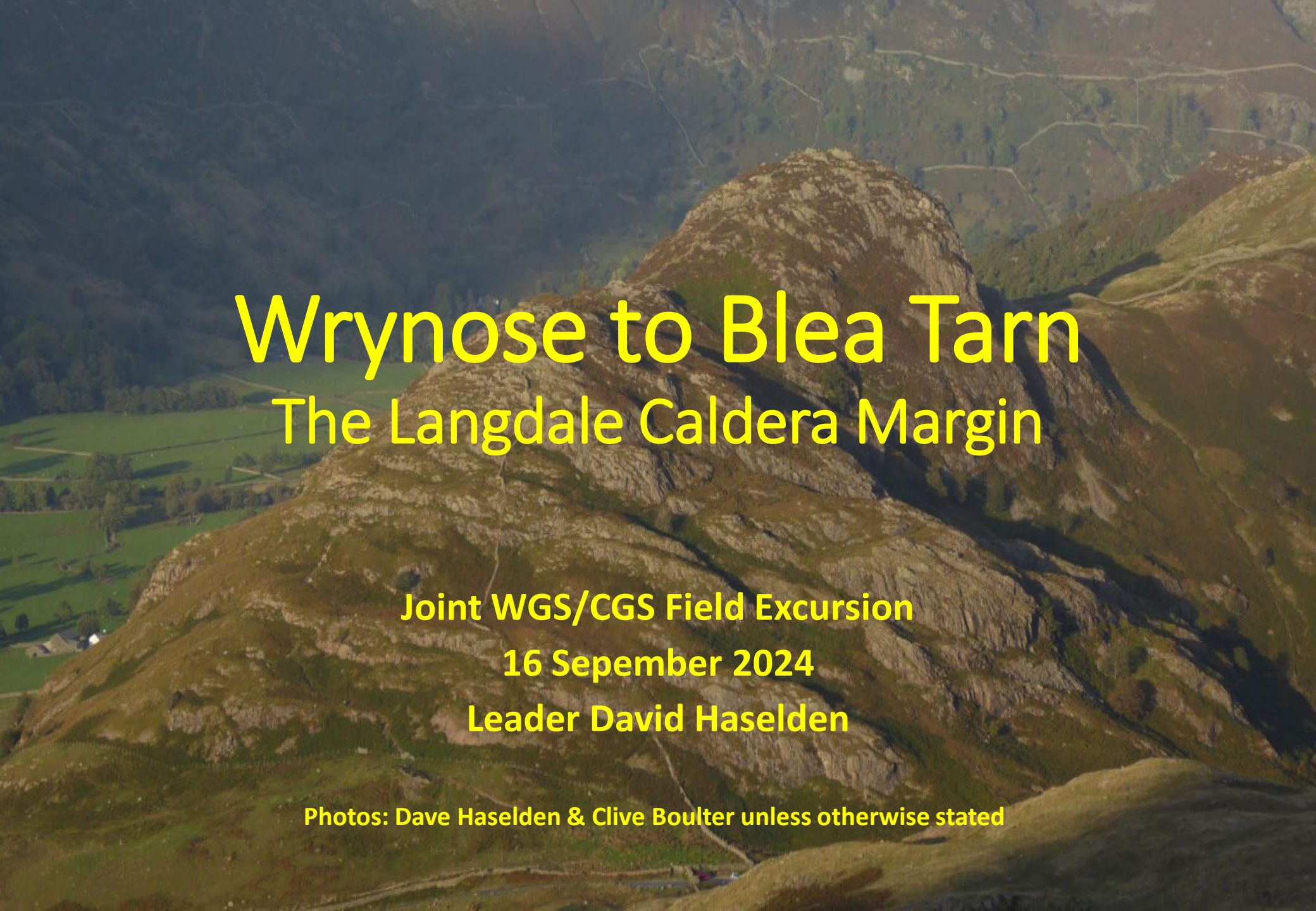


Wrynose to Blea Tarn

The Langdale Caldera Margin

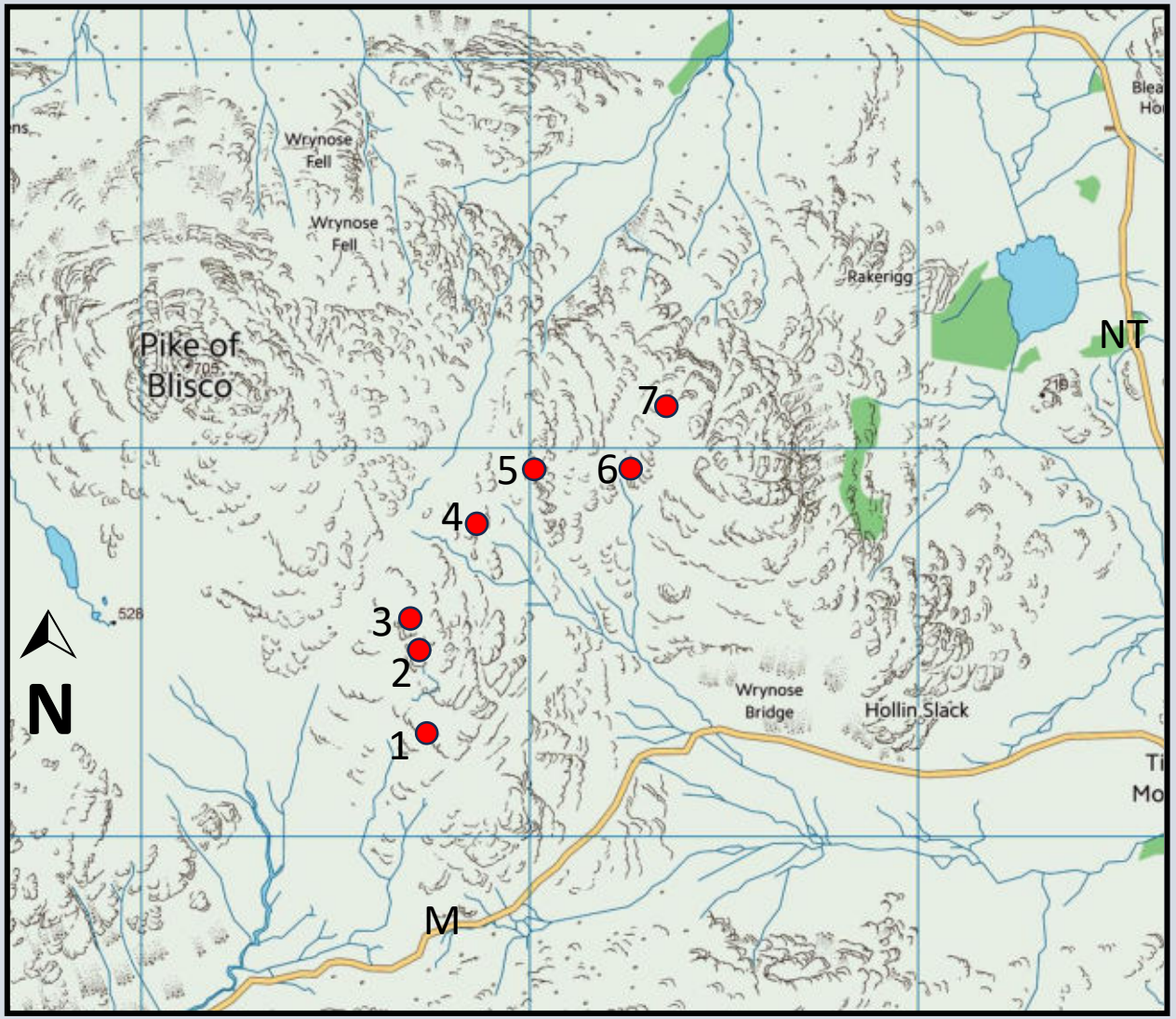
Joint WGS/CGS Field Excursion

16 Sepember 2024

Leader David Haselden

Photos: Dave Haselden & Clive Boulter unless otherwise stated

LOGISTICS



- Meet at the Blea Tarn National Trust Car Park (NT on map) (NY 2956 0432) to consolidate car use, discuss the weather and decide whether to go up the Crinkles or do this alternative to the Crinkle Crags Excursion in the event of low cloud.
- We will head up to the Three Shire Stone (M on map) **for 10h00** and set off towards Teighton How (**NY 27736 03273)**
- None of the walking is on well-defined paths and much is over open fellside, boggy in places. The descent from Blake Rigg to Blea Tarn is steep and only partly on a weakly defined path.
- The excursion is approximately 5km in length with ~300m of ascent and ~450m of descent.
- The excursion finishes at Bleaberry Knott, but if time allows other aspects of the area may be included on the way back to the NT car park at Blea Tarn.

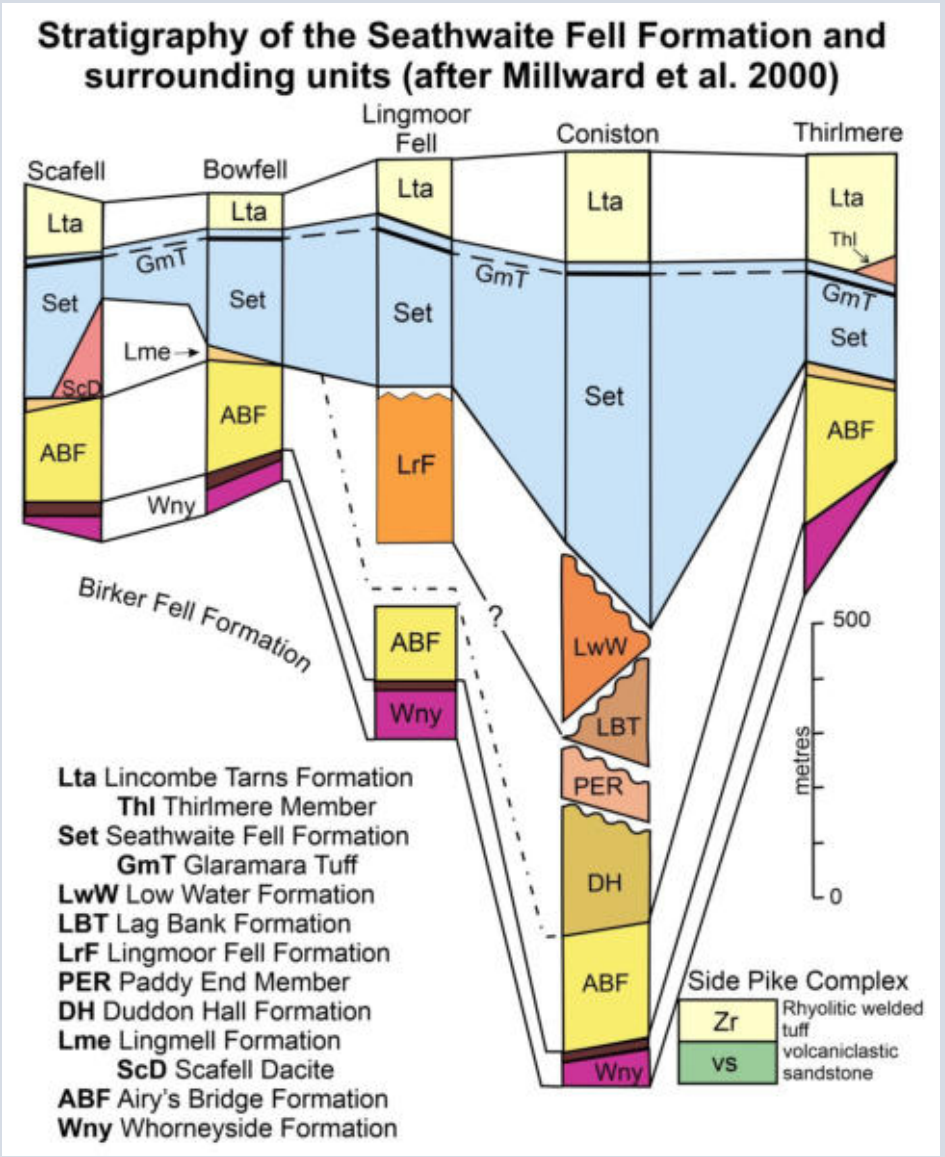
INTRODUCTION

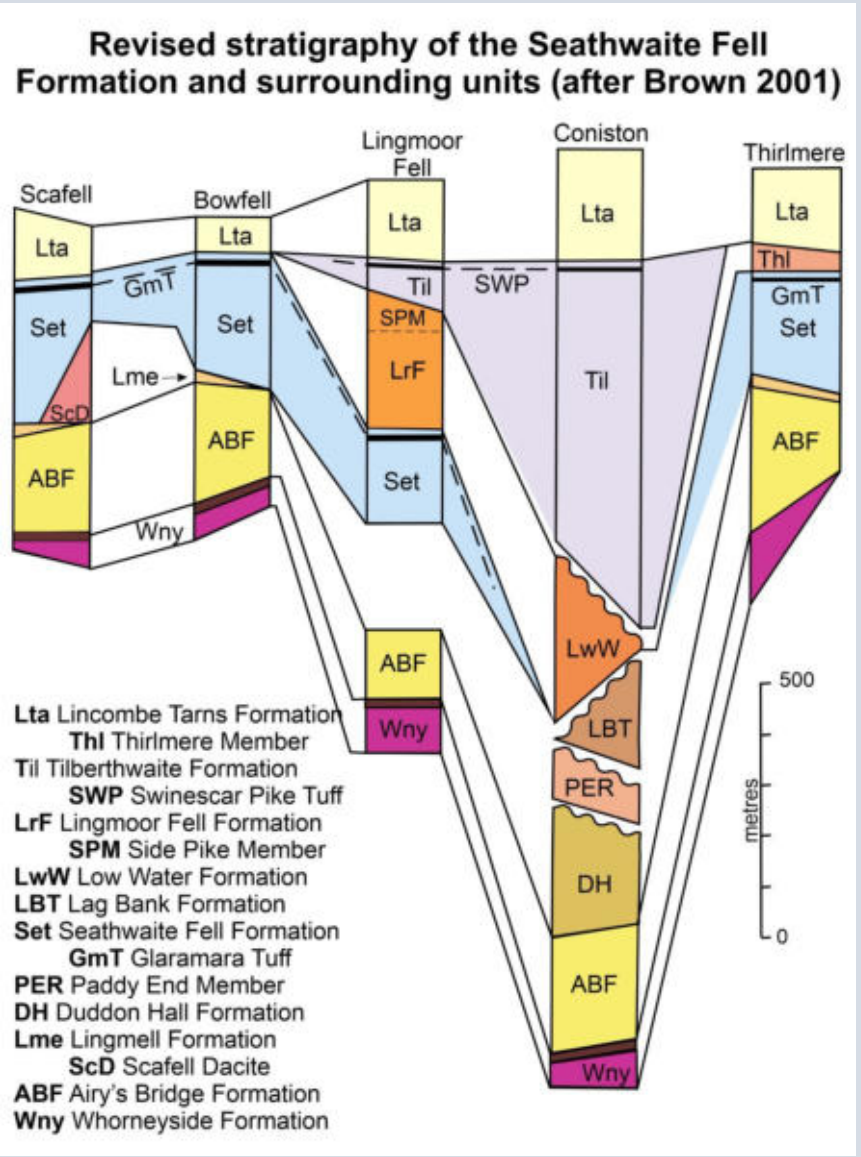
The main focus of the excursion is the Langdale Caldera but the area also provides an opportunity to examine part of the margin of the earlier Scafell Caldera. The route takes advantage of some magnificent exposures of the Birker Fell Formation andesite lava flows which are the greater part of the plateau lava field pre-dating the abrupt change to paroxysmal eruptions. Explosivity started with andesitic magmas but became predominantly silicic. The initial andesitic explosivity is represented by the Whorneyside Formation: the lower Wet Side Edge Member [andesitic welded ignimbrite] and the upper bedded-tuff [air fall deposits from a gigantic phreatoplinian eruption]. Most of the excursion is in the former Side Pike Complex, a 5 km^2 area that could not be tied into the regional stratigraphy in the BGS resurvey.

Detailed work on part of the established stratigraphy of the Scafell Caldera was extended to the former Side Pike Complex with dramatic consequences for the stratigraphy of the Borrowdale volcanics and its volcanological model (Brown, 2001). At Long Crag five metres of stratigraphy are so distinctive that Brown (2001) could identify them as being the Glaramara Tuff from of the uppermost Seathwaite Fell Formation which is the sedimentary infill of the Scafell Caldera. Having got this reference point it was apparent that the underlying twenty or so metres of water-lain volcaniclastics are the equivalent of the Seathwaite Fell Formation which is typically 100s of metres thick and at its maximum is 540 metres; this is a massively reduced section compared to the Scafell Caldera section just a short distance away on Crinkle Crags. This work implies a marginal Scafell Caldera setting and the identification of the younger Langdale Caldera.

Mapping by Dave Haselden and Clive Boulter has now documented this caldera and in particular the large number of VTFs, many of which are substantial structures. The new stratigraphic elements identified by Brown (2001) provided the basis for the mapping and additional units have been recognised during the mapping (Haselden and Boulter 2021).

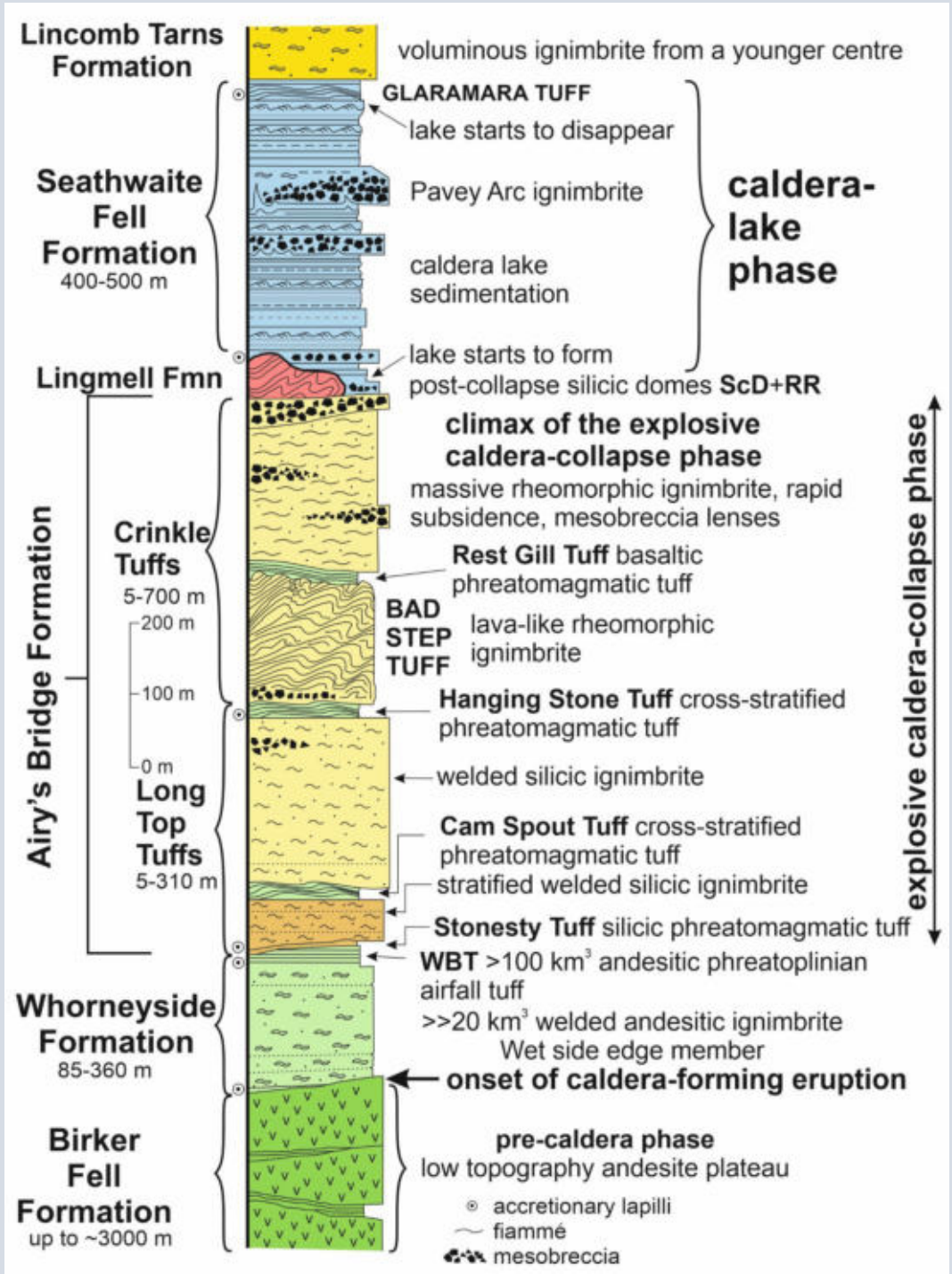
More recent work by a number of postgraduate students from Leicester University studying under Mike Branney has added a further twist to the story (E. McGowan Personal Comms.). Based on geochemical analysis the ‘Glaramara Tuff’ at Long Crag and Side Pike does not correlate with the Glaramara Tuff further north and must be a separate tuff ring deposit. This throws into question the stratigraphic correlation made by Brown [2001] and used as a basis for the mapping. However, geochemical analysis of the Side Pike Ignimbrite correlates it with the Paddy End and Stickle Pike Members of the Lickle Formation found in the Coniston area to the south where they overly the Scafell Caldera succession, thus re-confirming the stratigraphic basis used by Haselden and Boulter (2021).



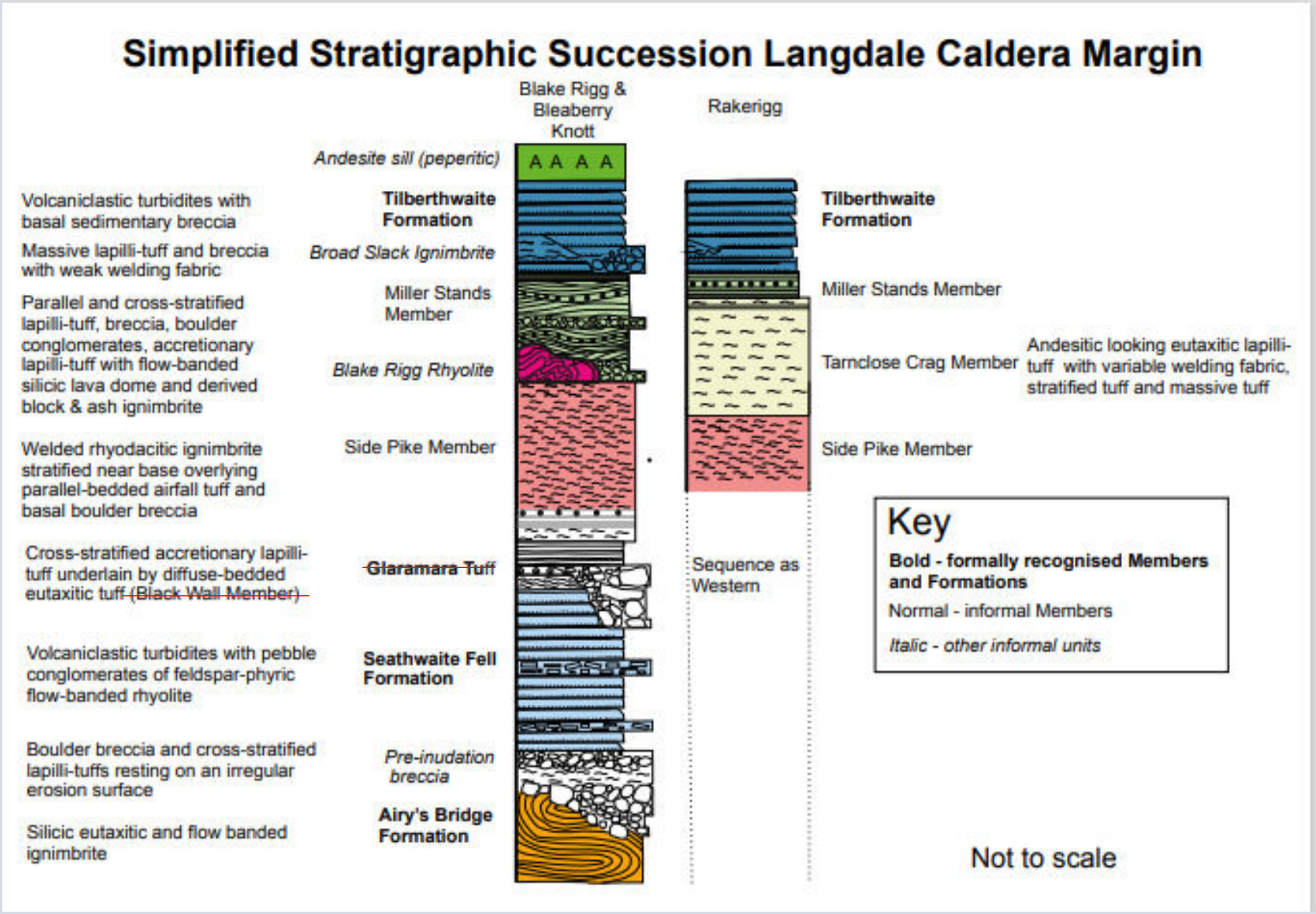


Comparison of the correlations made in the Ambleside Memoir (Millward *et al*. 2000) and those made after recognition of Airy's Bridge and Seathwaite Fell Formation elements in the former Side Pike Complex (Brown 2001). The latter has been modified to remove some stratigraphic correlations that have not been generally accepted (Millward 2004).

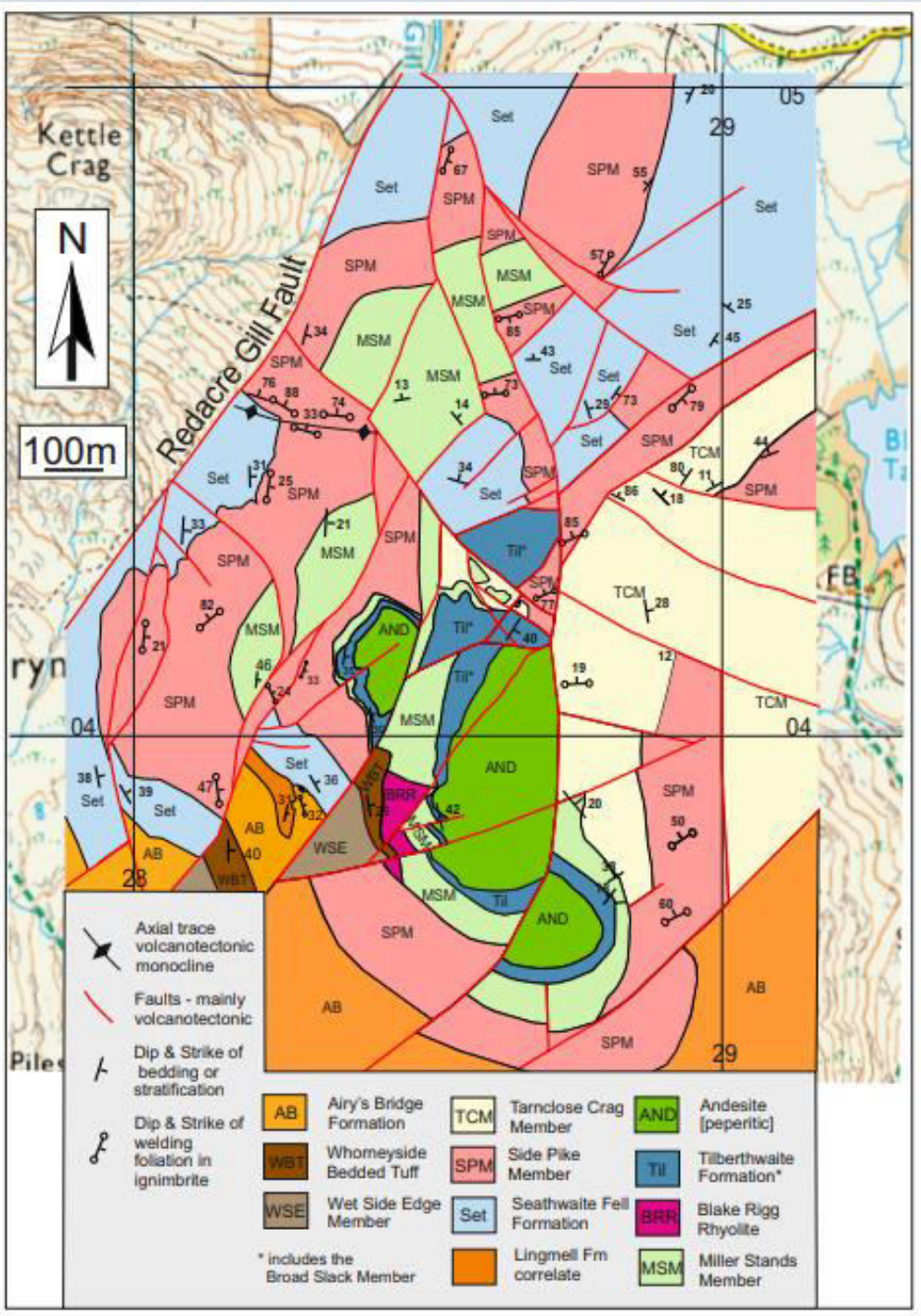
Section locations are as follows: Scafell NY 215072; Bowfell NY 245065; Lingmoor Fell NY 305045; Coniston NY 290990; Thirlmere NY 320130; Side Pike Complex NY 285045.



Scafell Caldera stratigraphy as seen in the Central Fells (adapted from Brown et al. 2007).



Although the identification of the Glaramara Tuff and Blackwall Member has been called into question, the stratigrahical relationship to the Scafell Caldera succession remains valid based on correlation of the Side Pike Member with the Paddy End and Stickle Pike Members of the Lickle Formation..



Geological Map of the former Side Pike Complex after Haselden and Boulter (2021)



Locality 1 NY 27736 03273
Birker Fell Formation

On the first part of the traverse to Long Crag there are many excellent exposures of andesite lava flows and intercalated stratified rocks both pyroclastics and reworked materials. This part of the Birker Fell Formation has a higher percentage of andesite than the average 60%. Overall the unit has the form of a plateau andesite field.

Locality 1 is the top of an andesite sheet where a sedimentary network infills the gaps between feldspar-phyric andesite blocks. Is this the rubbly top of a lava flow where sediment was washed into the gaps between the andesite blocks? Or is it the top of a peperitic sill and unconsolidated sediment was injected into the andesite which fragmented on contact with the cool wet sediment? The lack of vesiculation in the sediment together with the sediment lamination suggest this is a lava rather than a peperite.

Locality 2 NY 27721 03506
Wet Side Edge Member of the Whorneyside Formation

Andesitic welded ignimbrite with a weak welding fabric. The WSE marks the start of large-scale explosivity in the Scafell Caldera.

Coin is 21.4 mm in diameter.





Locality 3 NY 27697 03564 Whorneyside bedded tuff & evidence for early piecemeal caldera collapse

Perfectly parallel-bedded airfall tuff from an exceptionally large magnitude andesitic phreatoplinian eruption that immediately pre-dated the rhyolitic Airy's Bridge component of the Scafell Caldera. Large volumes of water accessed the magma chamber and created a very damp eruption. Sorting is much poorer than typical airfall tuffs. Damp ash and lapilli clumped together and showered out of the umbrella cloud.

Extensional features are widespread in this vicinity and impact sags are common. During piecemeal caldera-collapse, blocks of this tuff were tilted. The headwalls of the slide blocks were extended as here and the toes developed compressional structures such as thrust faults as at Stonesty Pike.

Conjugate normal faults create horst & graben patterns as can be seen in the background of this photo

Locality 4 NY 27861 03797 Airy's Bridge Formation overlain by sedimentary breccias and thin ignimbrites



This is a well-exposed example of the pre-inundation deposits before the Scafell Caldera began to fill with water. The equivalent unit at **Locality 7** is less clearly displayed.

At this locality is a bedded sequence of boulder to pebble sedimentary breccias comprising clasts of the underlying welded ignimbrite. These deposits rest on the youngest Airy's Bridge unit in the region which is probably a high-grade lava-like ignimbrite. It is either the Bad Step Tuff or some other part of the Crinkle Member.



This exposure of phreatomagmatic tuff and that at the base of the succession on Side Pike must belong to a separate, coincidental, tuff ring eruption.

FROM THIS REFERENCE POINT TRAVERSES WILL BE MADE TO THE SOUTH AND EAST

Locality 5 NY 27992 04002 Long Crag "Black Wall Member" and "Glaramara Tuff", Seathwaite Fell Formation

This locality was the key stratigraphic marker following the work of Brown (2001) and provided the definitive reference point for identifying stratigraphy in this challenging area formerly known as the Side Pike Complex.

The identification of the underlying sedimentary sequence as the Seathwaite Fell Formation is now based on correlation of the Side Pike Ignimbrite with the Lickle Formation to the south.



Locality 5 NY 27992 04002 “Glaramara” Phreatomagmatic Tuff at Long Crag

The whole of the field of view is rich in accretionary lapilli and the stratification plus the cross-stratification show that this unit was deposited from a low-concentration pyroclastic density current.

South from here, over the grassy gully, the tuff has been removed by erosion at the base of the Lingmoor Fell Formation. The tuff exists in only small pockets in the area mapped for this excursion guide because of this erosive event.

Coin: 21.4 mm in diameter.

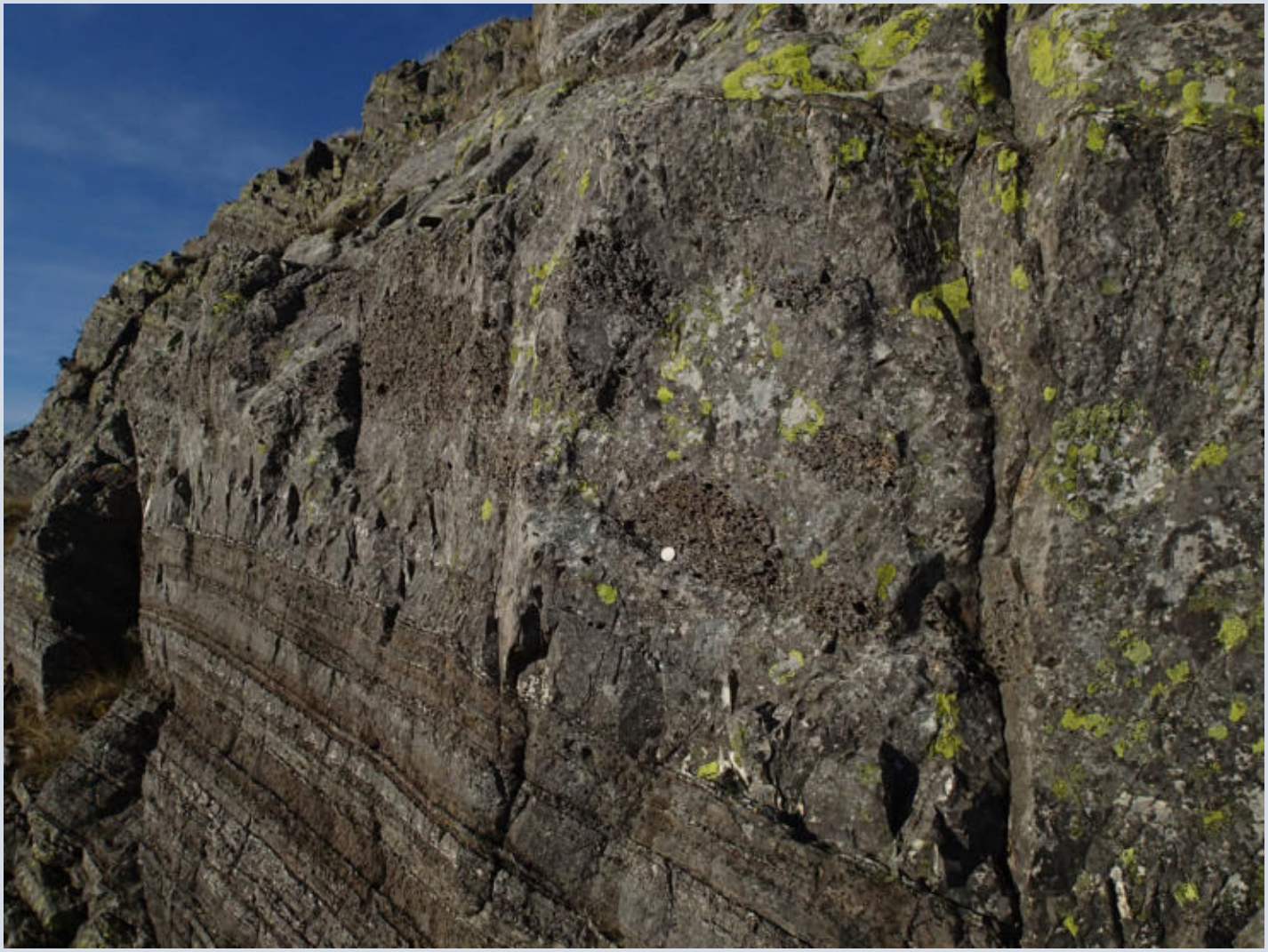
Locality 5 NY 27732 03270
“Glaramara Tuff” at Long Crag
Closeup view of the multiply rimmed accretionary lapilli up to 1 cm long.





South along the west side of Long Crag there is continuous exposure of the massively reduced Seathwaite Fell Formation section most of which is seen in this photograph **[NY 28010 03892]**. The well-developed bedding is mainly turbiditic in origin but none of the distinctive members [Three Tarns, Harrison Stickle, Cam Crags, Bell Crags, Dungeon Ghyll, Pavey Ark, Bowfell Links, Cockley Pike] seen in the Scafell Caldera can be identified. Some of the layers have reverse graded pumice fragments a few cm in size and one layer has up to 50 cm pumice clasts from a subaqueous eruption.

Just below this point is the Airy's Bridge Formation which here is either a flow-folded rhyolite or a lava-like ignimbrite correlated with the Oxendale Tuff by the BGS.



NY 28010 03894

Pumice breccia bed, roughly half way up the Seathwaite Fell Formation sequence. This is the result of a subaqueous explosive eruption within the Scafell Caldera. The coin is resting on a pumice clast.

At **Locality 6** correlates of this bed occur about halfway through a 70 m thick Seathwaite Fell sequence.

Coin is 21.4 mm in diameter.

[P9293117]



P1490823

Return to Locality 5 NY 27732 03270

Above the phreato magmatic tuff there is an erosive contact with an overlying pebble/boulder breccia and the start of the Langdale Caldera succession. The contact is in the form of deeply-incised gullies and can be traced to the south near the top of the crags of Long Crag.



Immediately above **Locality 5** the pebble/boulder sedimentary breccia is only a metre or so thick. Above that is eight metres of mainly parallel-bedded airfall tuffs , some of which has been aqueously reworked. This is overlain overlain by a distinctive rhyolitic welded- ignimbrite – the Side Pike Ignimbrite which is about 30 metres thick.

A traverse from **Locality 5** going east will give a good idea of the internal features of the Side Pike Ignimbrite and is a good opportunity to study the variation in weld intensity.



This is a very distinctive exposure **[NY 28040 04022]** a few tens of metres east of **Locality 5**.

Careful examination of the variation in weld intensity on the traverse suggests the Side Pike Ignimbrite is in fact two pyroclastic flow units. Recent geochemical studies correlate the lower unit with the Paddy End Member and the upper unit with the Stickle Pike member of the Lickle Formation.

Examples of the welding fabric on the traverse



NY 28067 04044
Left: a high concentration of small fiammé around 2-3 cm in length. This is a characteristic feature of the Side Pike.

Right: microfolding of the parataxitic welding fabric creating a crenulated effect.



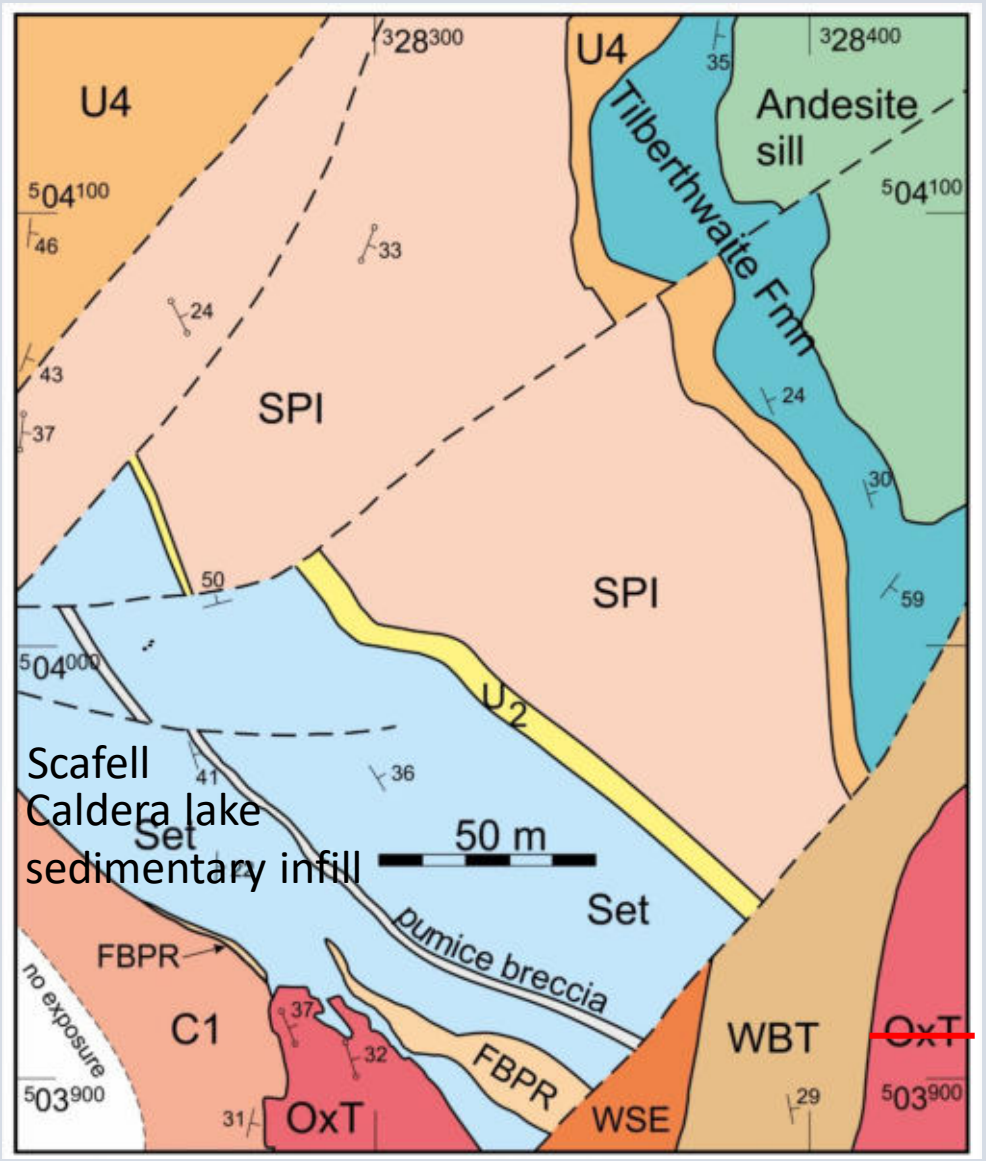


NY 28067 04039 & 28076 04058 have large fiammé and wrapped lithics.

Left: a wrapped lithic that has not been compacted.

Right: a very large fiammé showing extreme flattening.





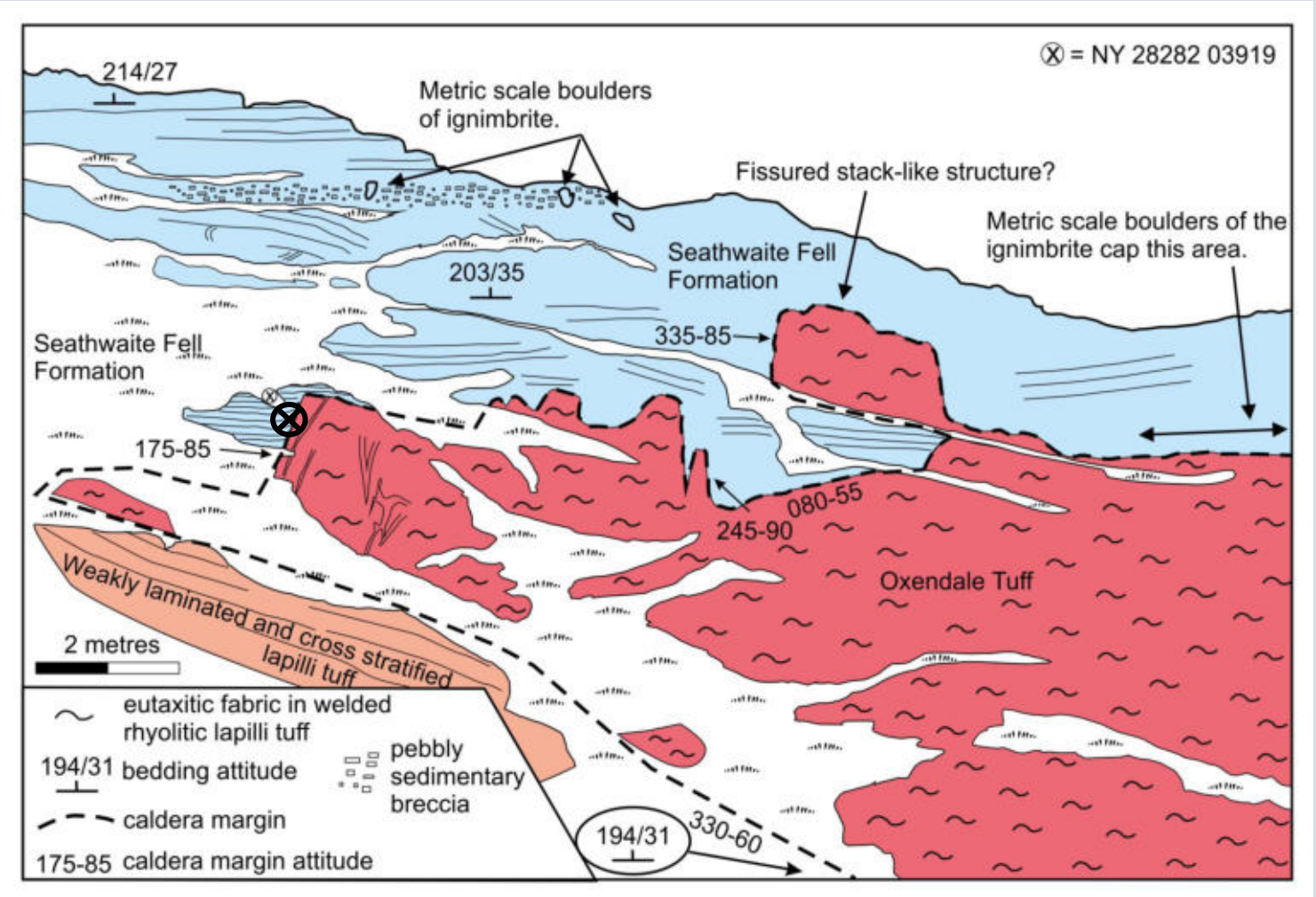
dip & strike – welding foliation

LOCALITY 6 NY 28282 03919 Scafell Caldera Margin

This locality was documented in Branney & Kokelaar [1994] and the relationships here were used to support the chaos/megabreccia interpretation of the former Side Pike Complex. Boulter *et al*. (2020) have interpreted the locality as being the steep-sided margin of the Scafell Caldera.

U4	Unit 4 Cross stratified lapilli tuff & boulder conglomerate
SPI	Side Pike Ignimbrite - welded rhyolitic lapilli tuff
U2	Unit 2 Side Pike Member - parallel bedded tuffs
Set	Seathwaite Fell Formation - turbiditic volcaniclastic sandstones
C1	Subaerial succession of stratified lapilli tuff, boulder conglomerates
OxT	Welded rhyolitic lapilli tuff **Oxendale Tuff?**
WBT	Whorneyside Bedded Tuff andesitic air fall tuff
WSE	Wet Side Edge Member

LOCALITY 6 NY 28282 03919 Scafell Caldera Margin



This line drawing from Boulter et al. (2020) covers the main features of **Locality 6** and the next slide is a photograph of approximately the same area. In red is part of the Airy's Bridge Formation – a moderately welded silicic lapilli tuff, possibly the Oxendale Tuff or part of the Crinkle Member. In places a locally derived boulder conglomerate overlies the welded ignimbrite and this in turn is overlain by weakly-laminated and cross-stratified lapilli tuff deposited by dilute PDCs..

These two units are interpreted as pre-inundation deposits formed before the caldera lake was established. In blue is the Seathwaite Fell Formation which is a mainly turbiditic unit. At ⊗ bedding in the turbidites but-up against a steeply-dipping contact with the Airy's Bridge unit. This contact has a variable attitude but is mainly steep. It is interpreted as the post-caldera collapse margin of the Scafell Caldera. The alternative interpretation is that it represents the edge of a mega-block that ploughed into the sediments

LOCALITY 6 NY 28282 03919 [⊗] Scafell Caldera Margin



Below: the small crag south of the reference point NY 28282 03919 with sediment-filled fractures in the in-situ welded ignimbrite.
Right: a sediment-filled fissure in the welded ignimbrite that is continuous with the overlying Seathwaite Fell Formation.







A boulder conglomerate from the pre-inundation deposits that immediately overly the in-situ welded ignimbrite. The boulders are mainly of welded ignimbrite and the welding fabrics are variably orientated from boulder to boulder. Careful examination is necessary to identify the boulder/matrix contacts.

Immediately above the boulder conglomerate, in some areas, is a weakly-stratified ignimbrite with a weak welding fabric which is also part of the pre-inundation sequence.





An example of the pebbly turbidites at Locality 6.

The Seathwaite Fell Formation at **Locality 6** has a lower part of thin to medium bedded sand-grade turbidites whereas the upper part is thickly bedded pebbly coarse-sand turbidites deposited from high-concentration turbidity currents. The soft-sedimentary deformation at this locality is comparable in intensity to that seen in much of the Scafell Caldera.

Two horizons of pebbly breccias are distinctive. The pebbles are flow-banded rhyolite which has pink feldspar phenocrysts around a millimetre in length. The uppermost example thickens to the south.

Approximately halfway through the seventy metre thick sequence is a zone of white weathering beds including a bed of large pumice clasts correlated with the similar bed on Long Crag.

Between Locality 6 and the summit of Bleaberry Knott the outcrop of the Side Pike Ignimbrite is repeated by faulting.

Locality 7 is around the summit of Bleaberry Knott.



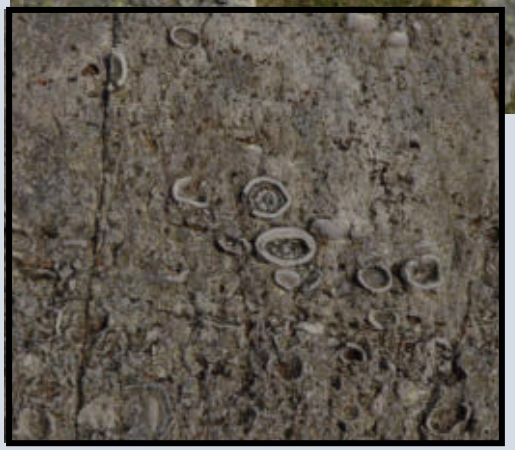


Locality 7 NY 28346 04111

Left Uppermost Side Pike Ignimbrite. In the upper nine metres the axial ratio of fiammé decreases and large [<20 cm] silicic lithics become common. These features are useful to monitor where exposures are in the stratigraphy.



A weakly stratified accretionary lapilli tuff caps the Side Pike Ignimbrite [closeup photo below].



It has been interpreted as a co-ignimbrite air fall deposited from the phoenix cloud associated with eruption of the Side Pike Ignimbrite

The Miller Stands Member on the summit of Bleaberry Knot.

A silicic cross-bedded tuff with large accretionary lapilli represents a deposit from a low density pyroclastic current.

The pale lower part of the photo is the Miller Stands Member. Above the erosional contact is the basal sedimentary breccia of the Tilberthwaite Formation marking a return to caldera lake depositional conditions.





Fans of **peperite** might want to check out the lower contact of the andesite sill close by at NY 28375 0413. This contact is generally well exposed for several tens of metres.

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