenside took place. From 1827 to 1957, the mine saw near continuous work, extracting vast quantities of ore. The mine finally closed in 1961 after the ore veins were exhausted.

Throughout its lifetime, it is estimated 2.4 million tonnes of ore was extracted. This equated to 200,000 tones of lead and 2 million ounces of silver.

Most of the ore was in the form of galena, found in mineral rich veins that descend over 600 m through the Birker Fell Formation. Mineralisation abruptly ceases upon reaching the Skiddaw Group (Gough, 1965; Stone et al., 2010).

K-Ar dating of ore-bearing microgranites within the mine suggest the ores were deposited between 360-330 Ma (Stone et al., 2010), roughly 90-120 Ma post-BVG volcanism.

Nowadays the mine is only accessible during special events. Otherwise, it is not permitted to climb the spoils due to risk of collapse.



# Locality 2 – Blea Cove – Andesite Lavas

Andesite lava of the Birker Fell Formation. Generally, the outcrops show few features beyond a pitted surface where phenocrysts have weathered out.

Higher up the sequence, an autobreccia layer displays recessed andesitic blocks.



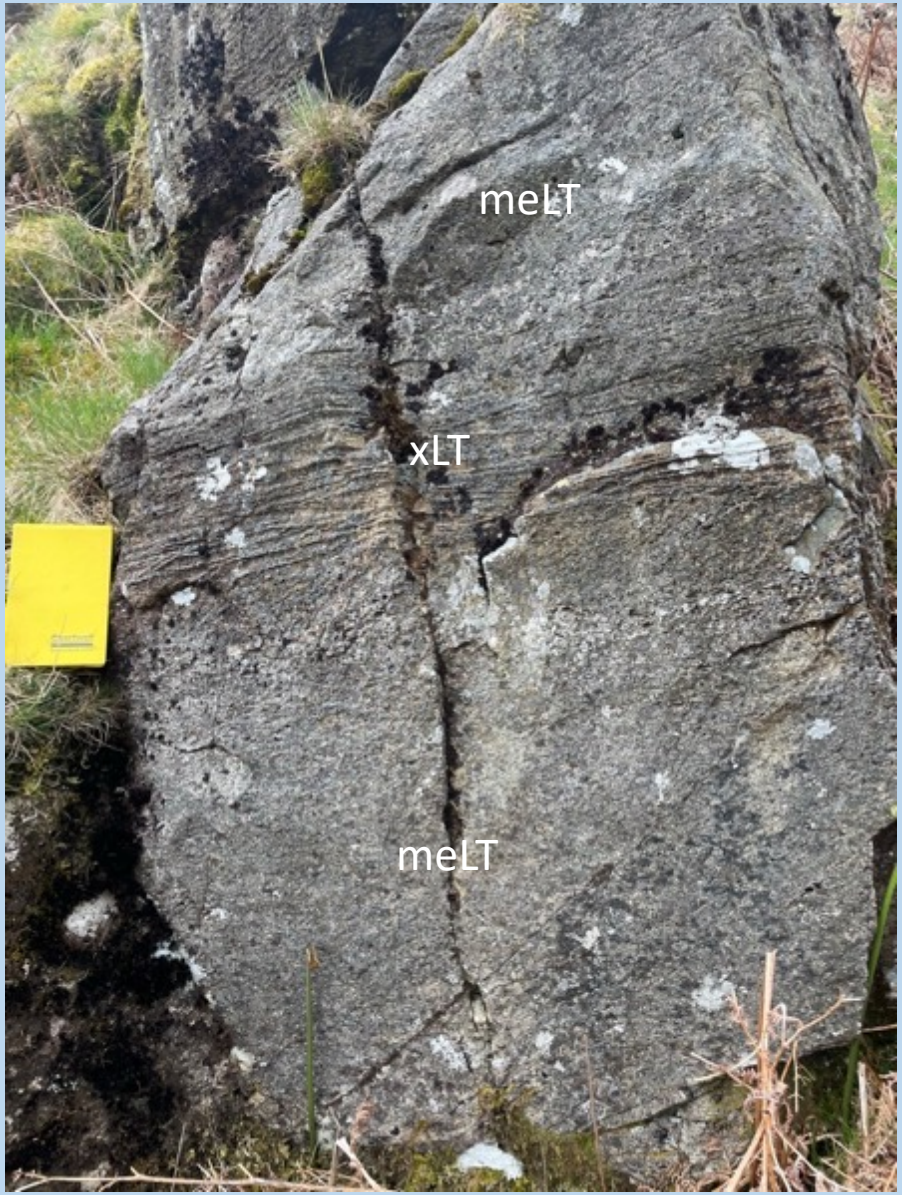


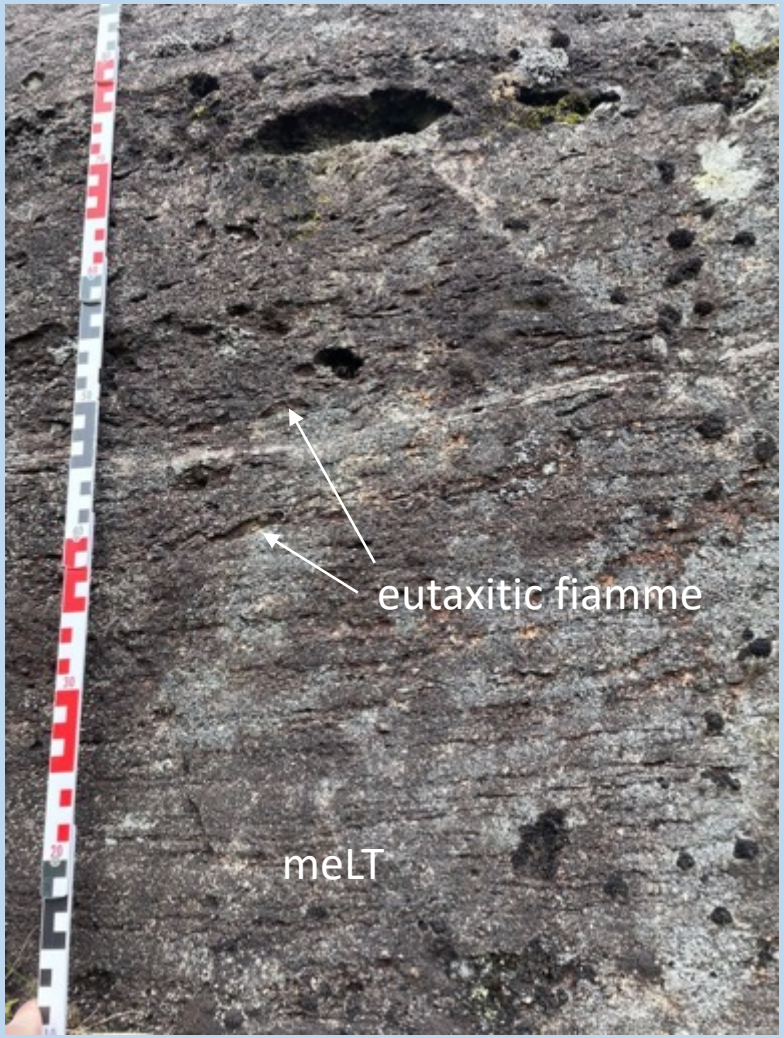
# Locality 2 – Blea Cove – Small ignimbrite

Within the lava is a thin grey silicic ignimbrite, mostly displaying metre-thick massive eutaxitic lapilli tuff (meLT).

In the middle of the ignimbrite, there is a 25 cm thick cross bedded lapilli tuff (xLT), indicating a traction-dominated flow-boundary zone, possibly suggesting a waning in the pyroclastic flow, before waxing again and depositing a massive deposit once again.

The ignimbrite is overlain by another andesitic lava, and so records a small explosive eruption during a predominately effusive eruption phase.



# Locality 3 – Blea Cove – Thirlmere Member

Crossing over a fault, the outcrops dramatically shift to a highly welded massive parataxitic lapilli tuff (mpLT), known as the Thirlmere Member.

The high-grade nature of welding seen here suggests the ignimbrite was rapidly erupted from fissure vents that produced low-column fountains that prevented the deposit from quickly cooling.

The highly attenuated fiamme are near vertical within proximity to the fault adjacent with the Birker Fell lavas. In places display sizeable rheomorphic folds, suggesting fault movement soon after emplacement, whilst the ignimbrite was still hot and ductile.

The Thirlmere Member is very similar in lithology and geochemistry to the Crinkle Tuffs of the Airy's Bridge Formation. Further investigations are ongoing to determine if the Thirlmere Member is part of the Crinkle Tuffs, or if the two were emplaced via similar mechanisms during separate caldera-collapse events.



# Locality 3 – Blea Cove – Thirlmere Member




Very steep rheomorphic folding within the ignimbrite likely formed due to slumping occurring as active volcanotectonic faults moved. The shape of the folds suggest downthrow of the fault was to the northwest (right hand side of the photo).

The ignimbrite was very pumice rich. However, the occasional white silicic accidental clast can be found in some outcrops. Being much colder than the ignimbrite, these experienced far less ductile deformation, and are instead wrapped by the parataxitic fiamme (indicated by white lines in photo).



# Locality 4 – Blea Cove – Esk Pike Formation

The contact between the parataxitic ignimbrite and overlying sediments of the Esk Pike Formation is not well seen. Furthermore, a lot of the Esk Pike exposures are covered in vegetation, or poorly weathered. However, a disused slate quarry provides an excellent alternative!

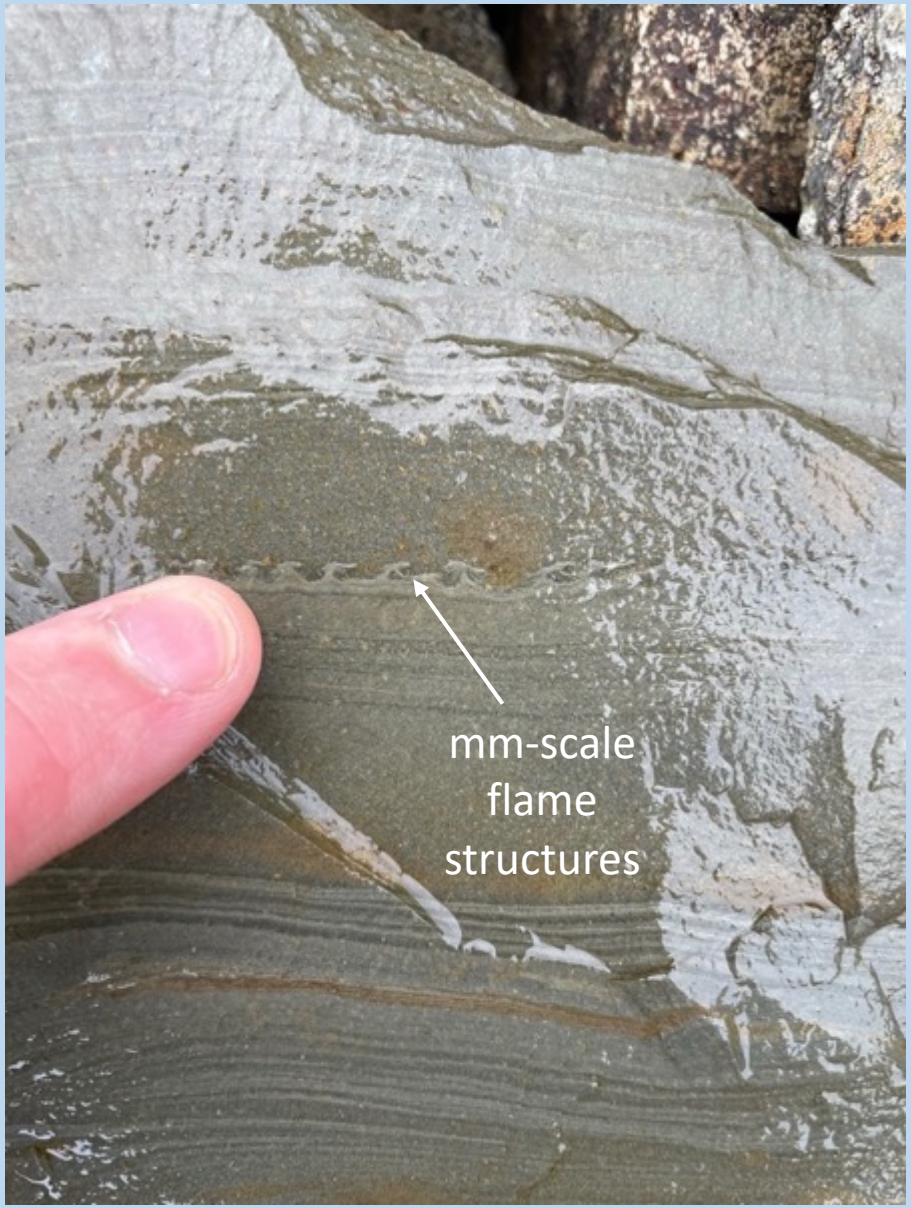
The well cleaved mud- to sand-grained sediments experienced low-grade metamorphism, transforming them into slate. While the metamorphism may have transformed the rocks slightly, it did little to impact the well preserved soft-state deformation features found within the sediments (see next page).

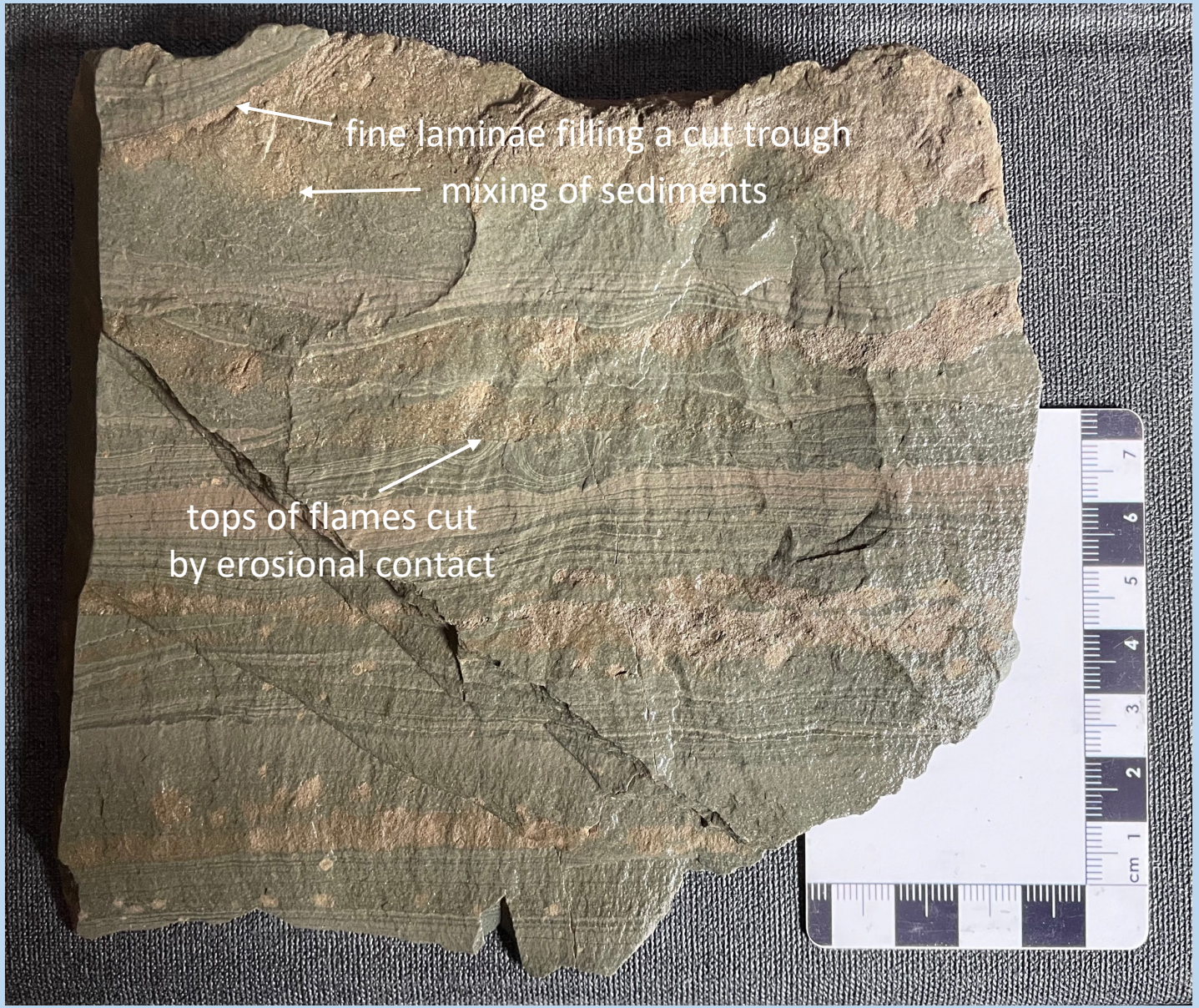
Sediments alternate between fine-grained, green muds and slits, and coarser-grained brown sands. The finer grained sediments typically form mm-thick parallel laminations, with the occasional cross-bedding. The coarser grained sediments are often the cause of the soft-state deformation, creating flame and load structures, erosional contacts, or turbulent mixing of different grain sizes. Occurring every few centimeters, these sandstones were likely deposited via frequent mass flows.

Higher up in the sequence, pebbly sandstone and breccia deposits are present. Throughout the Esk Pike Formation within the Helvellyn area, such conglomerates and breccias are thickest, and contain the largest clasts proximal to faults. This suggests the deposits were generated by and/or constrained by syndepositional faulting. In the case here, the major fault is the Birkhouse Moor Fault, just to the north.



# Locality 4 – Blea Cove – Esk Pike Formation




Wetting the surface of the slates really helps to bring the colours out

# Locality 4 – Blea Cove – Esk Pike Formation

Within the Esk Pike Formation are several breccia and conglomerate deposits. The deposits are likely the result of mass flows, or even collapsing fault scarps into the palaeo lake.

Large rounded boulders of the parataxitic ignimbrite are easily visible within in the conglomerates (right), likely the result of rip-up and transportation of the underlying Thirlmere Member.






# References


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