Side Pike Traverse

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Photos: Clive Boulter unless otherwise stated.

LOGISTICS

Side Pike is a relatively low-level, fairly-easily accessible opportunity to examine welded ignimbrite and other features associated with highly-explosive eruptions. Many equivalent itineraries in the Borrowdale volcanics require long days in the fells which may be defeated by poor weather. The Side Pike traverse is a good option to have as a poor weather alternative to more adventurous plans. Much of the traverse is either on the old path, or the new path, up to Side Pike and localities off the paths are close by. Parking is limited but the climb from the floor of Great Langdale is easy. The National Trust has a car park at Blea Tarn and there is a footpath from there to the foot of Side Pike. A visit to Side Pike provides a good vantage point for viewing the Langdale Pikes.

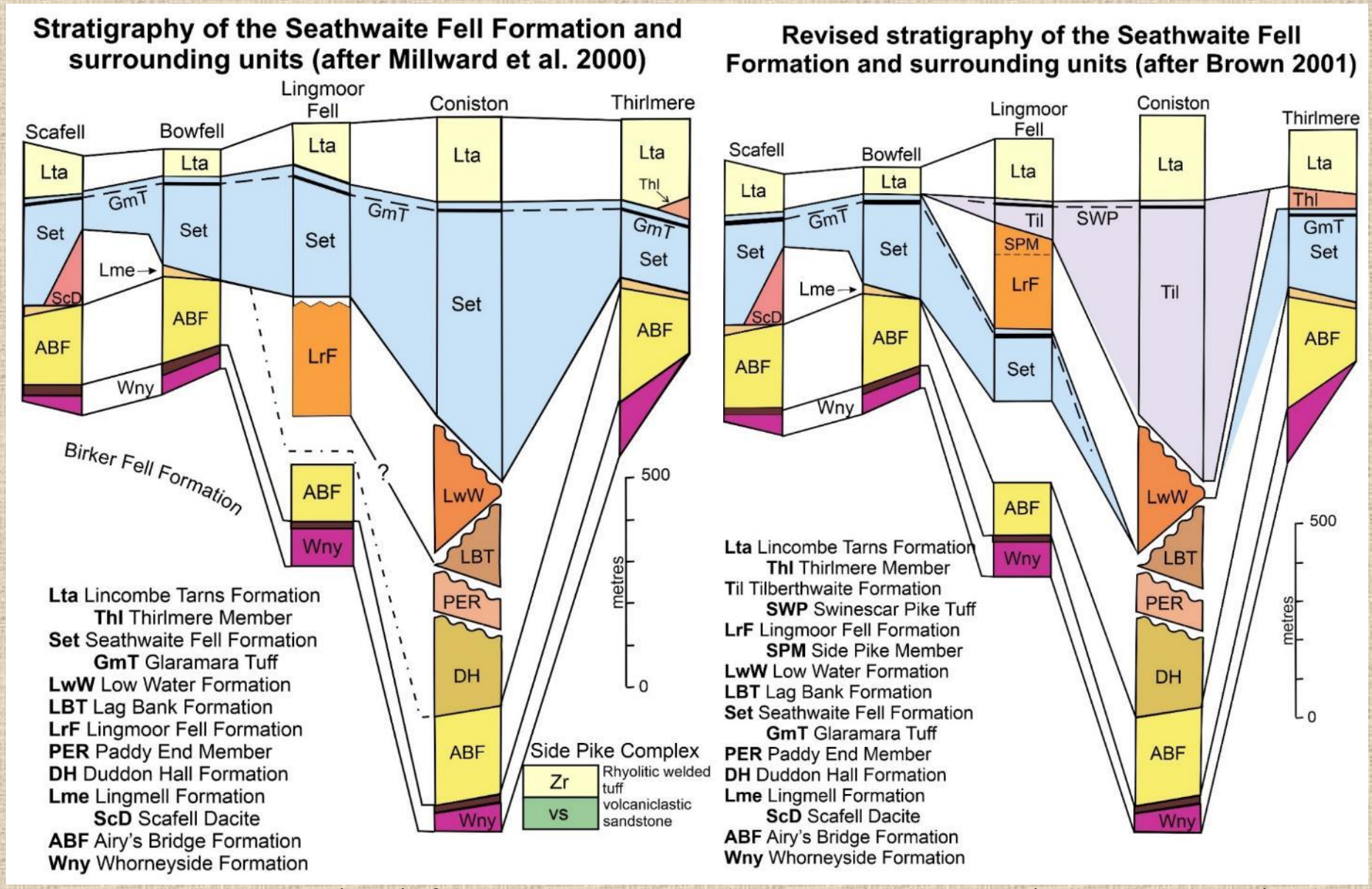
INTRODUCTION

In the 1980s/1990s resurvey, the deposits in a 5 km^2 area between Side Pike and Pike o' Blisco could not be tied into the regional stratigraphy and the notion of the Side Pike Complex was introduced [Branney 1988]. It was believed that the differences between this small area and its surrounds were created when flank failure of the volcanic edifice led to blocks, 100s of metres to around a kilometre in size, sliding in from parts of the stratigraphy no longer exposed. The blocks in this megabreccia were considered to be exotic.

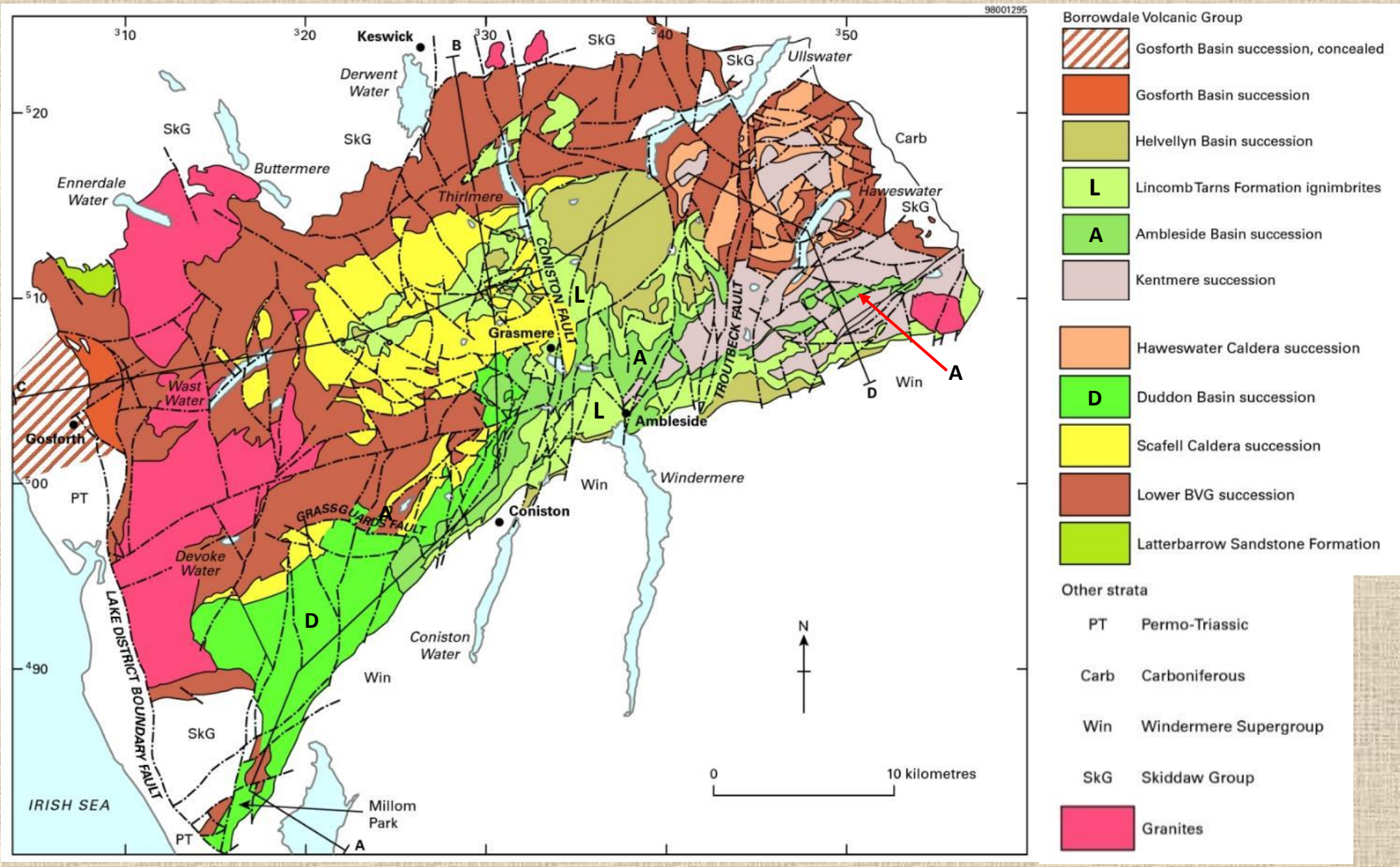
However very detailed work on part of the established stratigraphy of the Scafell Caldera was extended to what was the Side Pike Complex with dramatic consequences for the stratigraphy of the Borrowdale volcanics and its volcanological model [Brown 2001]. At Long Crag [NY 2799 0400], within the Side Pike Complex as originally defined, five metres of stratigraphy are so distinctive that Brown [2001] could identify them as being part of the uppermost Seathwaite Fell Formation which is the sedimentary infill of the Scafell Caldera. In this few metres, a welded ignimbrite is overlain by accretionary lapilli tuff, a pairing of rock types not uncommon in the Borrowdales but to someone who has spent many weeks getting thoroughly acquainted with the sequence by doing bed by bed logging, their characteristics were unmistakable! 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. Below this is a 70 metre thick sheet of rhyolite which is a much reduced section compared to the Scafell Caldera section just a short distance away on Crinkle Crags. The rhyolite is the equivalent of the Airy's Bridge Formation rhyolitic ignimbrites which are typically close to a kilometre in thickness. These major thickness variations could have been caused by erosion of typical accumulations of Scafell Caldera deposits but they are more likely the result of limited deposition on topographic highs on the caldera margin. Subsequent work [Boulter et al. 2020] has located part of the wall to the Scafell Caldera within the originally defined Side Pike Complex. The great differences in thickness of units explain why it was so hard initially to correlate the much reduced units with their much thicker equivalents in the Scafell Caldera. Such dramatic lateral differences over such a short distance are not uncommon in volcanic terrains but they make the job of mappers very difficult.

IMPLICATIONS OF THE REASSESSMENT OF THE SIDE PIKE COMPLEX

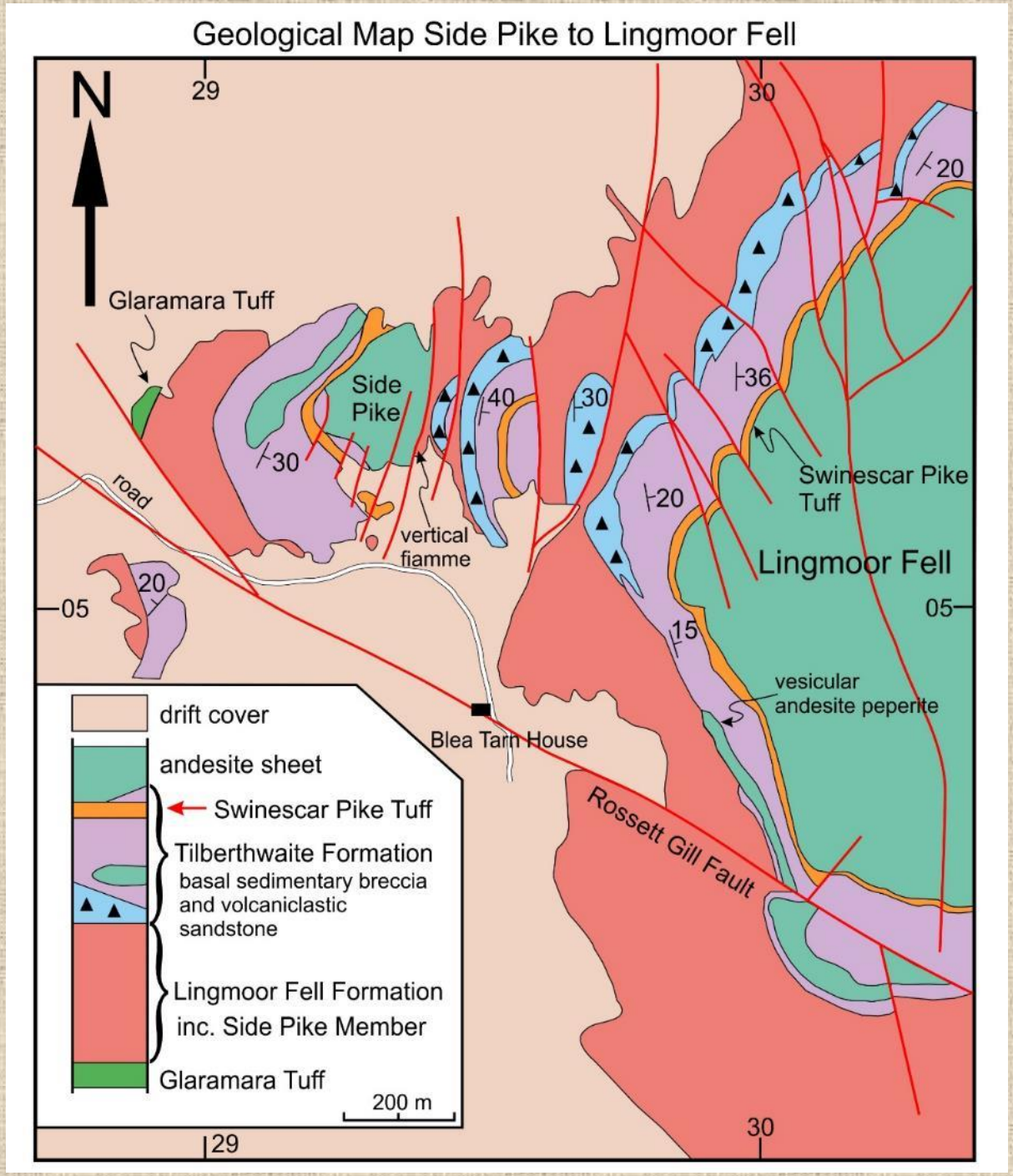
1. Because the stratigraphy is no longer exotic, Brown [2001] has recommended that the use of the term Side Pike Complex be discontinued.
2. In the resurvey, when the uncertain stratigraphy was projected through the Side Pike Complex onto Lingmoor Fell, incorrect stratigraphic assignments were made from here eastwards [see next slide]. This led to a large area of the southern strip of the Borrowdale volcanics [Ambleside 1:50,000 BGS Map] being wrongly assigned to the Seathwaite Fell Formation when it is much younger. The only published map that corrects this significant error is by Millward in the Proceedings of the Yorkshire Geological Society [2004, vol. 55, pp. 73-105]. This new formation has been named the Tilberthwaite Formation but it does not appear on any published BGS maps even though it covers a large area. On Earthwise P916047 [see two slides on] this new formation is shown as the Ambleside Basin Succession.
3. In the Coniston area the Tilberthwaite Formation, which was erroneously thought to be the Seathwaite Fell Formation, overlies, at an angular unconformity, major ignimbrite units such as the Lag Bank Formation and the Paddy End Member of the Lickle Formation and hence these were placed much lower in the regional stratigraphy than they should have been.
4. Welded ignimbrites, younger than the Seathwaite Fell Formation, in what was the Side Pike Complex, were generated in a caldera-forming explosive eruption which means that earlier work did not identify the associated Langdale Caldera.
5. What seemed to be a good stratigraphic marker, the accretionary lapilli-rich horizon at the top of a thick sedimentary sequence and just below the Lincomb Tarns Formation, is in reality two units of very different ages; the Glaramara Tuff is near the top of the Scafell Caldera sedimentary infill and the Swinescar Pike Tuff is near the top of the Tilberthwaite Formation, the sedimentary infill of the Langdale Caldera. Both probably represent major tuff ring deposits.
6. The regional implications are that an extra silicic caldera is present in the south Lake District and that the succession of ignimbrite eruption, probable caldera collapse, aqueous inundation, and sedimentary infill (as seen in the Scafell caldera), is repeated here by the eruption of the Lingmoor Fell, Lag Bank and Low Water Formation ignimbrites, followed by subsidence and sedimentary infill in the form of the Tilberthwaite Formation [Brown, 2001]. The Langdale Caldera itinerary covers this topic.



Comparison made by Brown (2001) of the correlations proposed in the Ambleside Memoir (Millward *et al*. 2000) and those made after recognition of Airy's Bridge Formation elements in the former Side Pike Complex. 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.



What is shown here as the Ambleside Basin succession is shown on the BGS 1:50,000 Ambleside map as Seathwaite Fell Formation. A = Tilberthwaite Formation formerly mapped as Seathwaite Fell Formation. Earthwise P916047, British Geological Survey.



Original mapping by M J Branney and E Johnson. Lithostratigraphy has been reassigned following the work of Brown [2001]. In this area the Side Pike Member is largely a single strongly-welded ignimbrite sheet. Some faults are extrapolated beneath drift cover.

Comparison of stratigraphic interpretations of the Side Pike area.

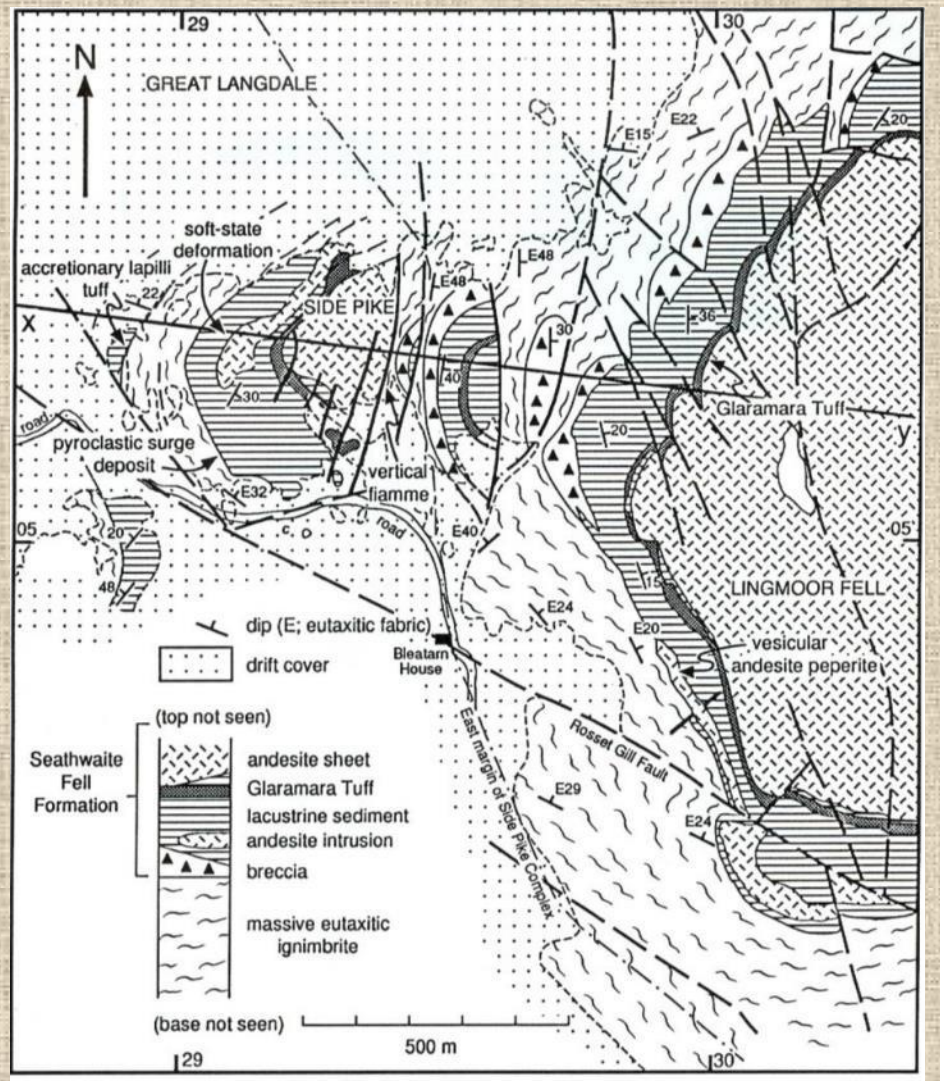
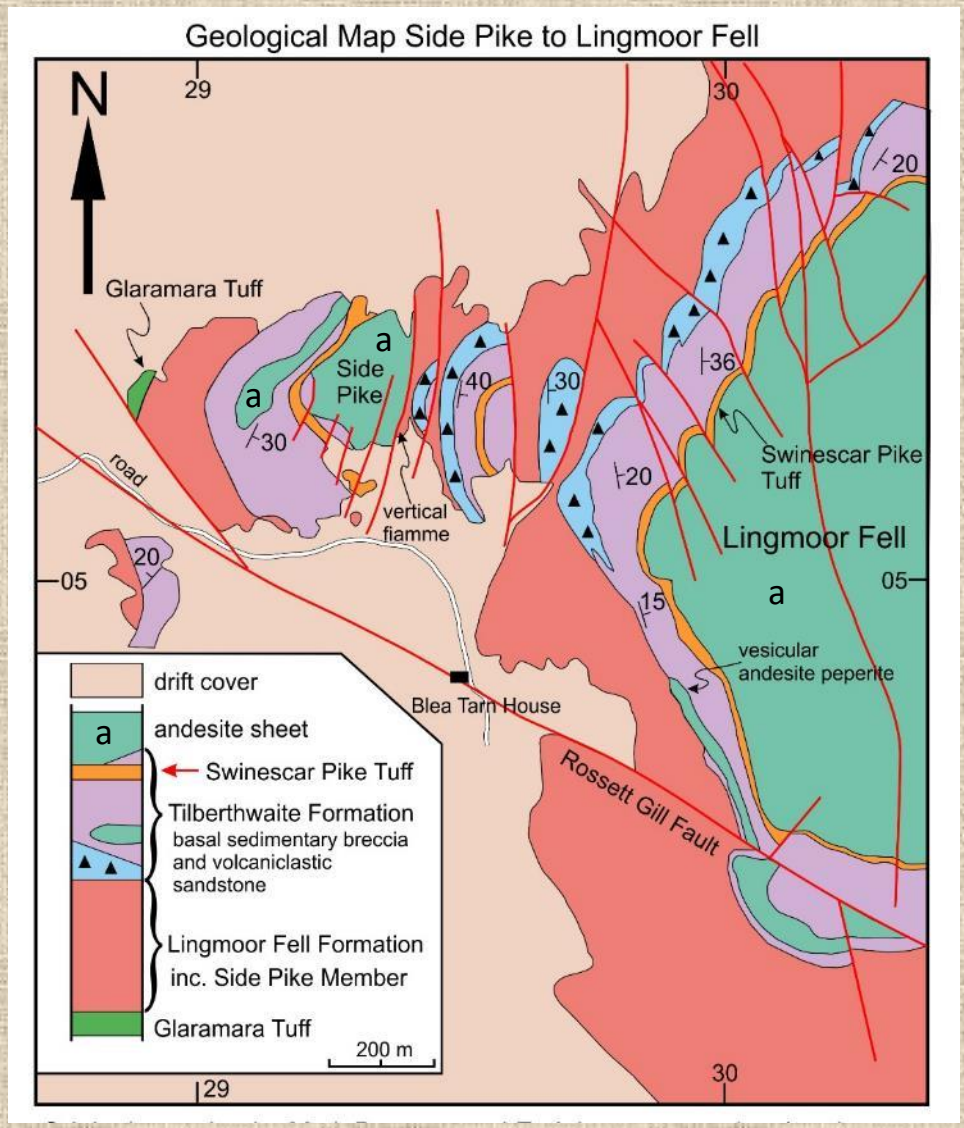
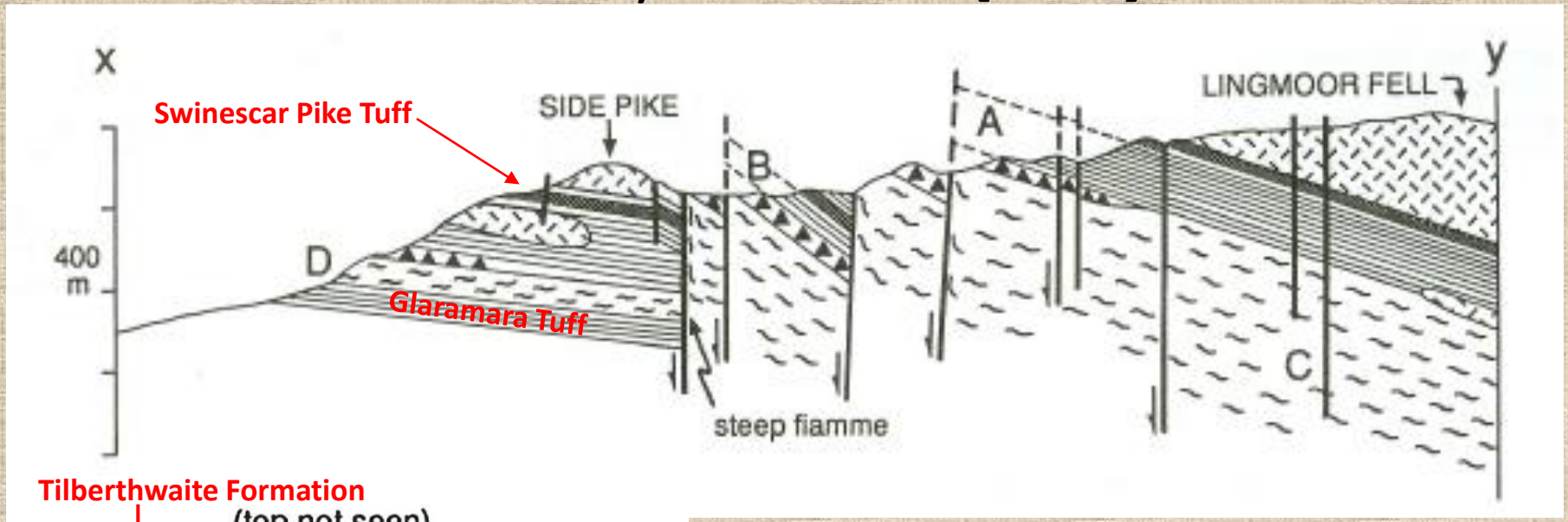


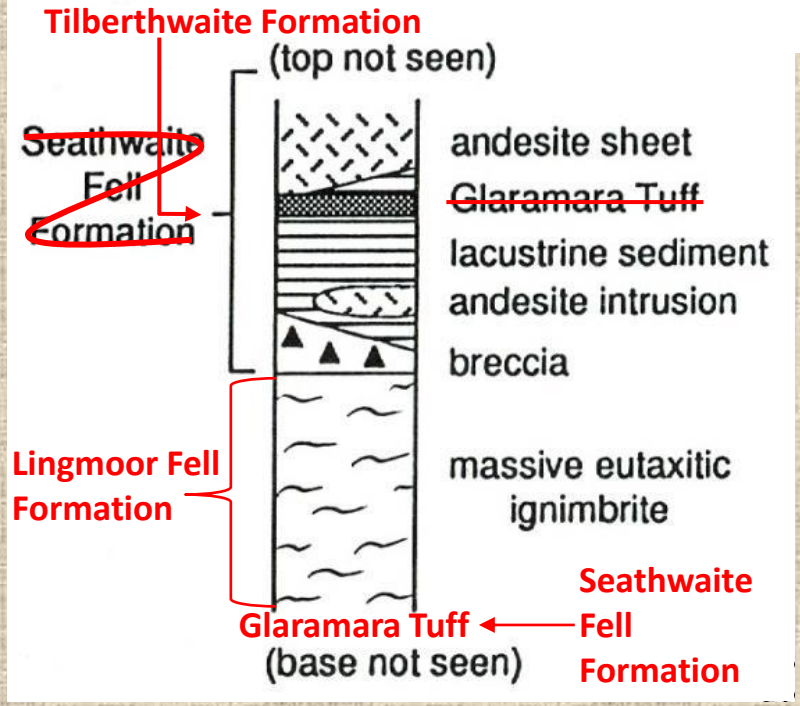
Figure 15. Map and true scale cross section of west Lingmoor Fell, to show thickness changes across formerly eastward-downthrowing volcanotectonic faults, which were reactivated to downthrow in the opposite direction (westward). Note the change in thickness of lacustrine sediments (between A and B) and of ignimbrite (between C and D), and the steep fabrics at two of the faults that record hot deformation of ignimbrite.



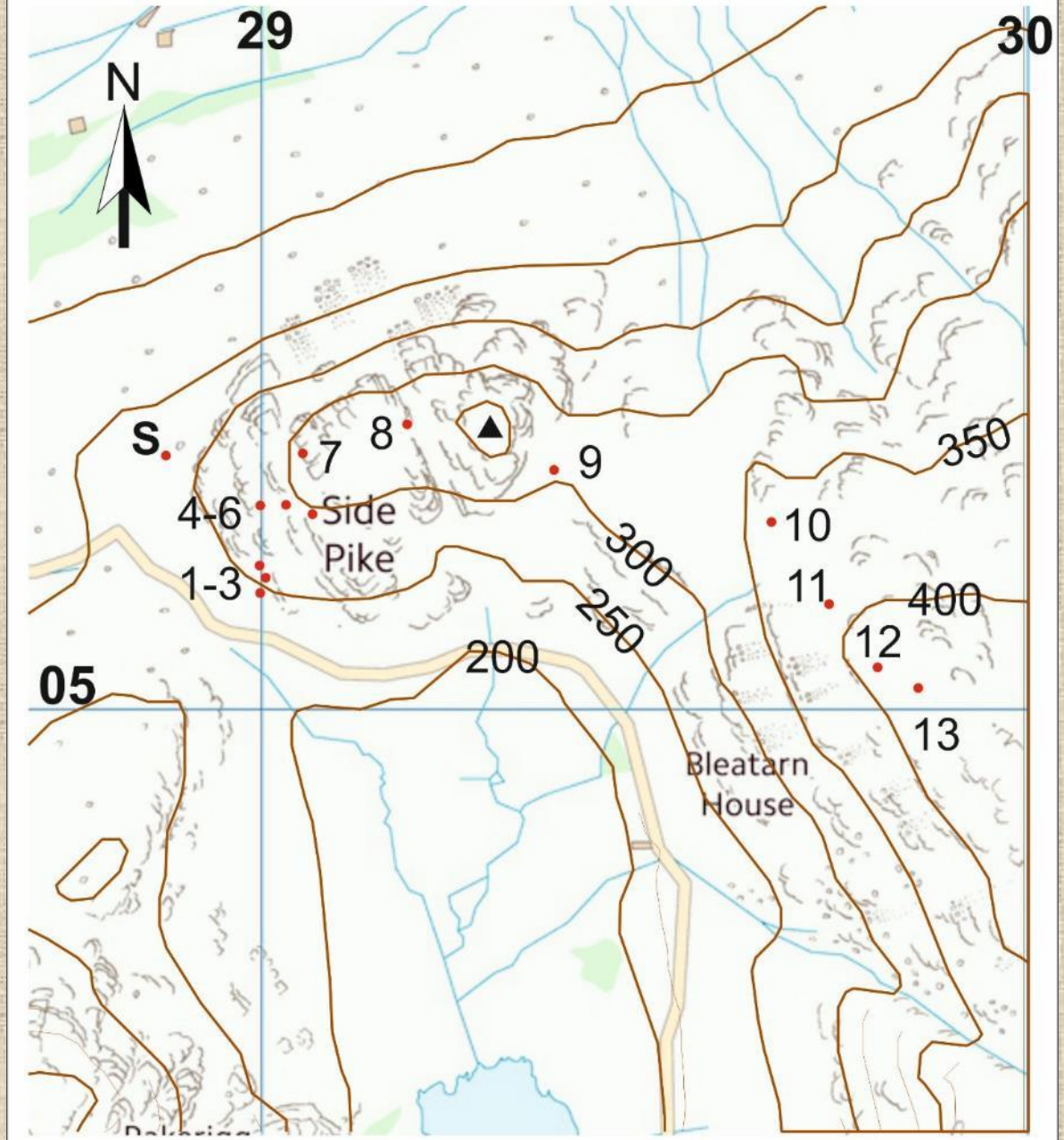
Map on the left is from: Branney, M.J. and Kokelaar, B.P. 1994 Volcanotectonic faulting, soft-state deformation and rheomorphism of tuffs during development of a piecemeal caldera, English Lake District. Geol. Soc. Am. Bull., 109, 507–530. The stratigraphic key for this original version is amended on the next slide.

Cross Section X-Y from the Side Pike geological map of Branney & Kokelaar [1994]





This cross section is from Branney, M.J. and Kokelaar, B.P. [1994, Volcanotectonic faulting, soft-state deformation and rheomorphism of tuffs during development of a piecemeal caldera, English Lake District. Geol. Soc. Am. Bull., 109, 507–530] and shows the stratigraphy prior to the reassessment by Brown [2001]. The latest interpretation is shown in red on the stratigraphic column.



Base map from Ordnance Survey OpenData. Kilometre grid.

LOCALITY MAP

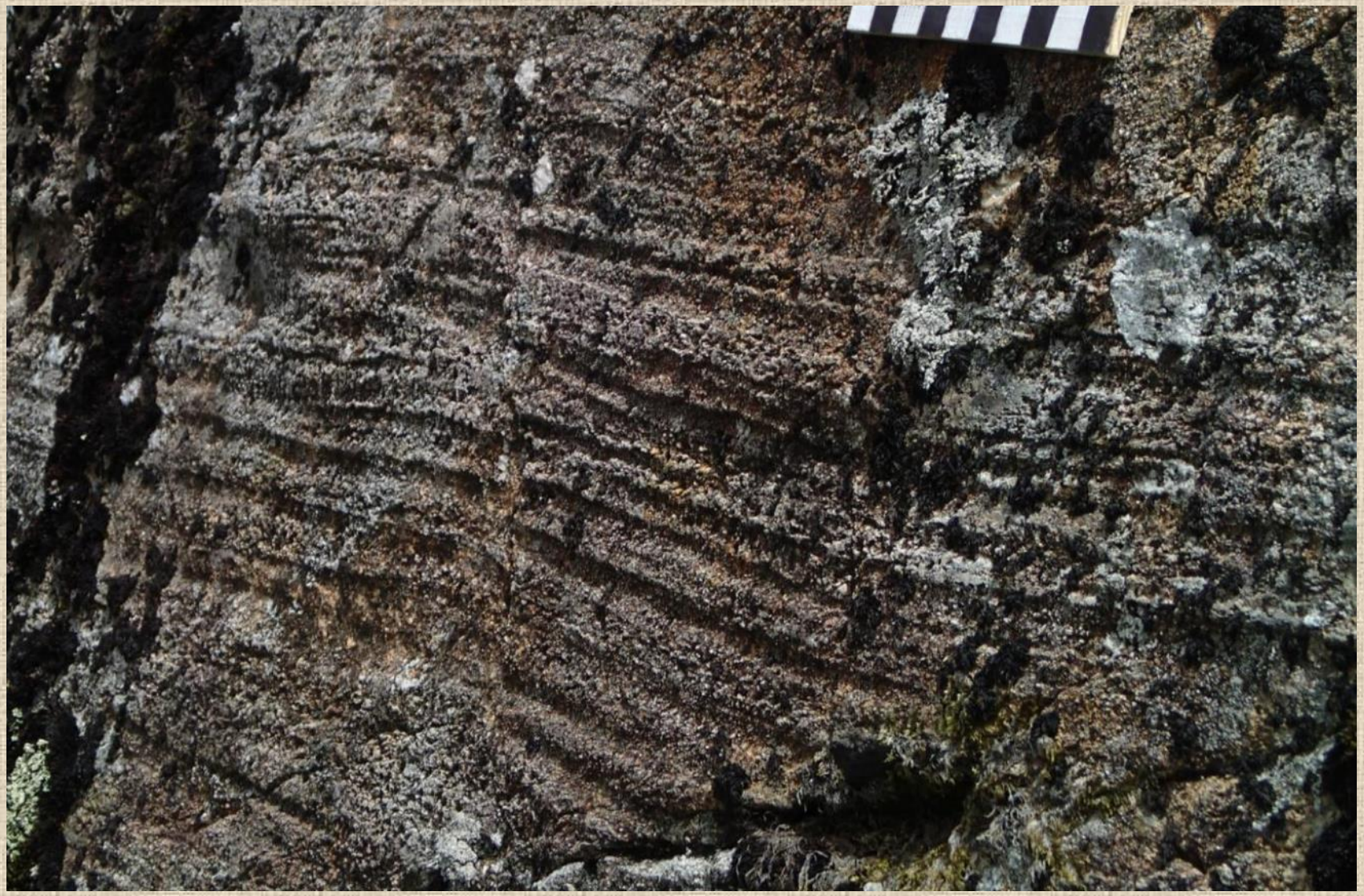
Start at **S**.

S on the locality map is the Starting Reference Point NY 28876 05336

Here limited exposures of accretionary lapilli tuff have been recognised by Brown [2001] as being part of the Glaramara Tuff. On its own this locality is not distinctive but having recognised the pairing of the Black Wall and Glaramara units at Long Crag near Pike o' Blisco [Brown 2001] it was possible to place the Glaramara in its correct stratigraphic position on Side Pike itself. This led to a cascade effect involving major changes to correlations and mapping along the southern edge of the Borrowdale volcanics.

A feature of the locality is that several of the layers are rich in accretionary-lapilli rim fragments showing that they were hard and brittle when in the pyroclastic current.

The Glaramara Tuff represents one of the largest tuff rings ever recorded.
The larger accretionary lapilli in the photo are almost one cm long.



Locality 1 NY 2900 0514 – Side Pike Member, Lingmoor Fell Formation.

The association of this cross-bedded lapilli tuff and the overlying welded ignimbrite shows that this is a primary pyroclastic rock. Structures of this style are produced by low density pyroclastic currents. Localities 1-5 are within a single ignimbrite cooling unit which was originally thought to be part of the Side Pike Complex but now has been shown to be one of four units within a member in the Lingmoor Fell Formation.

Locality 2 NY 2902 0516. A not very photogenic breccia within the ignimbrite sheet. Fragmentation has been attributed to steam explosions that possibly were fuelled by water from the surface that the pyroclastic current moved over – saturated ground/small lakes/streams. This is the Valley of Ten Thousand Smokes scenario.

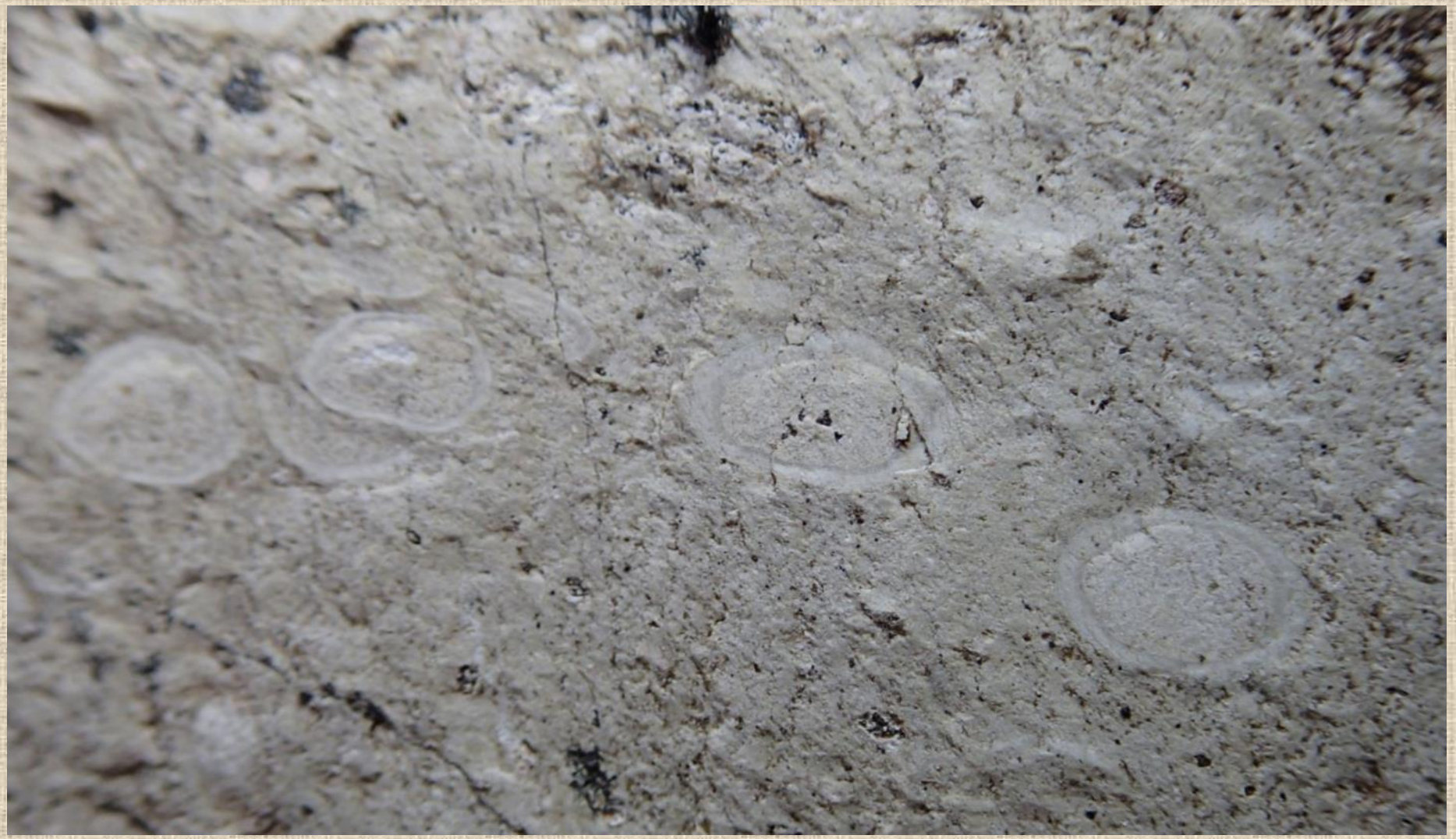
Locality 3 NY 2898 0520
This and the next three slides show variations in the degree of welding within the ignimbrite sheet. In this case the fiamme [flattened pieces of pumice] stand proud of the surface probably as a result of hydrothermal alteration.

Strongly welded Side Pike ignimbrite.

Locality 4 NY 2899 0528

Intensely welded ignimbrite – many of the fiamme are 3-4 cm long. The light specks are feldspars.

Small crag immediately above Locality 4: A rigid [lithic] fragment of the pre-eruption volcanic rock wrapped by the flattened pumice fragments. Photo 14 cm wide.



Locality 5 NY 2903 0528 – accretionary lapilli tuff at the top of the ignimbrite sheet. Again by association this thin deposit probably was related to the pyroclastic current that emplaced the ignimbrite. The dust and ash in Phoenix clouds above pyroclastic currents eventually settles out to form a co-ignimbrite air-fall layer. The accretionary lapilli are 4-5 mm long.

Locality 5 NY 2903 0528 Lingmoor Fell Formation [Side Pike Member]
Immediately overlying the ignimbrite sheet is more cross-bedded lapilli tuff interpreted as having been deposited by a low-density pyroclastic current, and hence it is an ignimbrite.

Locality 6 NY 29061 05260, Tilberthwaite Formation.
The first evidence on the traverse for the soft-sedimentary deformation which was used to support the megabreccia/chaos interpretation for the Side Pike Complex. A block of bedded volcaniclastics several metres in size is surrounded by mobilised granule-scale homogenised clastics. However, this locality is in the Tilberthwaite Formation and the intensity of the deformation is not exceptional for bedded sequences in the Borrowdale volcanics.

Locality 6 NY 29061 05260
Tilberthwaite Formation

Close to the previous exposure, vertical bedding which was believed to be evidence of the disruption generated during the formation of the Side Pike Complex chaos. It is now placed in the Tilberthwaite Formation.

Between **Localities 6 & 7** more evidence of mobilisation of granule-grade volcaniclastics in the form of injectites in the Tilberthwaite Formation.

Locality 7 NY 29049 05325 Tilberthwaite Formation
More vertical bedding striking towards the Langdale Pikes.

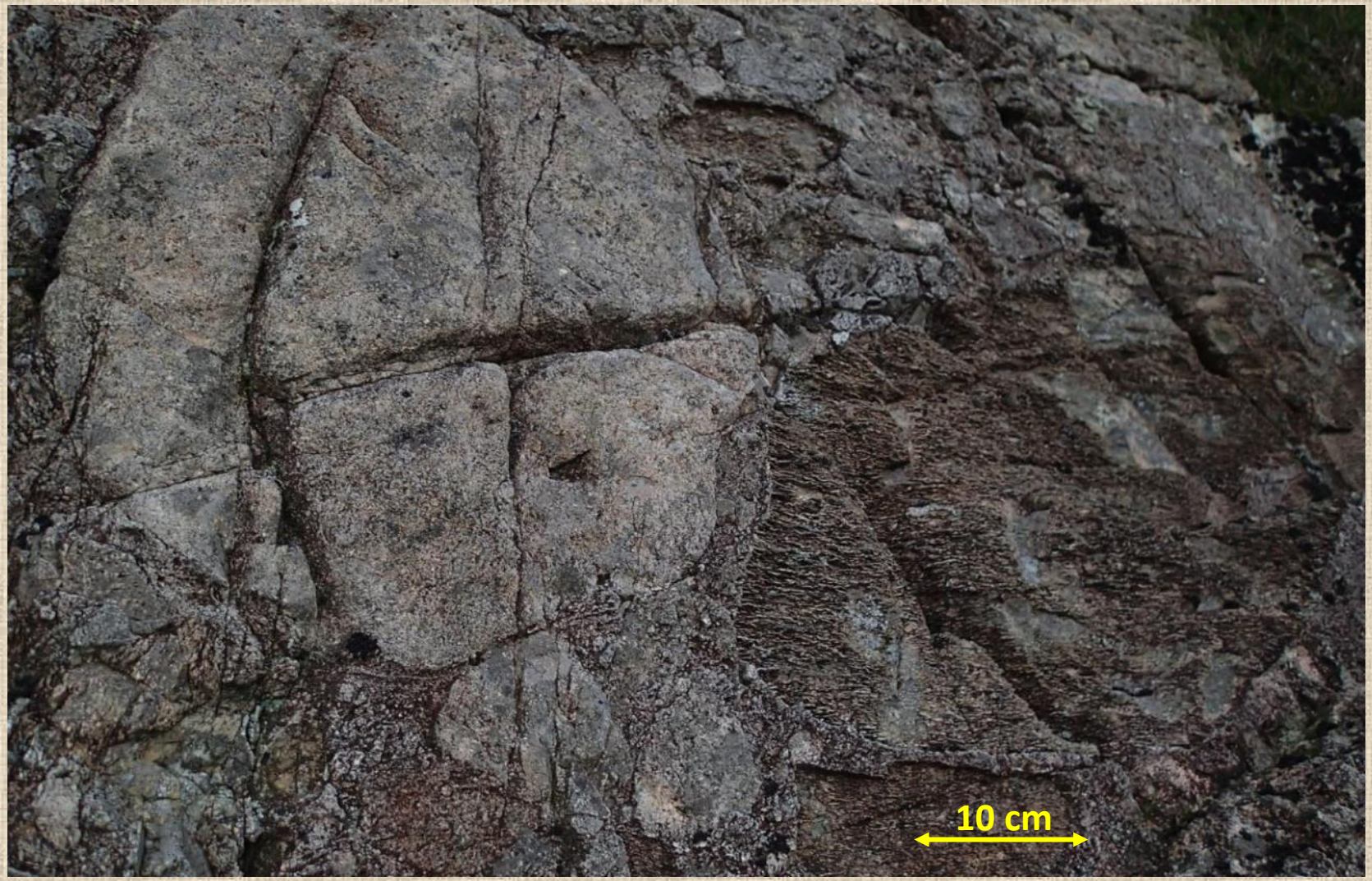
Locality 8 NY 29199 05351 Swinescar Pike Tuff.

Abundant accretionary lapilli in the Swinescar Pike Tuff which was originally thought to be the Glaramara Tuff and was considered to be the first point in the Side Pike Complex where a piece of stratigraphy could be tied to the overall succession. It is now known that there is a similar lacustrine sedimentary package to the Seathwaite Fell Formation, the Tilberthwaite Formation, which is much younger but which also has an accretionary-lapilli unit near its top contact very like the Glaramara.

Locality 9 NY 2938 0530

Vertical welding fabric in ignimbrite showing the location of a volcanotectonic fault that formed as the caldera was evolving. The ductile deflection of the fabric shows that the ignimbrite was still hot whilst the faulting took place.

In the original publications it was thought that the caldera involved was the Scafell but it is now apparent that it was a separate, younger, caldera named the Langdale Caldera by Brown [2001].



Locality 10 NY 29650 05242, Tilberthwaite Formation.

At the end of the ignimbrite eruptions that led to the formation of the Langdale Caldera, the topography would have been highly irregular with high cliffs created by the breaking up of the roof to the magma chamber. Erosion of these unstable fault scarps fed coarse breccias. The large welded-ignimbrite clast is 50 cm long and reflects its local derivation. This is in the Tilberthwaite Formation though originally it was mapped as Seathwaite Fell Formation .

Locality 11 NY 29725 05137
Tilberthwaite Formation.
The unit from Locality 10 is repeated by a fault. In this case the two large clasts are both of highly welded ignimbrite sourced from the fault scarps created by piecemeal caldera collapse. The foliation defined by the welding fabric is at very different attitudes from clast to clast showing welding took place before the boulders were transported.

These mesobreccias mark the start of the Tilberthwaite Formation which is the Langdale Caldera lake sedimentary infill.

Locality 12 NY 29795 05105, Tilberthwaite Formation.

Above the mesobreccia basal unit turbidites dominate. Cross-bedding on this scale is unusual in turbidite units but can be formed from high concentration turbidity currents. The style was referred to as the Disordered Turbidite Facies by those working on the resurvey.

Locality 13 NY 29858 05095 Swinescar Pike Tuff, Tilberthwaite Formation.
The central layer is cross-bedded accretionary lapilli tuff which was originally interpreted as being the Glaramara Tuff, a deposit from a tuff ring of unusual size. The Swinescar Pike Tuff mimics the Glaramara as it was formed in a very similar environment and it too is a useful stratigraphic marker as it is close to the top of its host unit the Tilberthwaite Formation.

NY 29943 04750 Not a planned locality but just to the south of the traverse [awkward access] a peperitic andesite intrusion into the caldera lake deposits shows veins of sedimentary material in the andesite and vesicles filled with sediment. The andesite sheet represents intermediate magma that was too dense to pass though the unconsolidated sediments and hence intruded into wet sediment.

SOURCES

The traverse is an amalgam of the 1990 Lake District GA Guide Itinerary 18 by Mike Branney and Excursion C of the 1990 International Association of Volcanology and Chemistry of the Earth's Interior/International Association of Sedimentologists Field Workshop, Volcanic Sedimentation in Ancient Terrains. Information from both these sources has been amended in the light of Brown [2001].

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