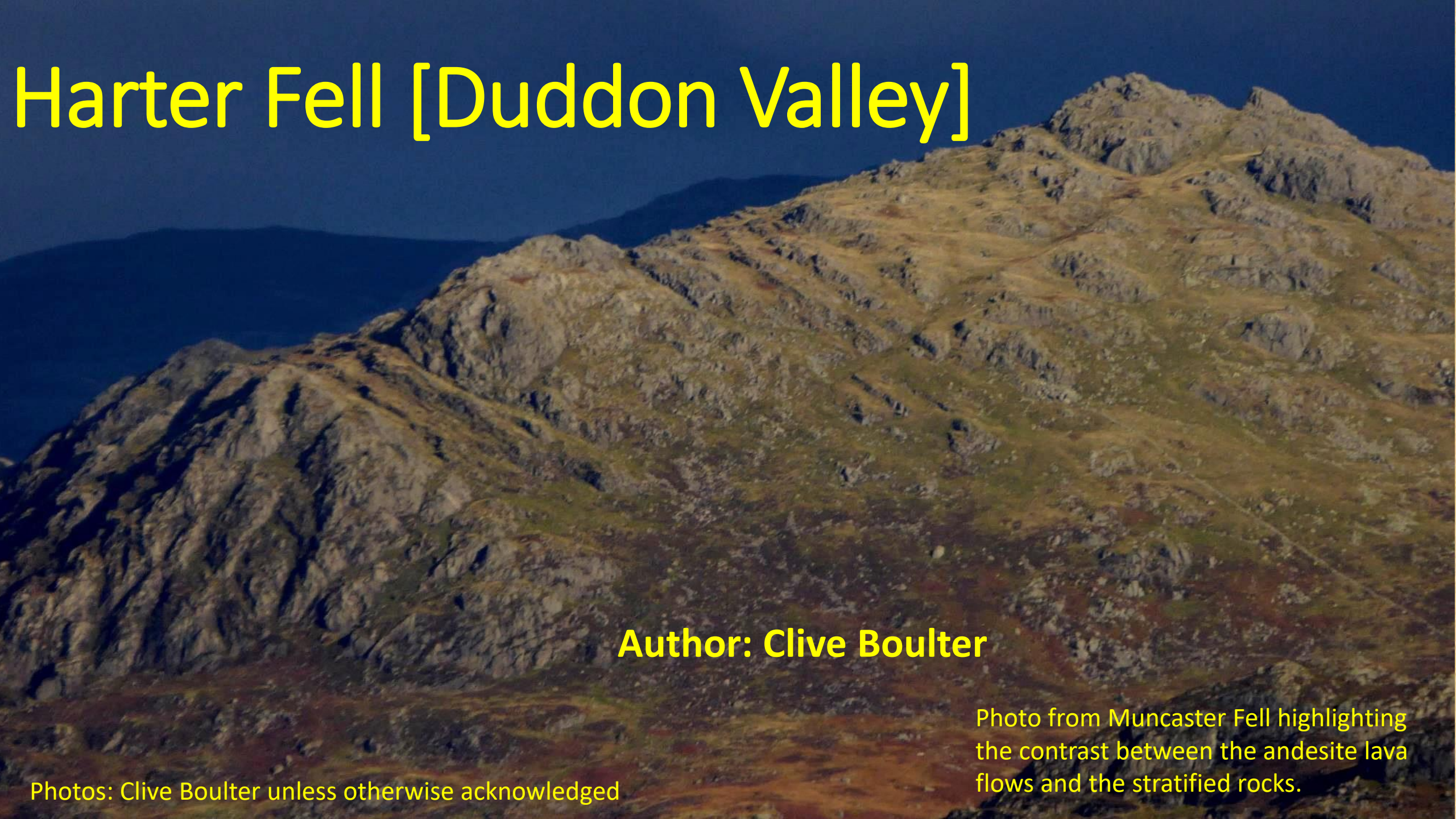
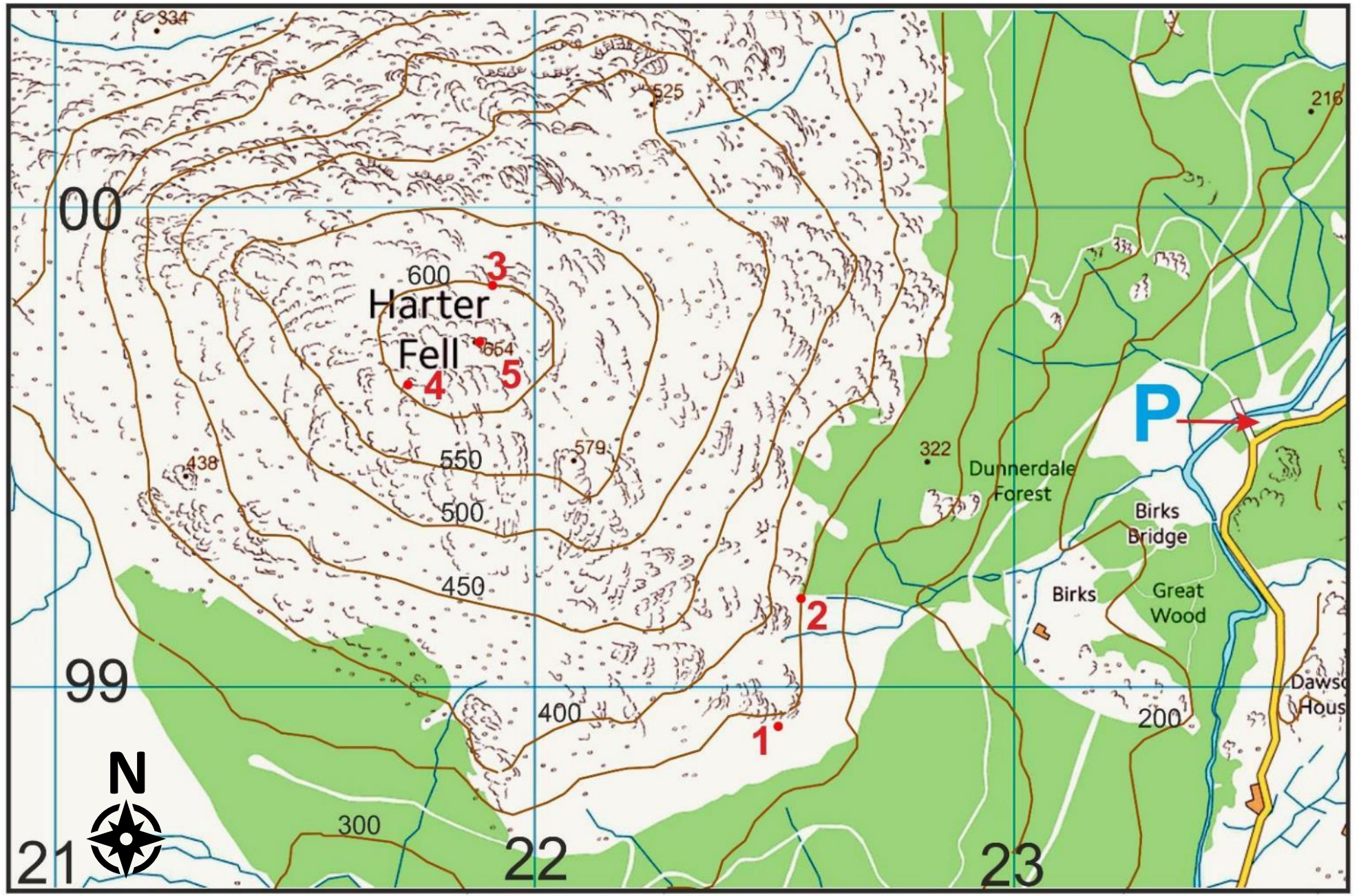
Harter Fell [Duddon Valley]



Author: Clive Boulter

Photo from Muncaster Fell highlighting the contrast between the andesite lava flows and the stratified rocks.

Photos: Clive Boulter unless otherwise acknowledged



Locality Map & Logistics

Park at Birks Bridge, Forestry Commission parking area SD 2350 9955

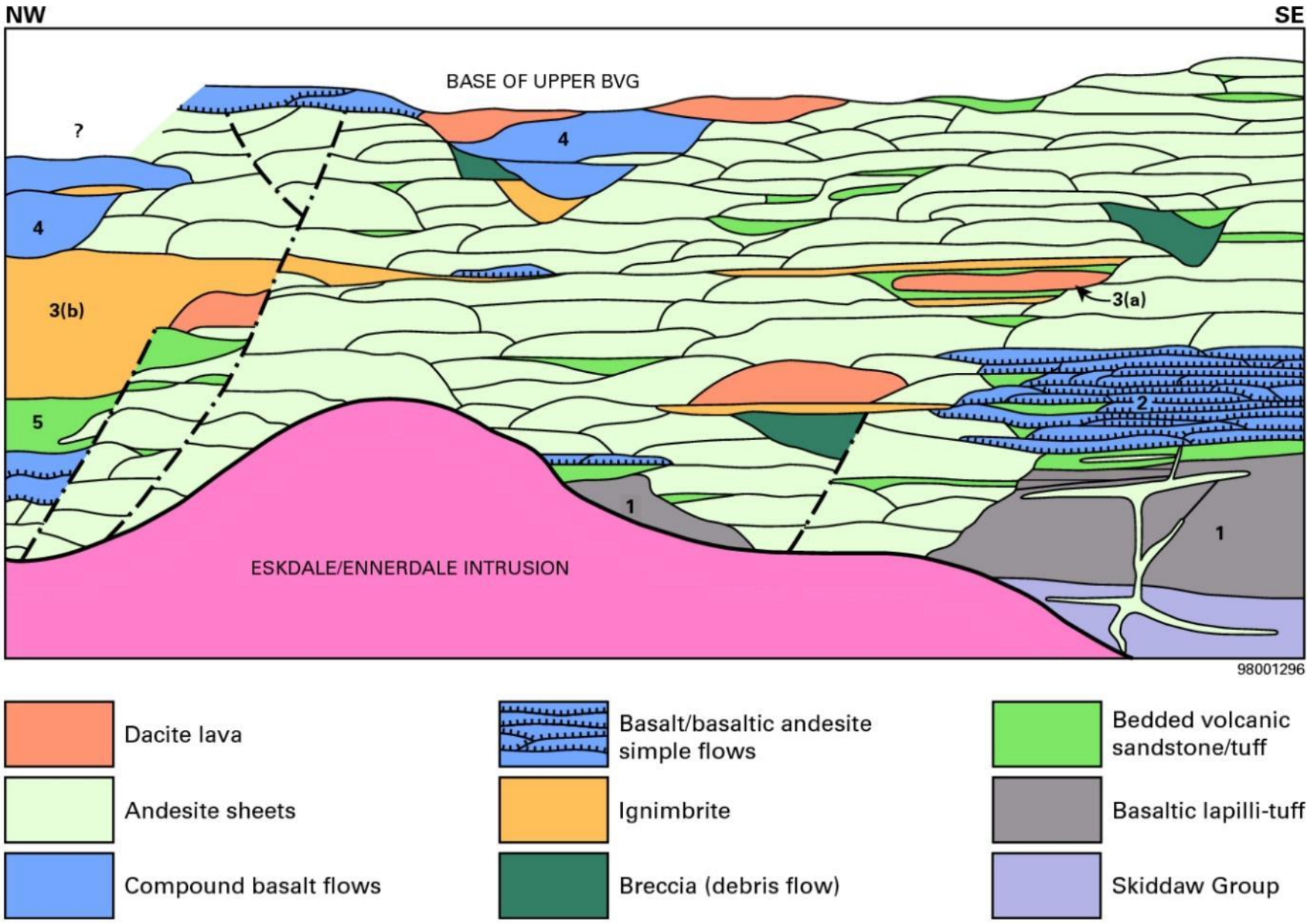
The traverse is on open fellside or on moderately-defined paths. Generally steep climbs are involved. This itinerary is a modified version of Itinerary 11 by D. Millward in the Geologists' Association Geology of the Lake District, 1990, edited by F. Moseley.

Base map from Ordnance Survey OpenData. Kilometre grid.

Background Information on geology seen at Brandy Crag [Location 1]

This excursion is entirely within the Birker Fell Formation which dominates the lowermost part of the Borrowdale Volcanic Group. The unit is up to 2700 m thick and about 60% is andesite lava flows [plus sills] but it also contains basalt, basaltic andesite, and dacite lava flows as well as pyroclastics [ignimbrites and airfall tuff] and reworked material [fluviatile and lacustrine]. Classic images of volcanic cones should be side-lined as this assemblage formed a low-profile plateau volcanic field mainly fed by fissure eruptions. The andesite lava flows are normally tens of metres thick, but individual flows can be 200 m thick. Most flows can be traced for no more than five kilometres. The typical flow has blocky autobrecciated margins and, on the upper flow surface, the cavities between fragments became infilled with sediment either washed in as pyroclastics were reworked or settled in from air-fall pyroclastic events. An overall extensional setting is the only way such a thick pile of subaerial volcanic material can accumulate and be preserved. Convergent tectonics, such as subduction at a continental margin, readily provide such opportunities as most arc systems are in tension [slab roll-back].

The main focus for the itinerary is the two prominent felsic marker horizons within this otherwise monotonous pile of andesites and derived materials. Locally in contact, but otherwise separated by a few tens of metres of bedded volcaniclastics, the Little Stand Tuff [LST] and the Great Whinscale Dacite can be traced laterally for 16 and 13 km respectively. The LST is a rhyodacite ignimbrite and in almost every exposure it is readily identified by the presence of lithophysae which are spherulites that have a central vug. As is the case for spherulites, lithophysae are characteristic of high-temperature devitrification of coherent silicic glass and are found in formerly glassy lavas as well as welded pyroclastic deposits. They begin to grow at an early stage in the cooling history, when the hot glass is still able to deform plastically, and involve nucleation of spherulites on small vesicles. As spherulitic crystallization proceeds, the vesicles are expanded by the exsolving volatiles. The vugs vary from circular to star shaped, and may remain open or be lines or filled with minerals such as agate or chalcedony. Lithophysae range up to larger diameters than spherulites, reaching a few tens of centimetres across [McPhie et al. 1993, Volcanic Textures, University of Tasmania, Centre for Ore Deposit and Exploration Studies].



Diagrammatic relationships between lithofacies within the Birker Fell Formation. The diagram approximates to a NW to SE cross-section from Wasdale to Devoke water and the Upper Duddon Valley.

1 Devoke Water Tuff
2 Birkby Fell Basalts
3a Great Whinscale Dacite & Little Stand Tuff
3b Craghouse Tuff & Seatallan Dacite
4 Throstle Garth & Wrighthow basalts
5 Eagle Crag Member

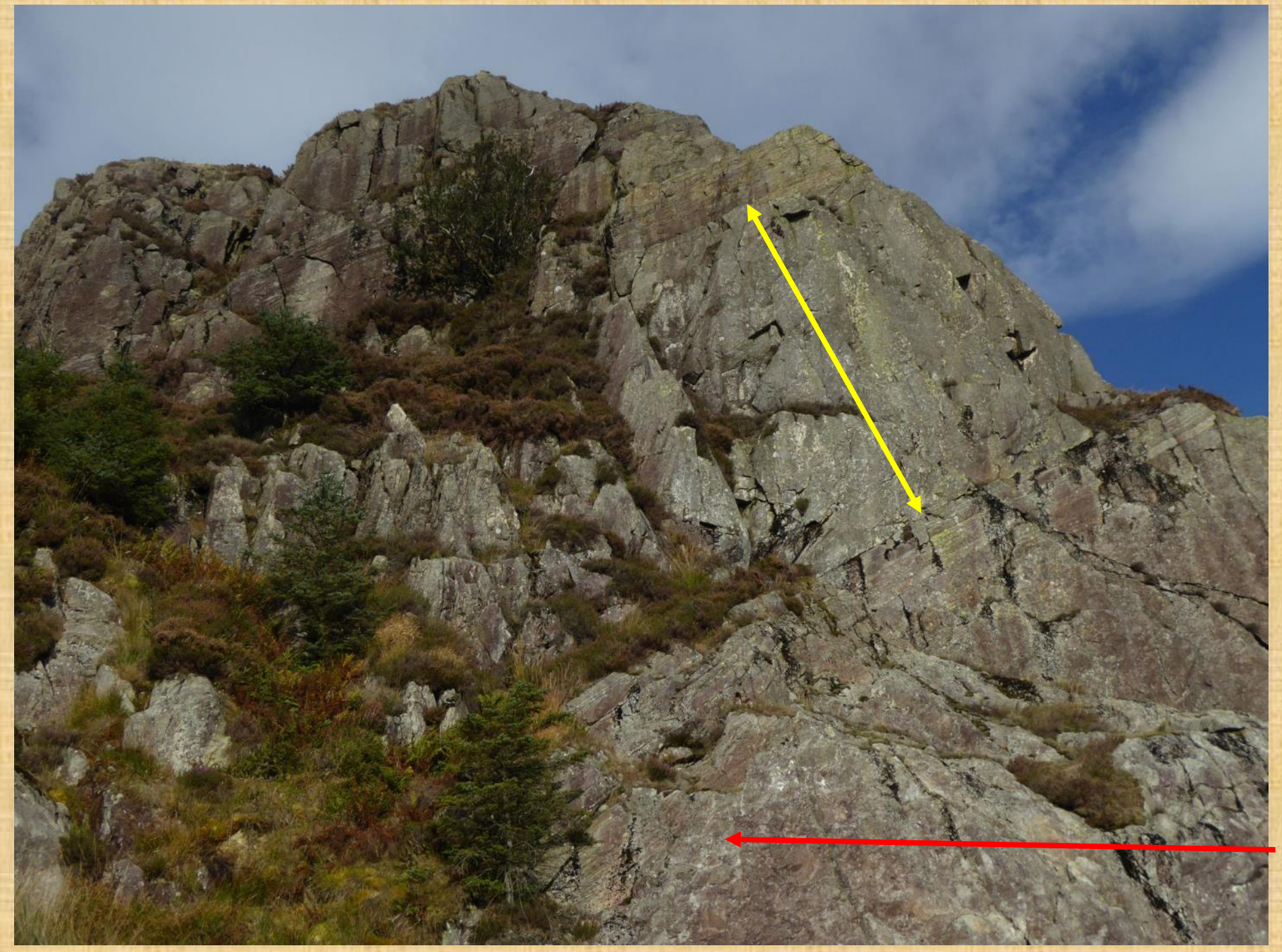
British Geological Survey
Earthwise P916408

Locality 1 Brandy Crag – marker horizons within the Birker Fell Formation [photo taken from SD 22490 98812]

Great Whinscale Dacite – dacitic lava erupted at high temperatures. Its base is just above the grassy ledge.

Between the GWD and the LST is an andesitic, bedded mixture of pyroclastics and fluvial reworked pyroclastics.

Andesite lava flow – the upper couple of metres is autobrecciated, cavities between clasts infilled with airfall tuff/reworked tuff. Between this flow and the LST is a couple of metres of bedded volcaniclastics.



Brandy Crag

Close up showing the full extent of the Little Stand Tuff [yellow] and the well-bedded material above and below it.

At this locality the characteristic nodular nature [lithophysae] of the Little Stand Tuff is not very prominent. Also, at best, the flattened pumice fabric is pretty weak and not evident at Brandy Crag. These features will be clearly seen near the summit of Harter Fell.

The upper autobrecciated couple of metres of the andesite lava flow has cavities between clasts infilled with white-weathering airfall tuff/reworked tuff.

Brandy Crag – the andesitic ignimbrite a few metres above the Little Stand Tuff.

The larger of the fiammé are around 10 cm long and the whole unit is a little over three metres thick.

Brandy Crag
Great Whinscale
Dacite.

The base of the GWD is at the colour contrast – lighter above [felsic] and darker below [andesitic]. The basal couple of metres of the GWD is autobrecciated and above that it is flow banded. The bulk of the GWD is flow jointed and the upper few metres can be amygdaloidal.

Brandy Crag – isoclinal folds of flow banding in the lower part of the Great Whinscale Dacite.

The basal few metres of the GWD is flow banded which displays flow folding. The lowermost two metres is commonly autobrecciated and many of the clasts have disrupted flow banding or flow folds.

Locality 2 SD 22542 99203
Fault with slickenlines and slickenside.

The fault dips 58° towards the SE and strikes 226-046°. The slickenlines plunge 52 → 098 [pitch 68° from 046]. The sense of movement cannot be securely determined. This minor fault is not along the gully and the fault that controls this topographic feature is not exposed though there is plenty of vein quartz in the scree including some moderate sized blocks.

Locality 3A Autobrecciated base of the Great Whinscale Dacite SD 21956 99823.

If you peer over the top of this mini crag you will see, very close by, the small rectangular tarn which is a key reference point.

Just a few metres west, towards the small tarn, is a good example of fluviatile reworking of primary pyroclastics. Very rarely on Harter Fell there is evidence for deposition in lakes [grading and elutriation channels].

The blocks in the photo are typically 15 – 20 cm.

In the general area above the rectangular tarn there are good exposures of the Great Whinscale Dacite. Both the GWD and the Little Stand Tuff are distinctive in their own right. Together they make an excellent marker horizon in the Birker Fell Formation in what would otherwise be a sequence perhaps overwhelmed by correlation challenges. These two units are found approx. 1200 metres above the base of the formation. Unusually laterally extensive, the GWD can be mapped over a distance of 13 km. Such a viscous magma can only flow so readily if it was erupted at high temperatures.

The bulk of the GWD is typified by the prominent flow joints shown here which are so distinctive they can be recognised in well-travelled erratics.

Locality 3B Little Stand Tuff SD 21880 99869

A complete section through this unit is easily accessible here highlighting the unit's distinctive nodular appearance. Also present [see below] is the weak eutaxitic fabric [alignment of flattened pumice fragments] that proves the ignimbritic origins of the unit. The in-situ exposure [left] shows the overall distribution of lithophysae [mostly 4 to 6 cm].

The in-situ exposure shown on the previous slide is north facing, damp, and has an organic coating. Better opportunities to examine lithophysae in detail are provided by joint faces on fallen blocks. On a fresh surface the 4-6 cm nodules weather positively whereas on joints, sectional views are seen. A 20p coin is circled in yellow on the left-hand photo.

Locality 3C impact sag
SD 21837 99857

For the bedded units between lava flows, and the obvious pyroclastics, it can be quite a challenge to determine how they were deposited. In this fallen block it is clear that a rectangular pyroclast approx. 16 cm long has impacted stratified airfall deposits.
The clast is picked out in faint green by selective epidotisation.

Locality 4 Isoclinally folded flow banding in andesite lava flow, Birker Fell Formation [approx. 3m section].
SD 21733 99619

The layering known as flow banding can result from just a few percent variations in the amount of tiny crystals [microlites] and/or tiny vesicles. During magma ascent, and whilst it flows over the Earth's surface, repeated episodes of fracturing, healing, and attenuation in the flow, stretch out pockets of different texture to create banding. Flow banding was once thought to be created by segregation of phenocrysts and microlites during magma flow. On close inspection the bands are seen to have ragged margins. Flow banding is normally weakly defined but can be emphasised by weathering to be nearly as well developed as bedding in sedimentary rocks.

Close to Locality 4 at SD 21727 99666 a thin layer [<20 cm] of small accretionary lapilli [smooth areas] overlies autobreccia at the top of the flow-banded Great Whinscale Dacite [also amygdaloidal].

Locality 5 Harter Fell Summit
SD 21850 99726

Autobrecciated top to an andesite lava flow with laminated sediment infilling cavities between blocks. By tracing such horizons the British Geological Survey has mapped several lava flows around the summit. As ever careful observations are required to be sure that an effusive origin has been determined rather than an intrusive peperitic contact.

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