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(Plate 12.3) Locality 12.8. Highland Boundary Fault in west bank of Keltie Water. See text for detail.

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(Plate 17.2) Locality 17.1. Beds of nodular calcrete in Stanley Limestone Member at top of Scone Sandstone Formation, River Tay, Stanley Mills.

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(Plate 17.4) Locality 17.2. Late Carboniferous quartz-dolerite dyke, showing right-lateral stepped contact with discoloured baked Cromlix Mudstone (right), River Tay west bank, Campsie Linn.

(Plate 18.1) Locality 18.1. Refraction of  $S_1$  spaced pressure-solution cleavage on the steep NW limb of a synform (far left on (Plate S.1) and (Figure 18.3)), Little Glen Shee. The cleavage fans around the minor folds and is at a higher angle to the bedding in the coarser grained beds. The curvature indicates grading towards finer grain size, and hence younging,

to the left. Thus the folds in (Plate S.1) are downward facing.

(Plate 18.2) Locality 18.3a. Characteristic  $F_2$  folds of spaced  $S_1$  cleavage in metasandstone at The Hermitage.

(Plate 18.3) Locality 18.3c. Lozenge-shaped microlithons' formed by  $S_2$  spaced pressure-solution cleavage (top left to bottom right) cutting a folded earlier,  $S_1$  spaced cleavage in metasandstone, The Hermitage.

(Plate 18.4) Locality 18.5a SE-verging  $F_4$  minor folds of composite  $S_1/S_2$  foliation in schistose metasilstone in the Flat Belt, NW of the Highland Border Downbend, Deuchary Hill.

(Table S.1) Lower Devonian Lithostratigraphy.

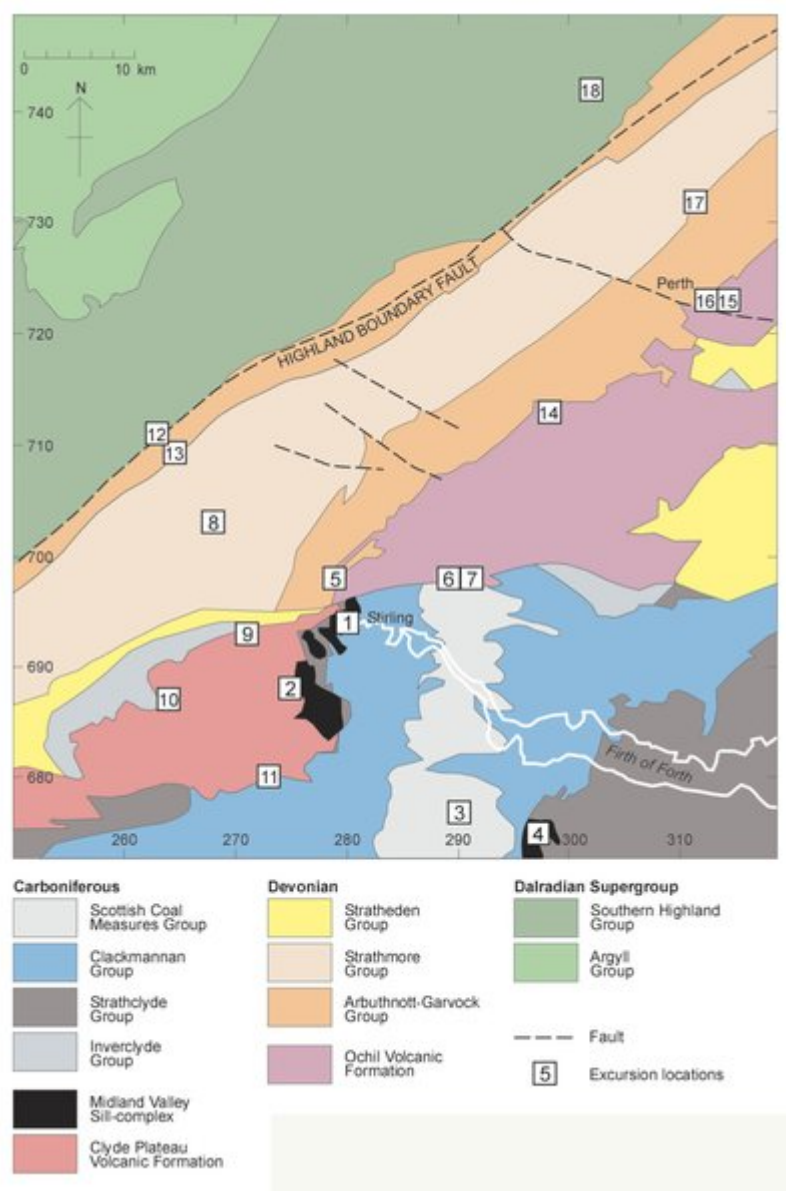
(Table S.2) Carboniferous Lithostratigraphy.

(Table 10.1) Characteristics of proximal and distal basaltic sequences

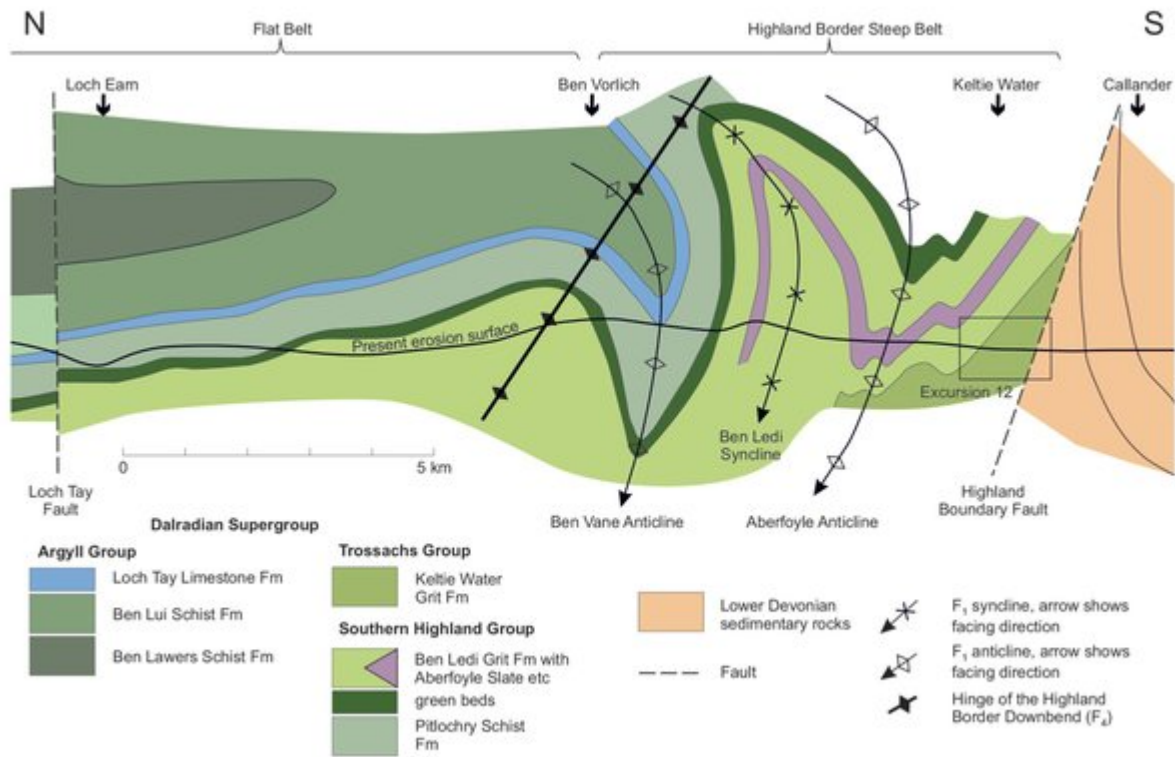
(Table 11.1) Lava Members in the Eastern Part of the Campsie Block.

(Front cover) Front cover

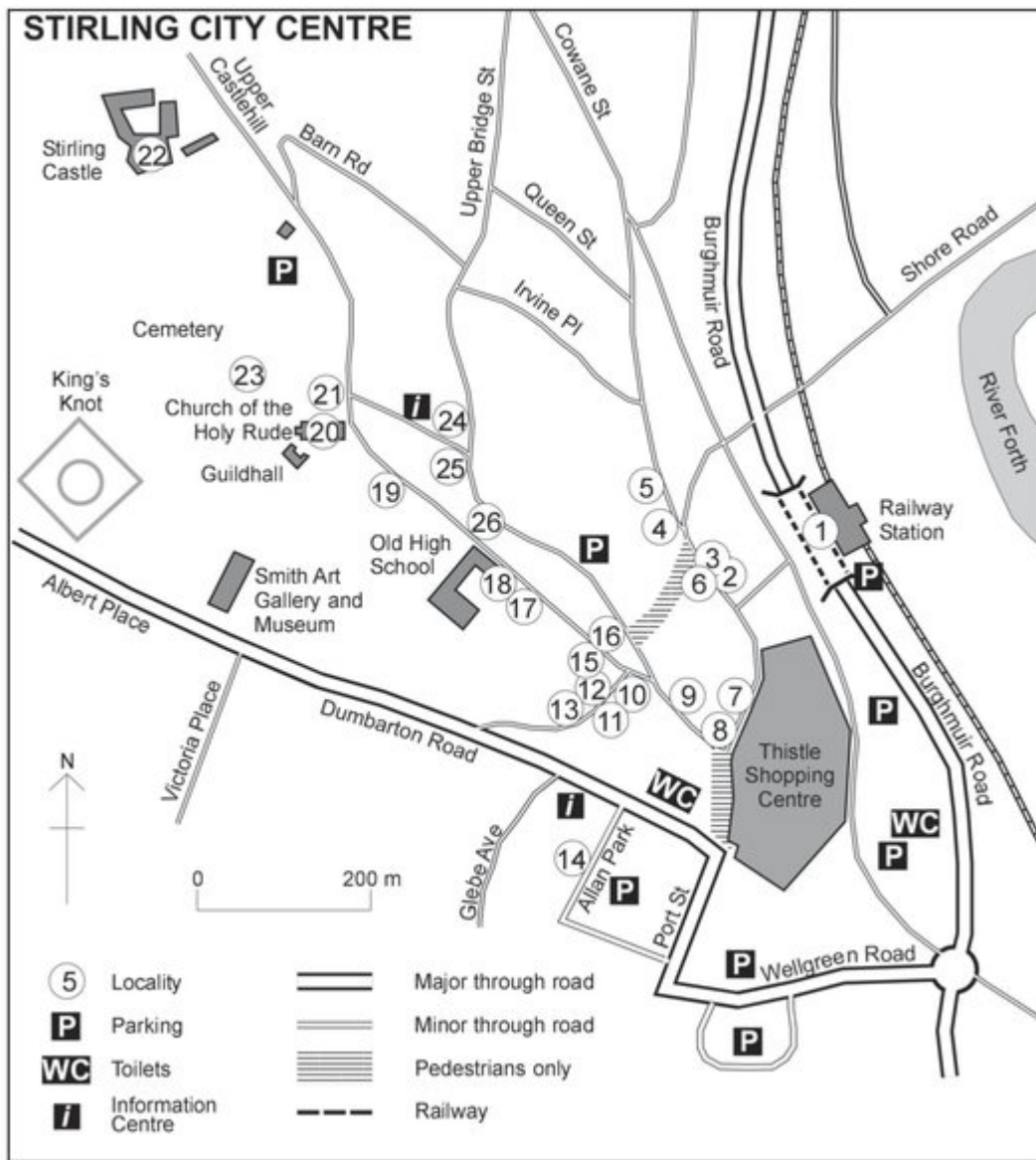
## References



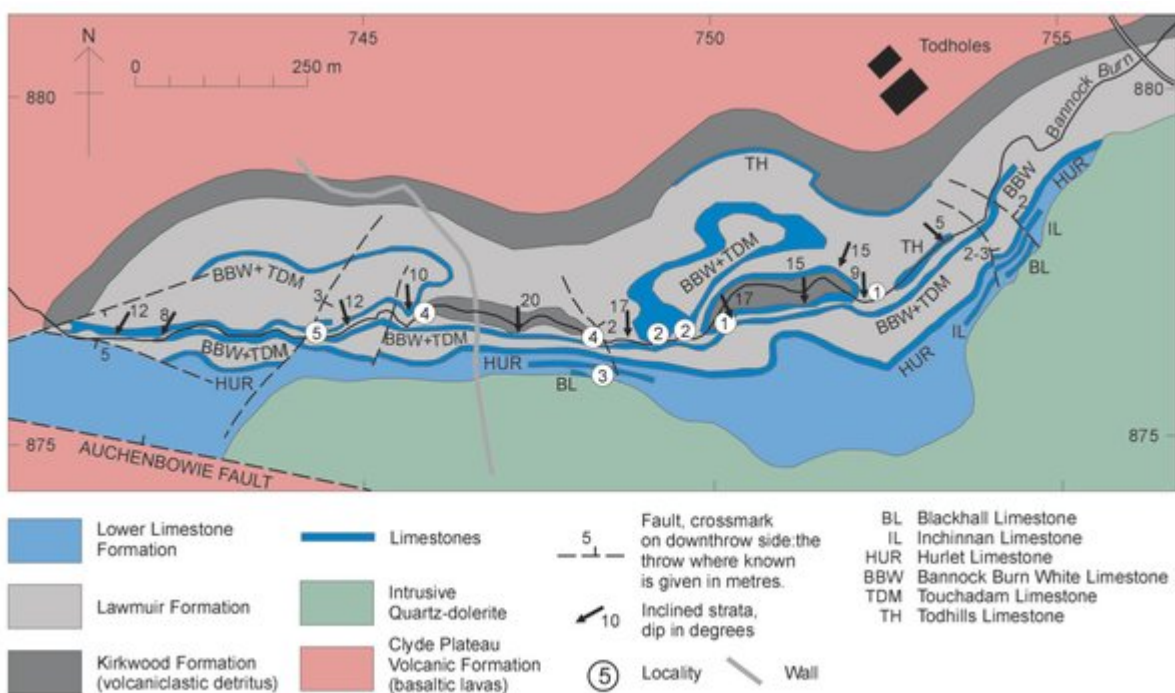
(Figure S.1) Outline geological map of the region covered by this excursion guide.



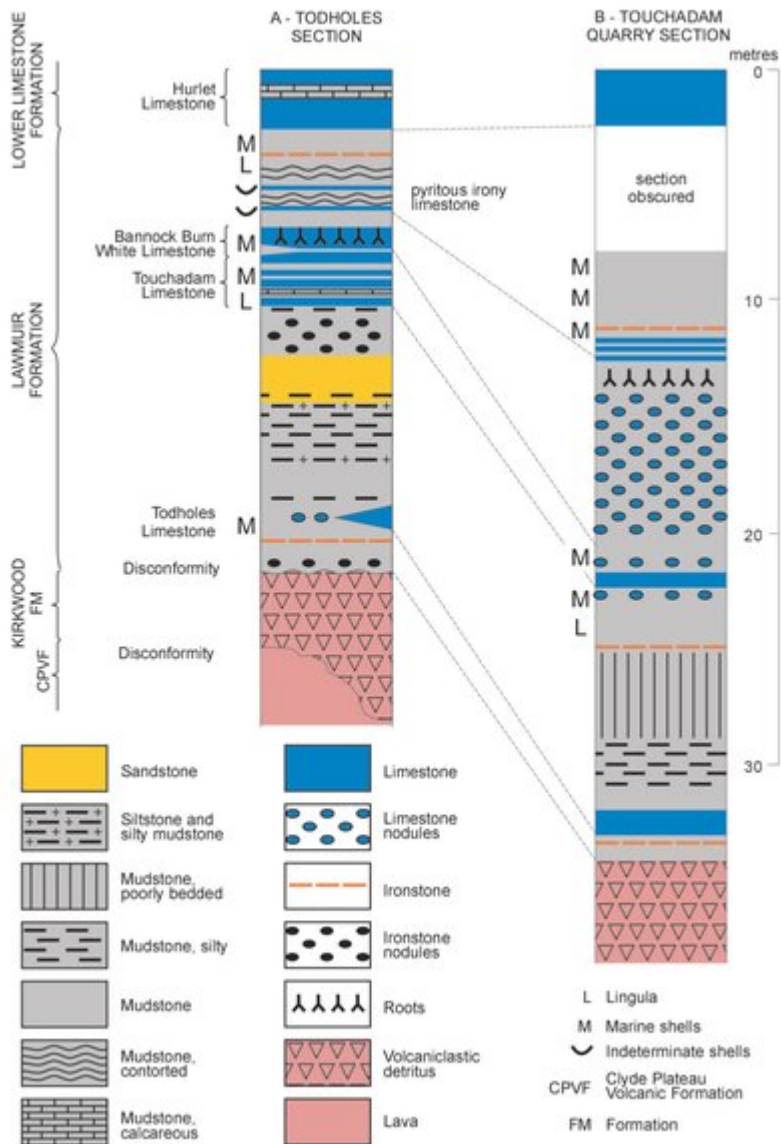
(Figure S.2) Cross-section of the Tay Nappe from Callander due north to Loch Earn, showing the Flat Belt, Highland Border Downbend ( $F_d$ ) and major downward-facing  $F_1$  folds in the Highland Border Steep Belt (adapted from Tanner et al, 2013, fig. 13).



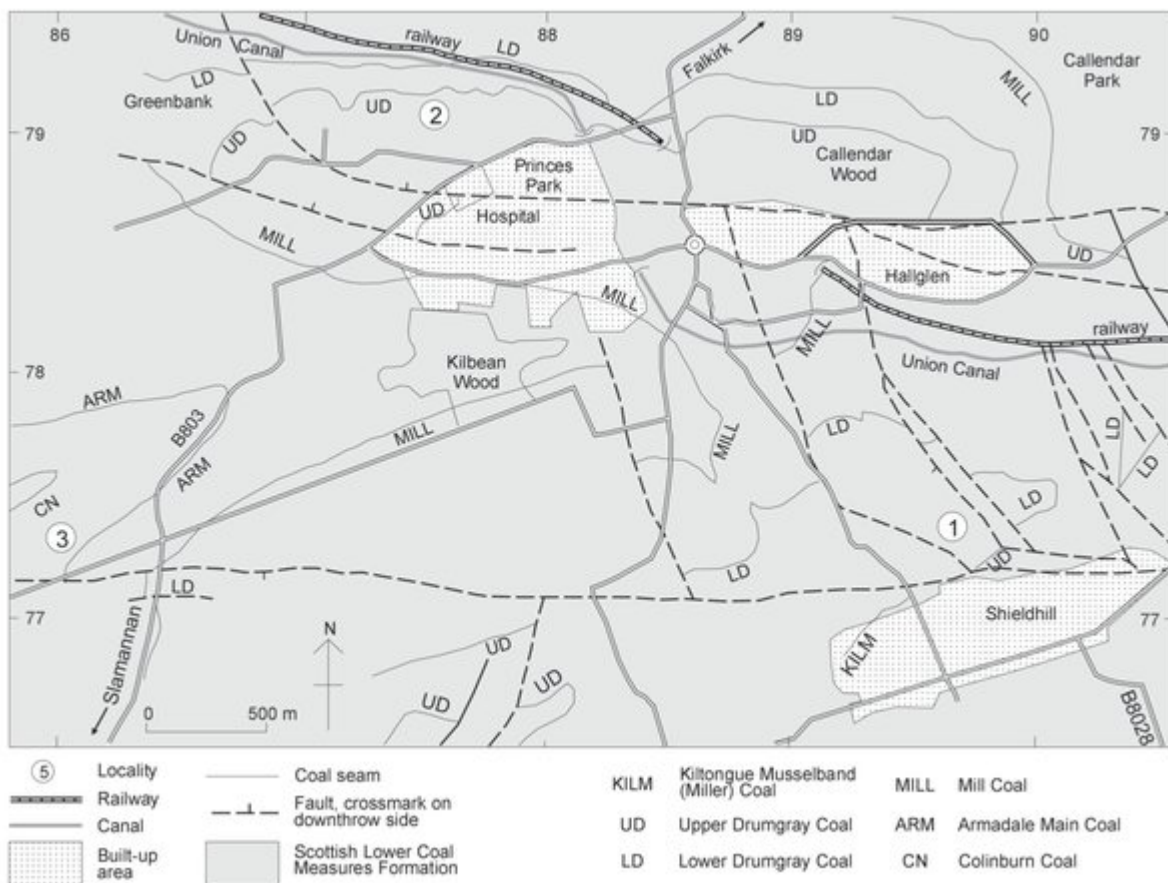
(Figure 1.1) Stirling city centre locality map.



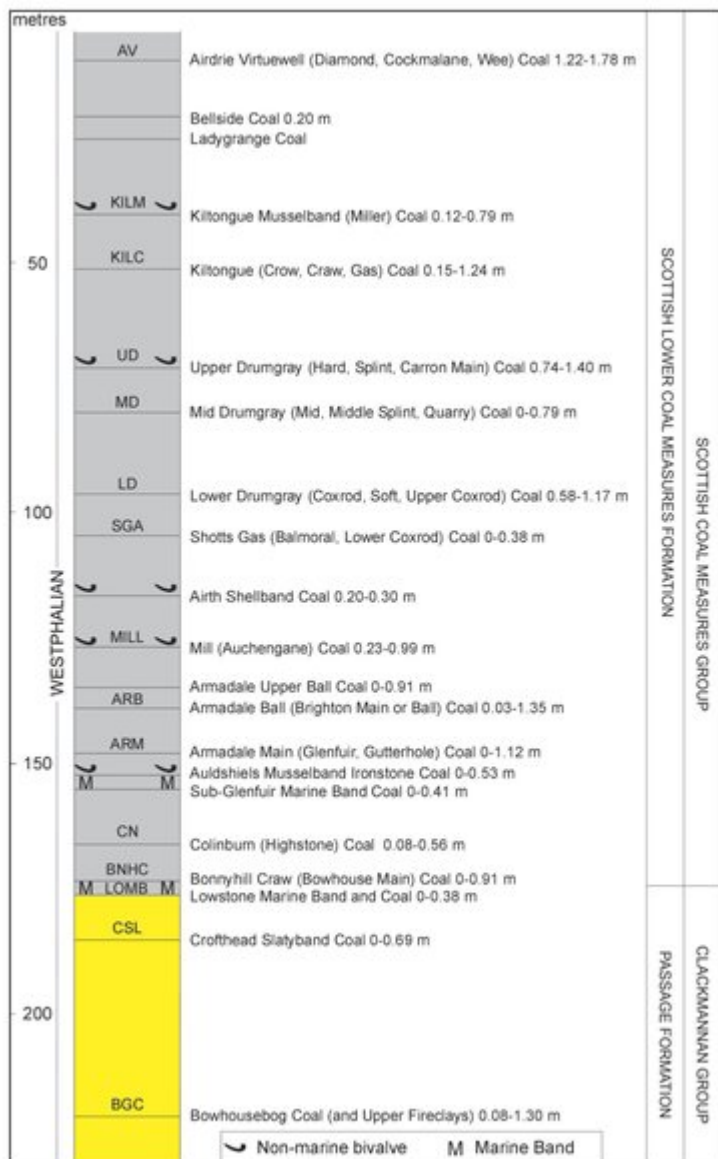
(Figure 2.1) Map of late Viséan rocks exposed in the upper Bannock Burn near Todholes, showing localities for Excursion 2. Adapted from Francis et al. (1970, fig. 13).



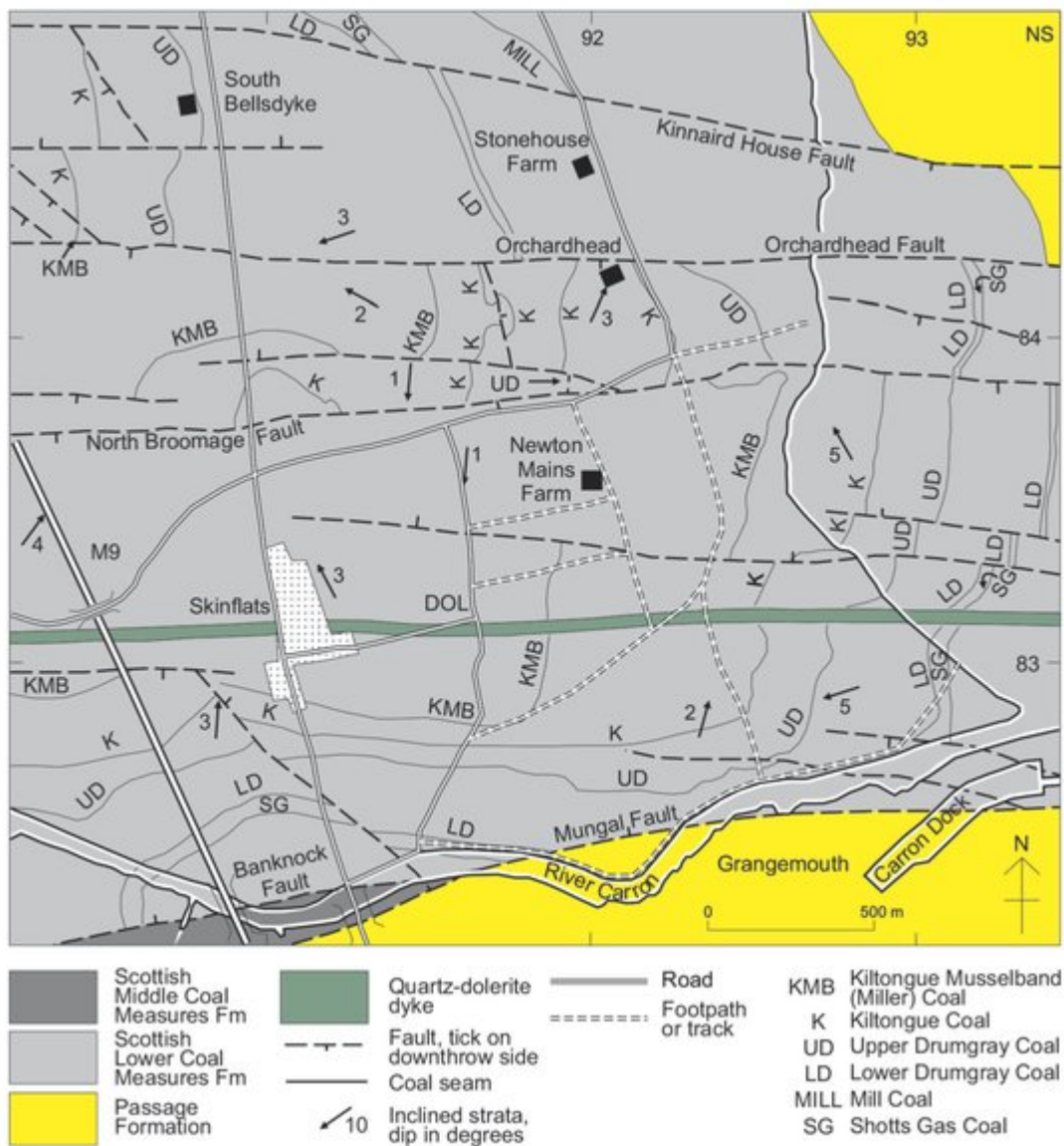
(Figure 2.2) Vertical sections of late Viséan rocks exposed in the Bannock Burn, (A) near Todholes and (B) near Touchadam Quarry. Adapted from Francis et al. (1970, fig. 15).



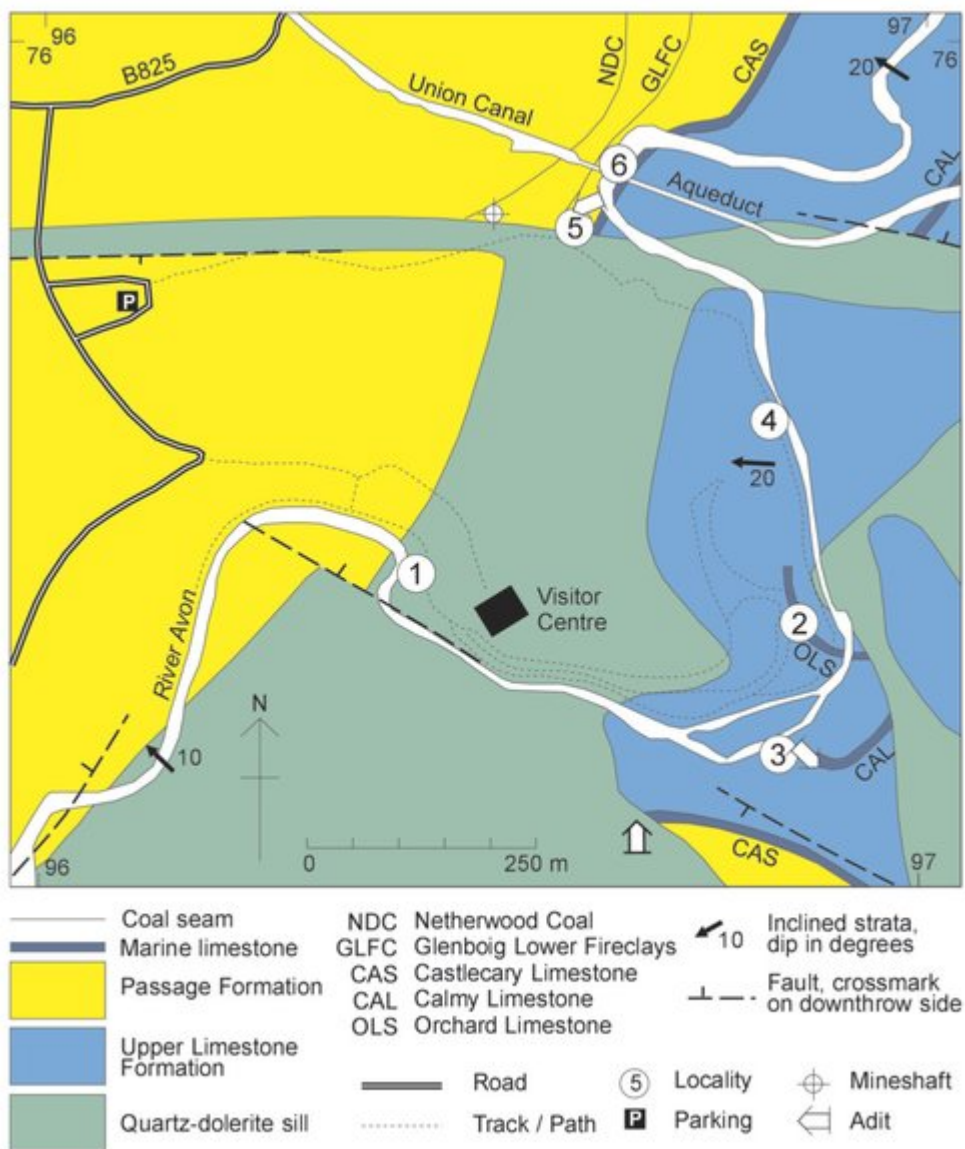
(Figure 3.1) Geological map of Falkirk area, showing Localities 1–3 for Excursion 3.



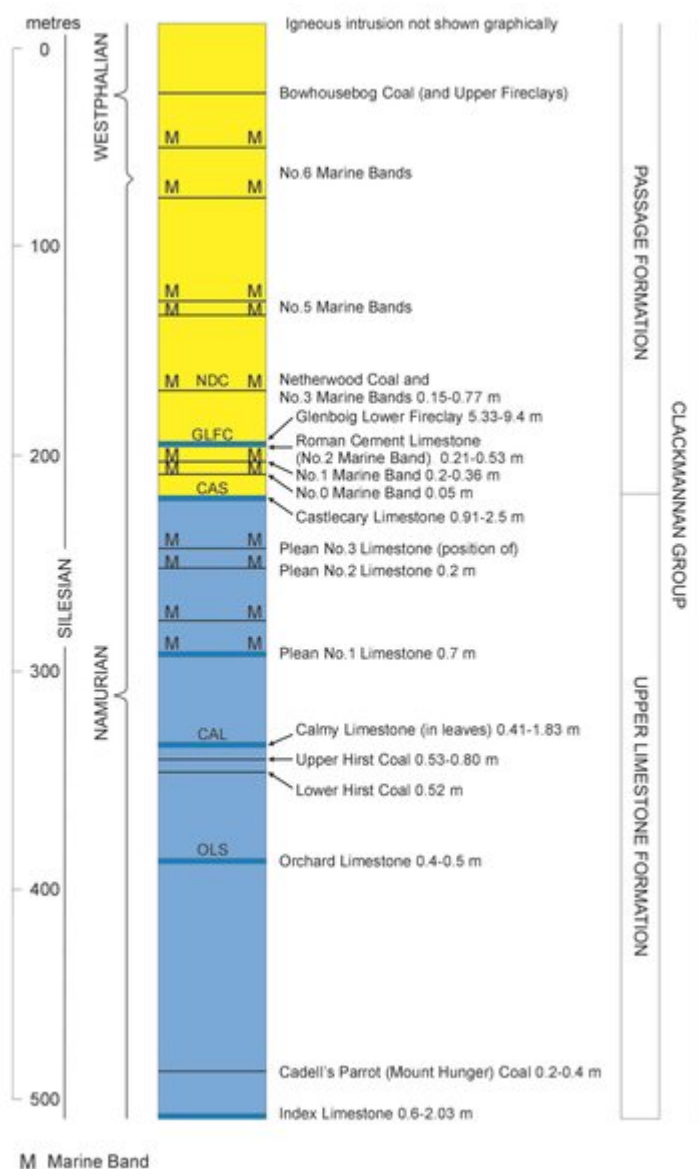
(Figure 3.2) Vertical section of Scottish Lower Coal Measures Formation in the Falkirk area.



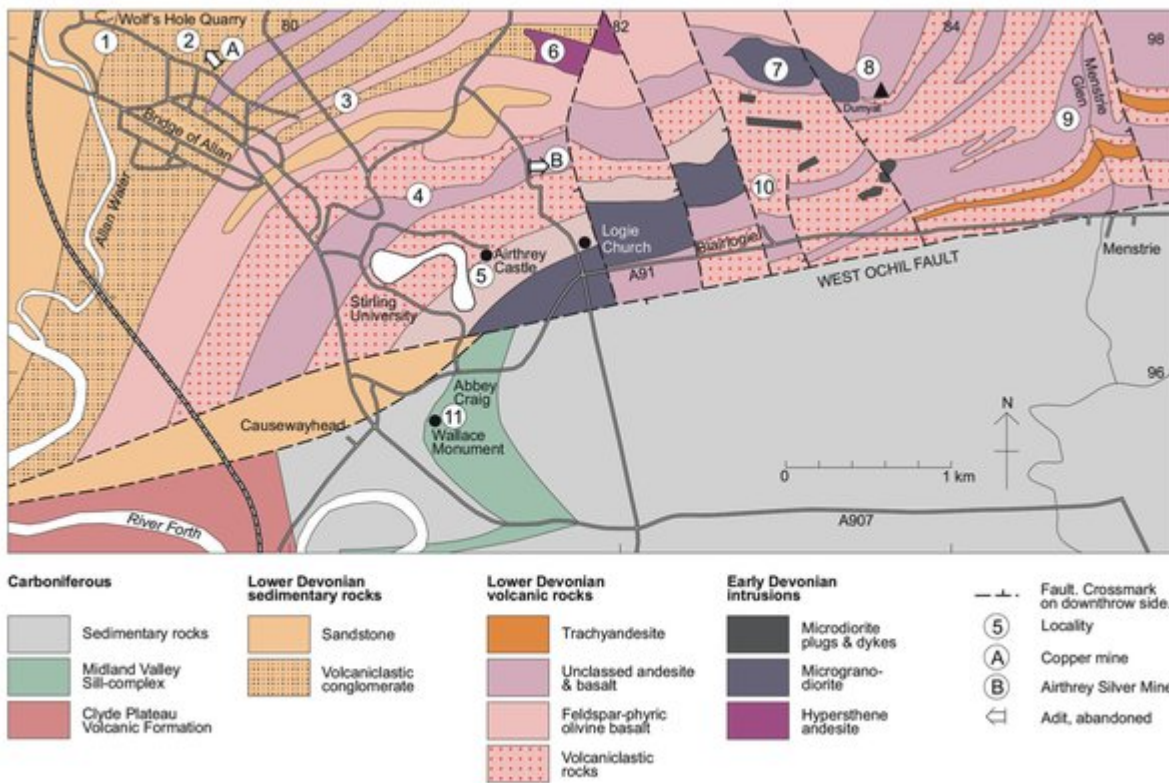
(Figure 3.3) Geological map of Skinflats area, Locality 3.4.



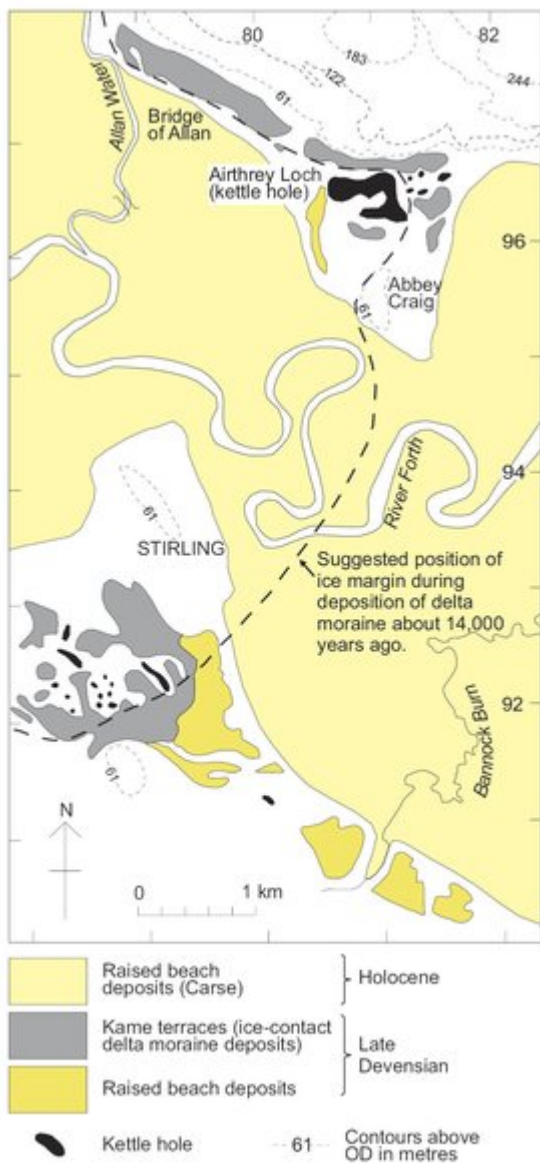
(Figure 4.1) Geological map of the area around Muiravonside Country Park, showing localities for Excursion 4.



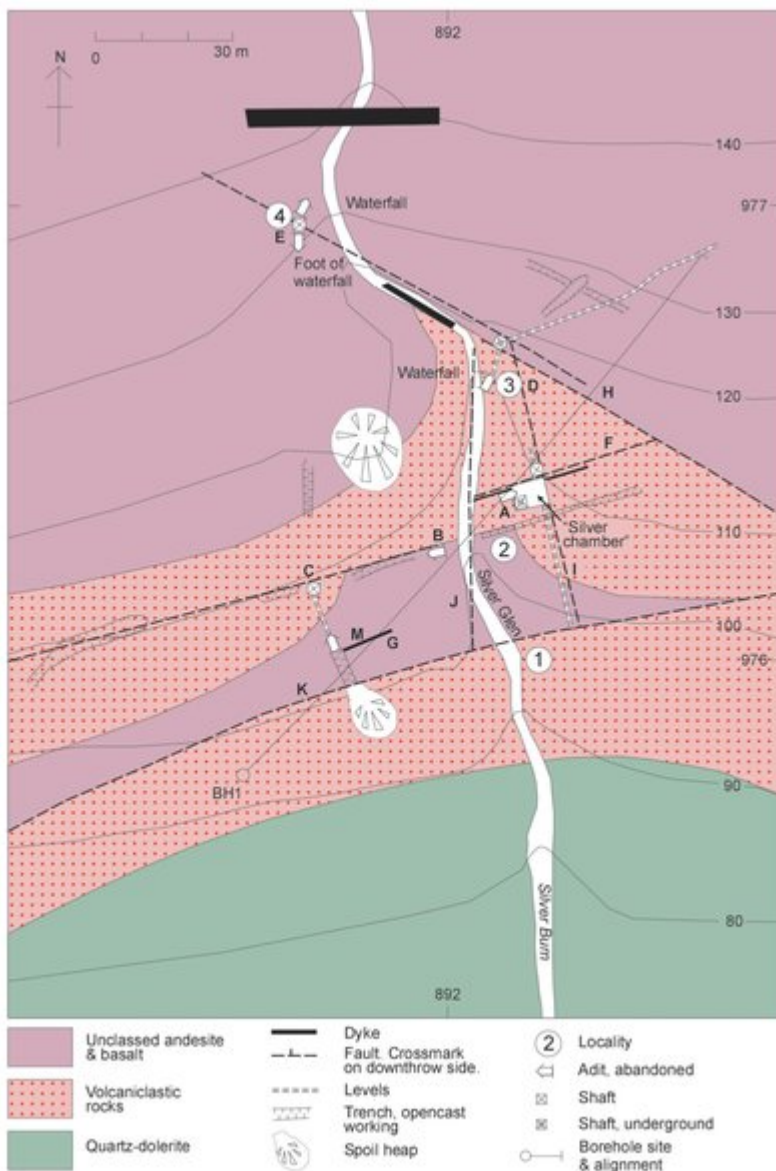
(Figure 4.2) Vertical section of the Passage and Upper Limestone formations in the Muiravonside area.



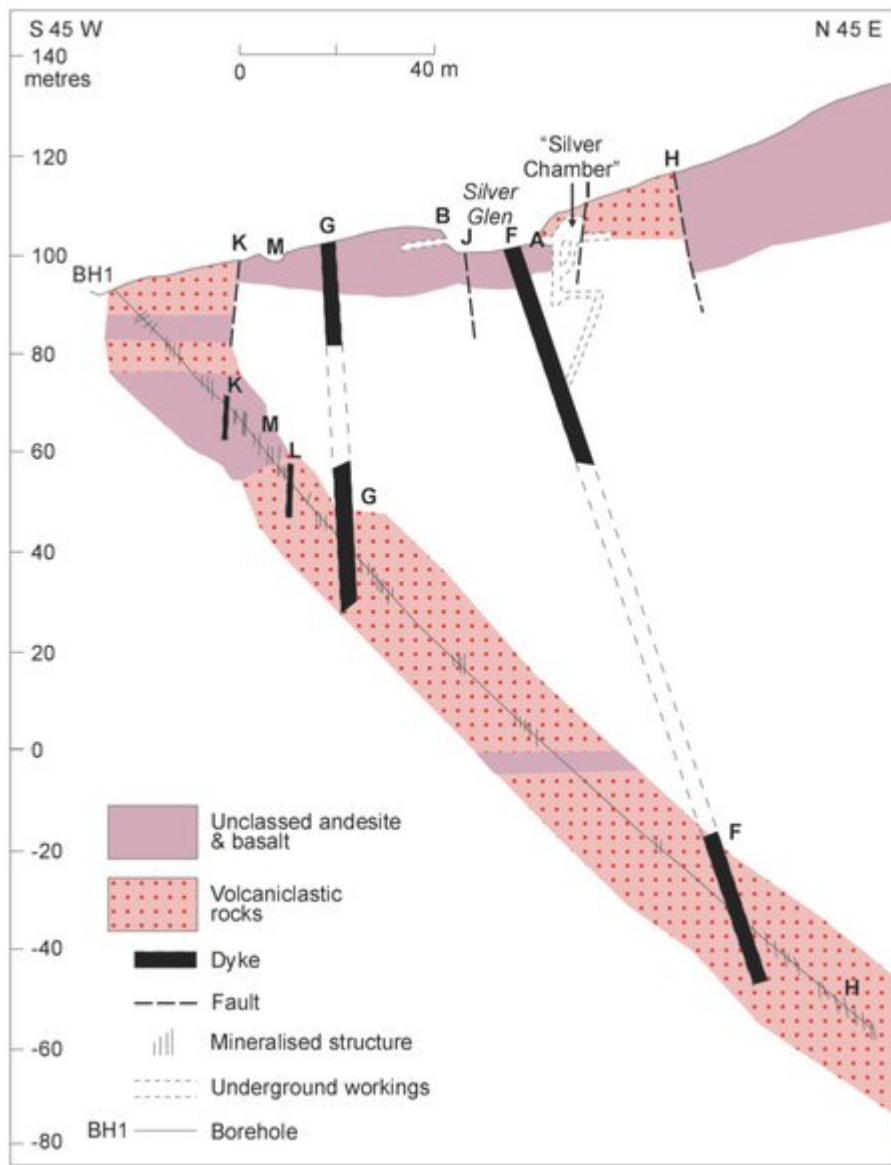
(Figure 5.1) Geological bedrock map of the Bridge of Allan–Menstrie area, showing localities for Excursion 5.



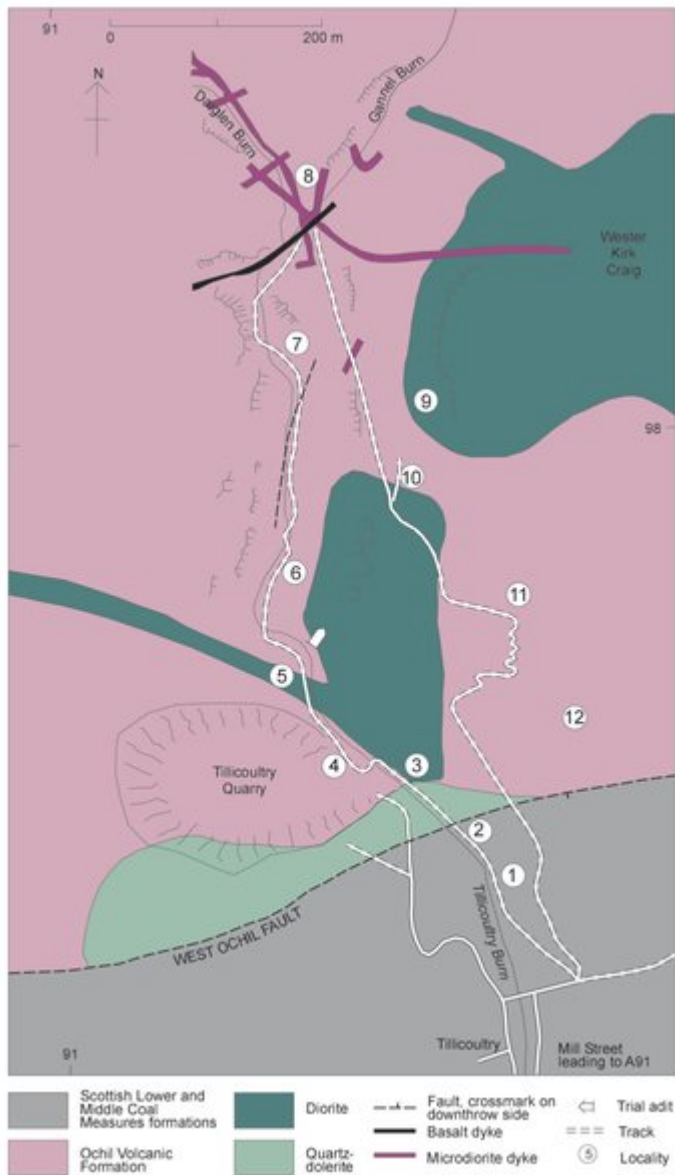
(Figure 5.2) Quaternary geological map of the Bridge of Allan– Stirling area.



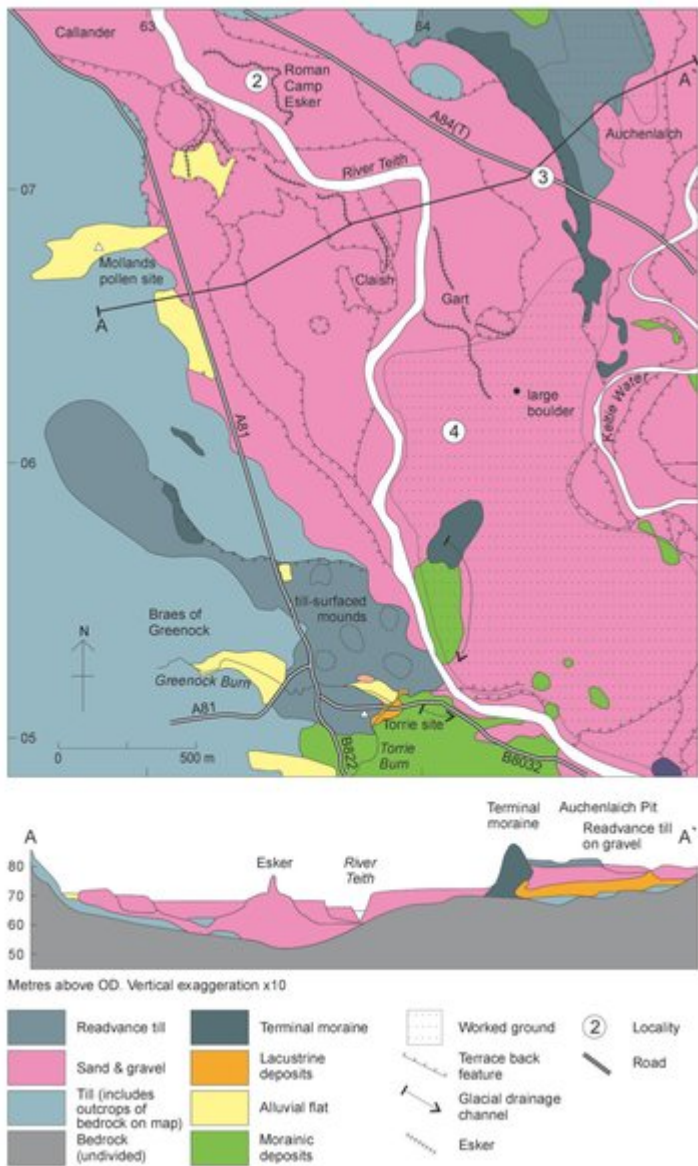
(Figure 6.1) Geological map of the Silver Glen, Alva, showing localities for Excursion 6. Adapted from Hall, Gallagher et al. (1982, fig. 4a).



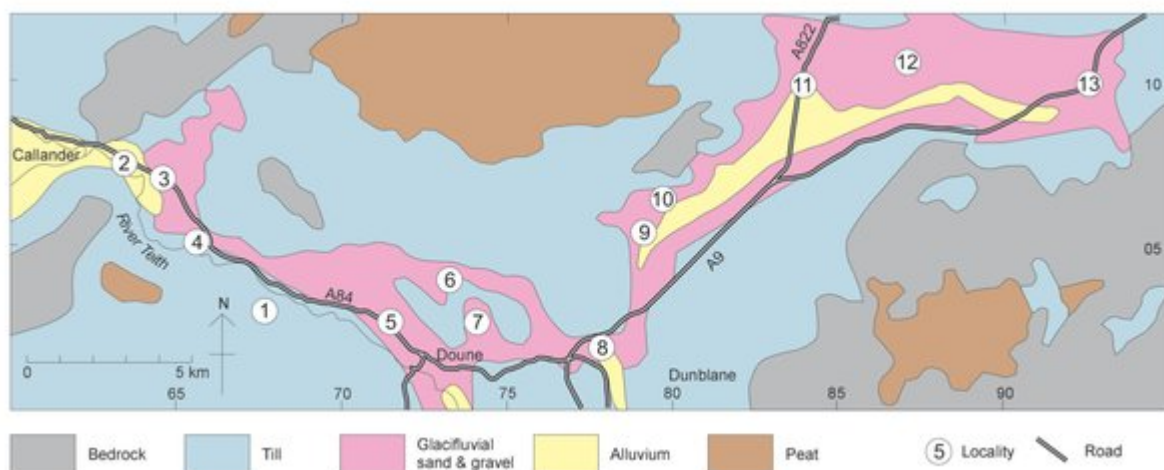
(Figure 6.2) Vertical section of mineral features in the Silver Glen. Adapted from Hall, Gallagher et al. (1982, fig. 4b).



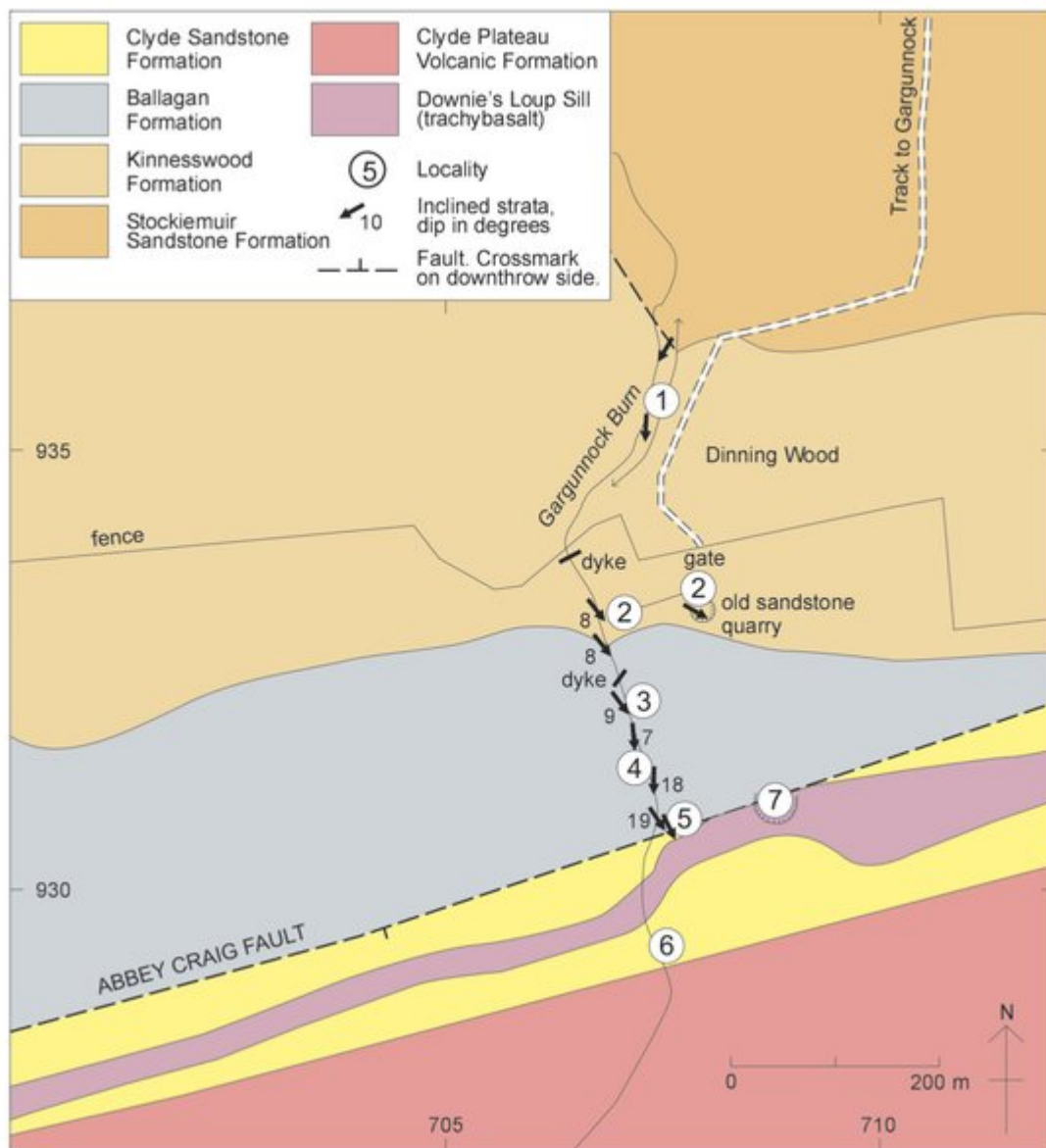
(Figure 7.1) Geological map of the area around the Mill Glen, Tillicoultry, showing localities for Excursion 7.



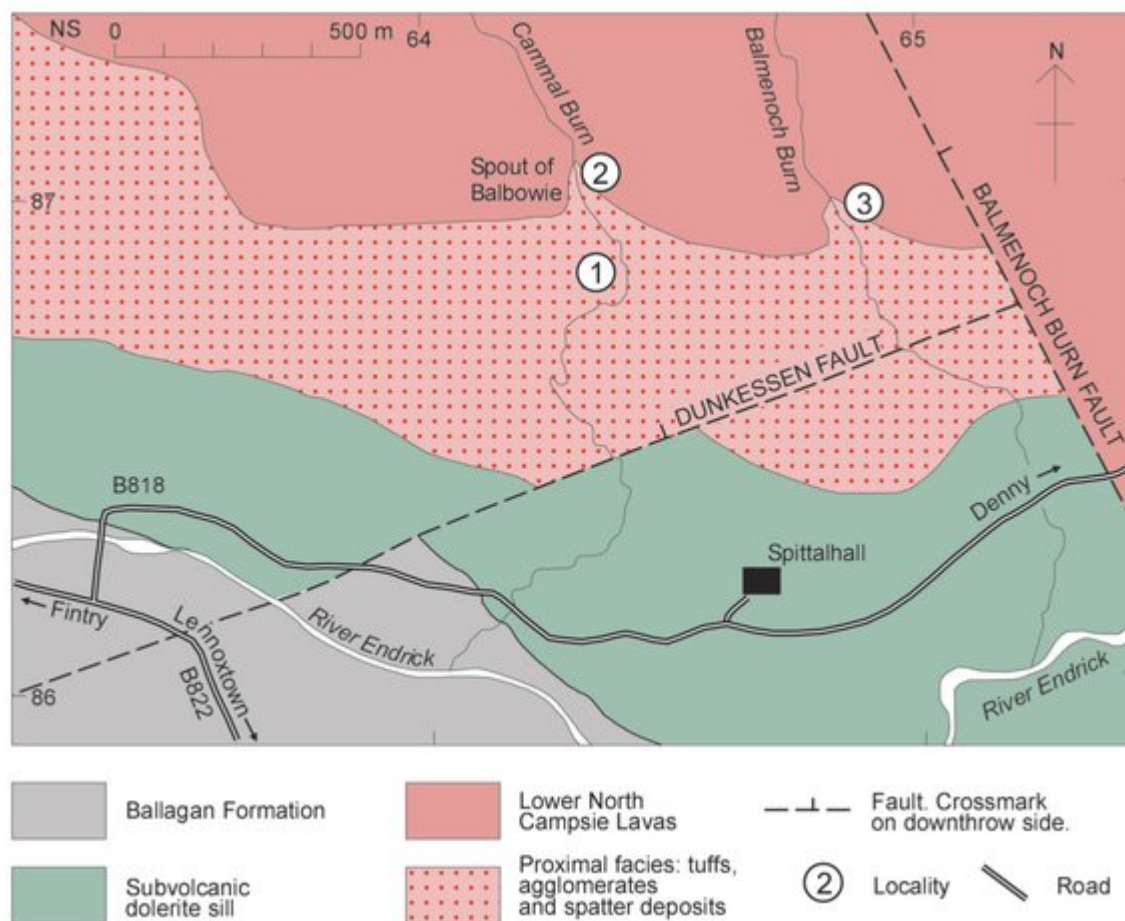
(Figure 8.1) Quaternary geological map and cross-section of the Teith valley south of Callander.



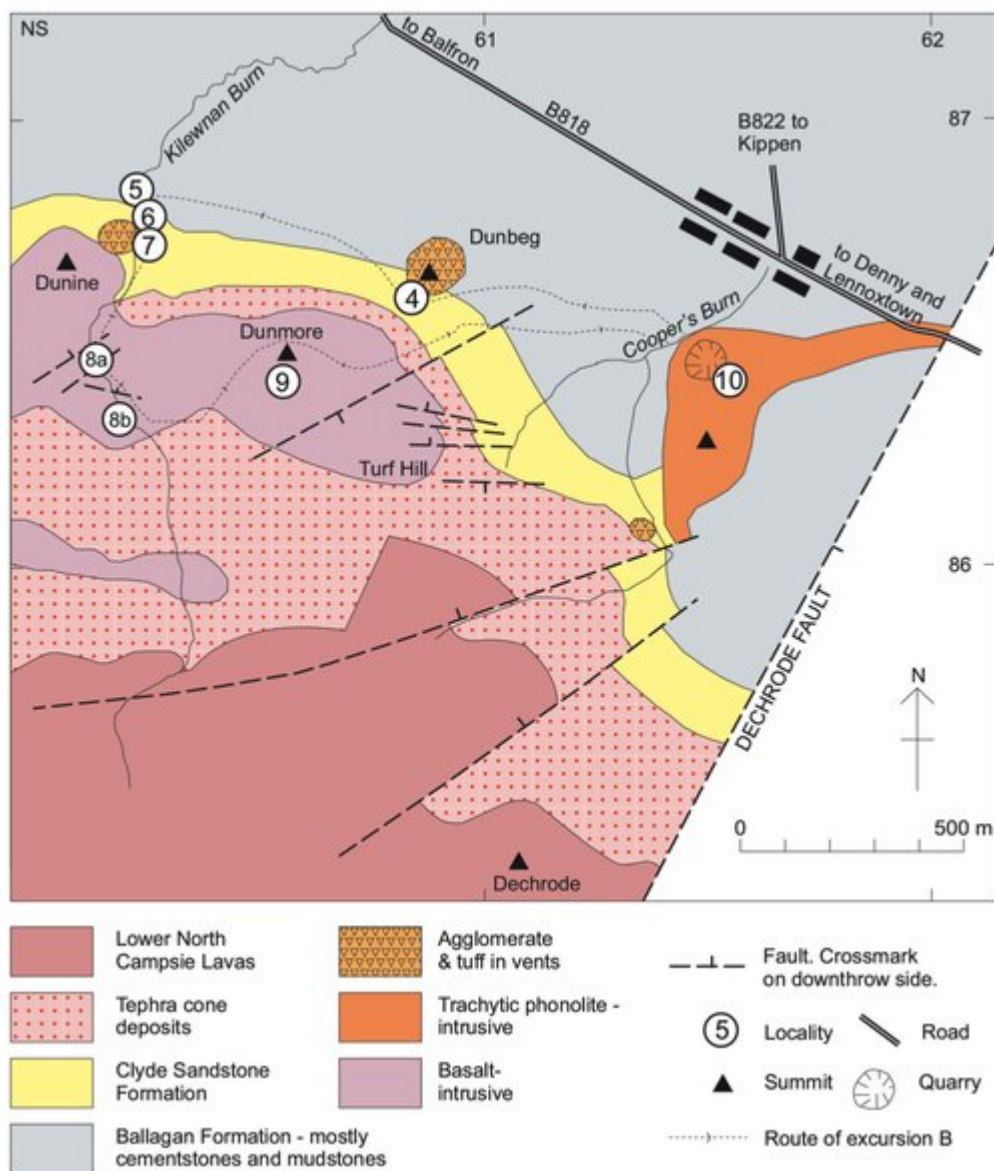
(Figure 8.2) Route map and generalised Quaternary geological map of the Teith valley and Strathallan, showing localities for Excursion 8.



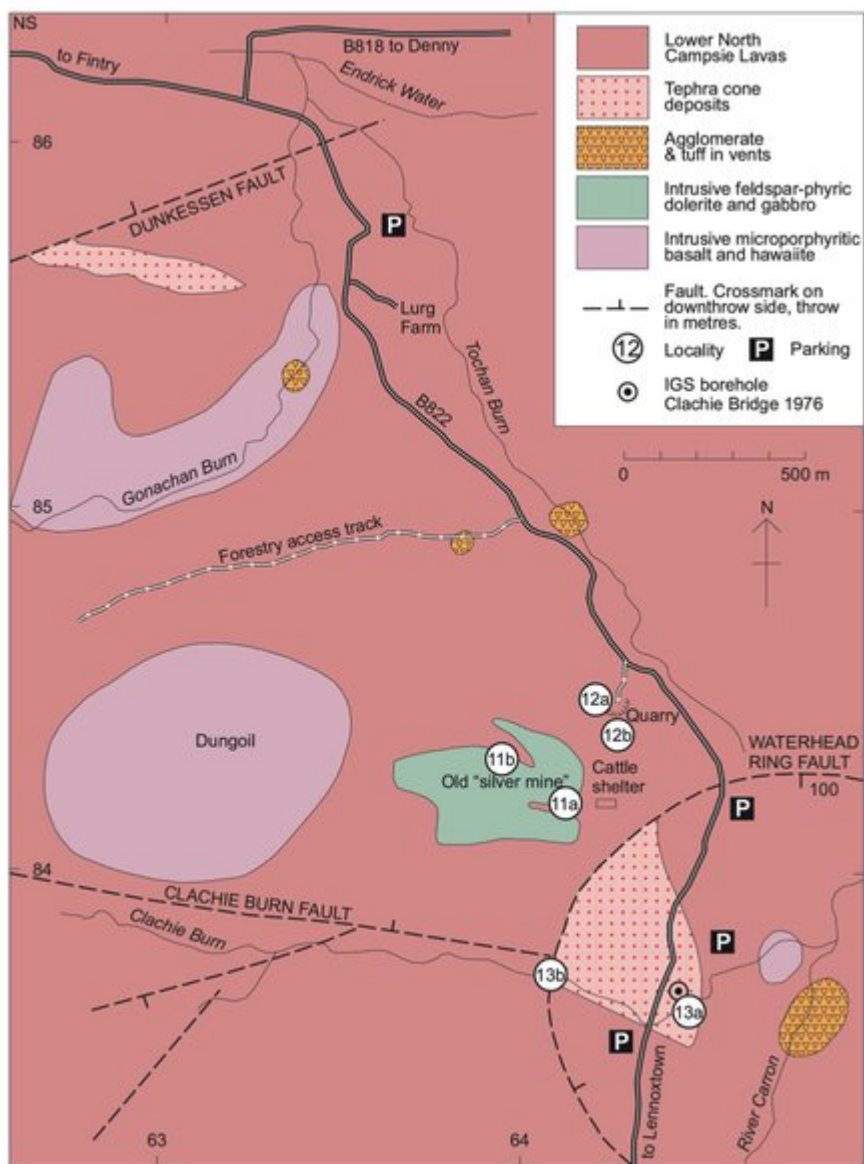
(Figure 9.1) Geological map of the area around the Gargunnoch Burn, showing localities for Excursion 9.



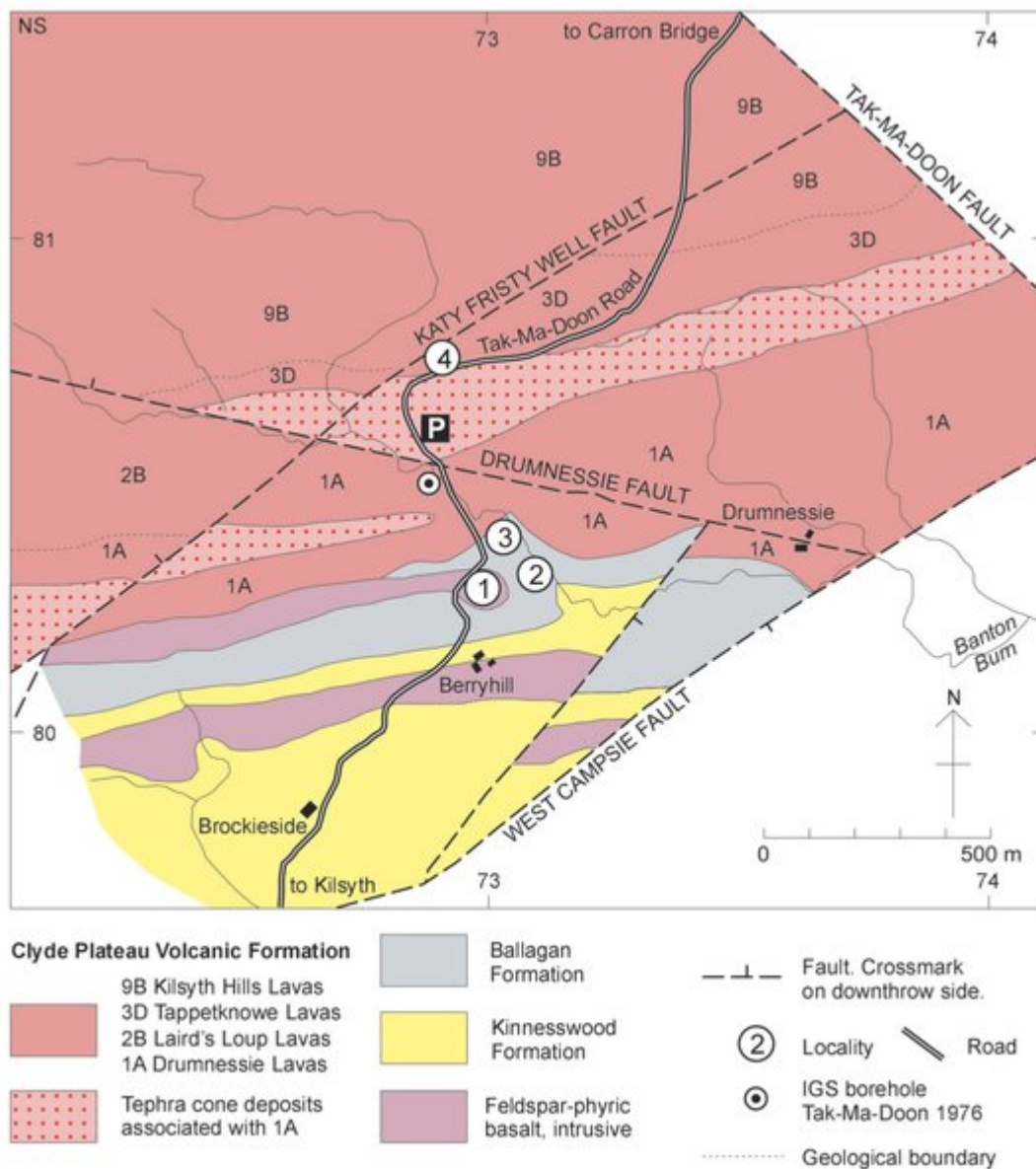
(Figure 10.1) Itinerary 10A geological map with localities – Cammal Burn.



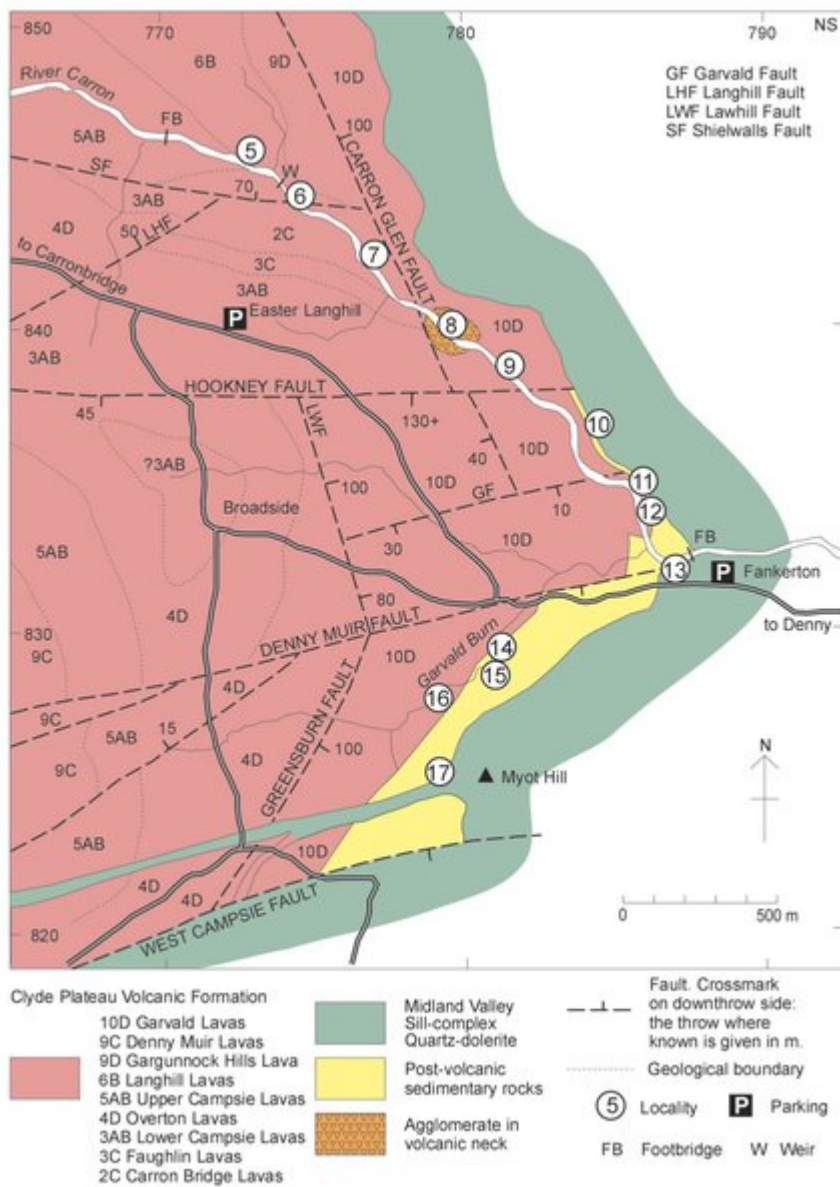
(Figure 10.2) Itinerary 10B geological map with localities – Dunmore area.



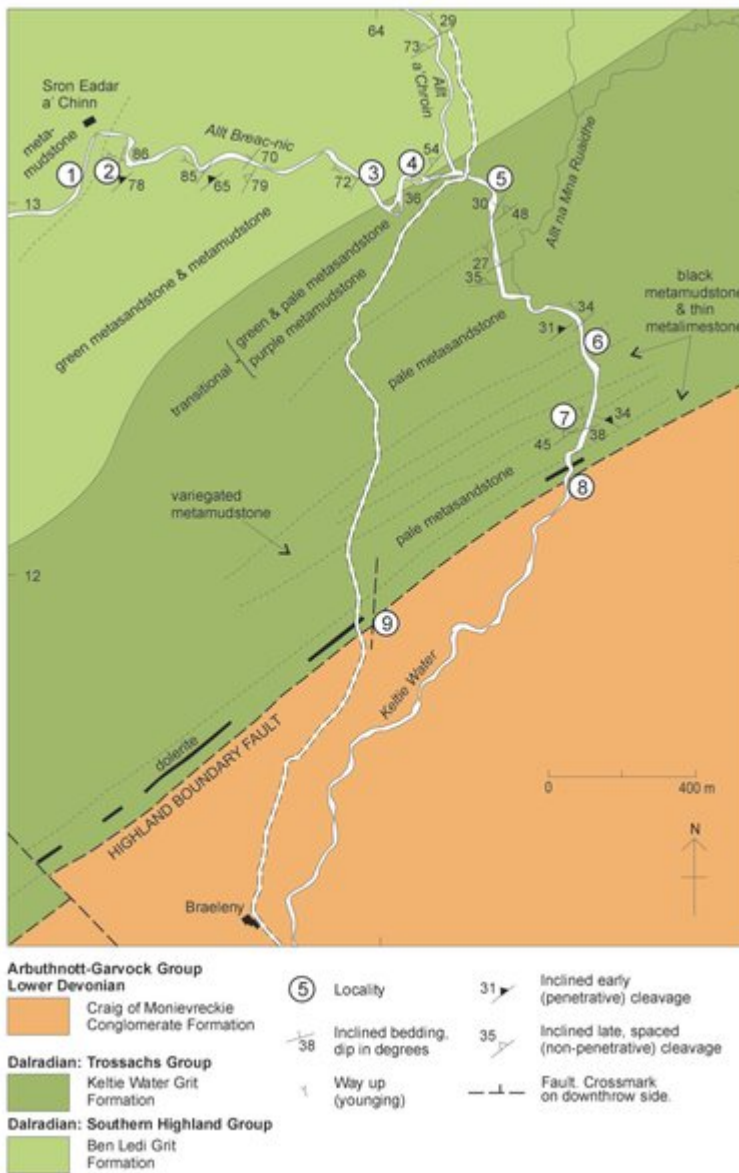
(Figure 10.3) Itinerary 10C geological map with localities – Dungoil area.



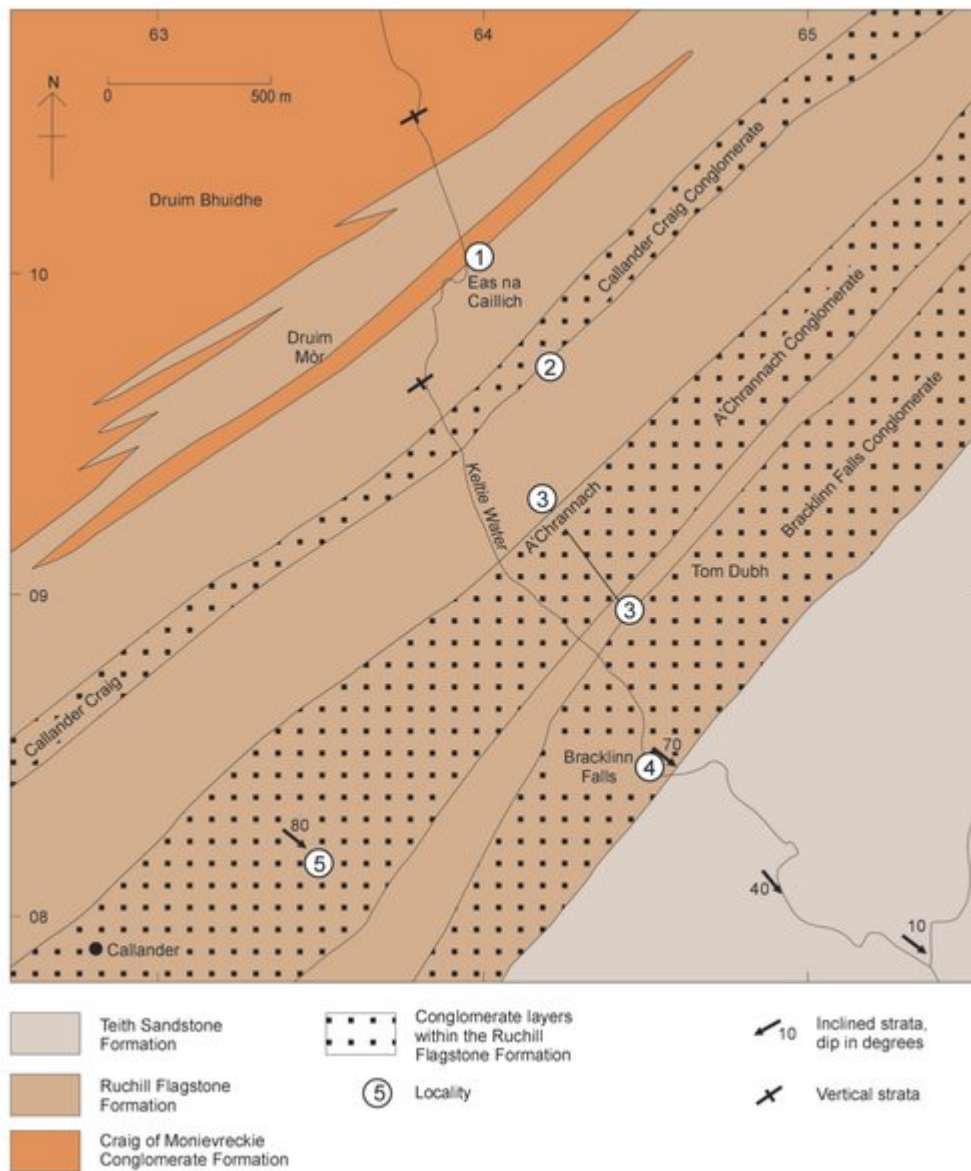
(Figure 11.1) Itinerary 11A geological map with localities – Banton Burn area.



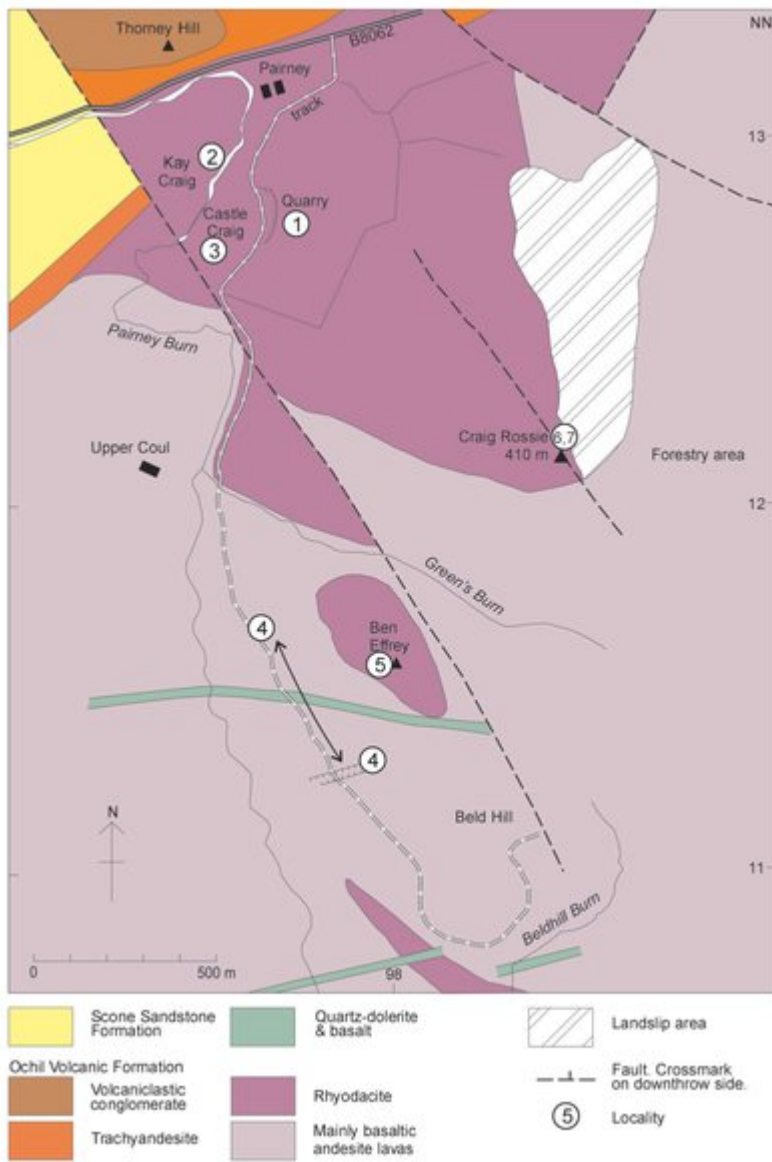
(Figure 11.2) Itinerary 11B geological map with localities – Carron Valley.



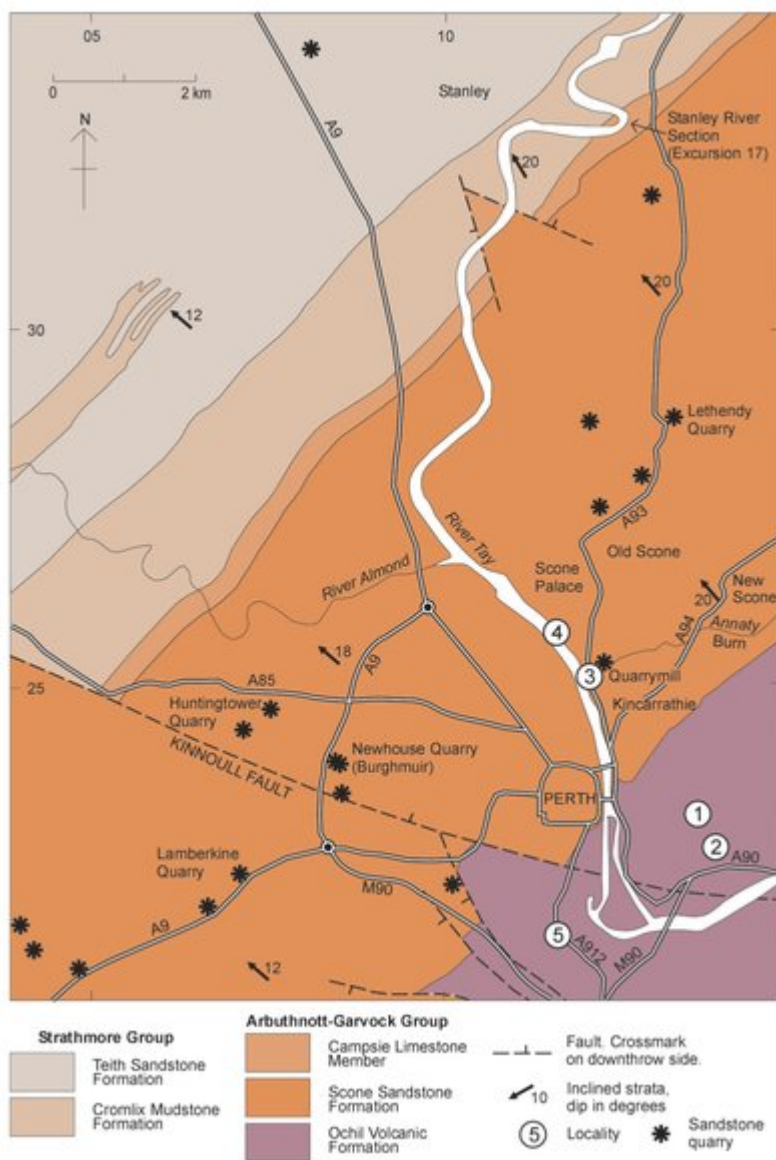
(Figure 12.1) Geological map of the Keltie Water section above Braelery Farm, showing localities for Excursion 12.



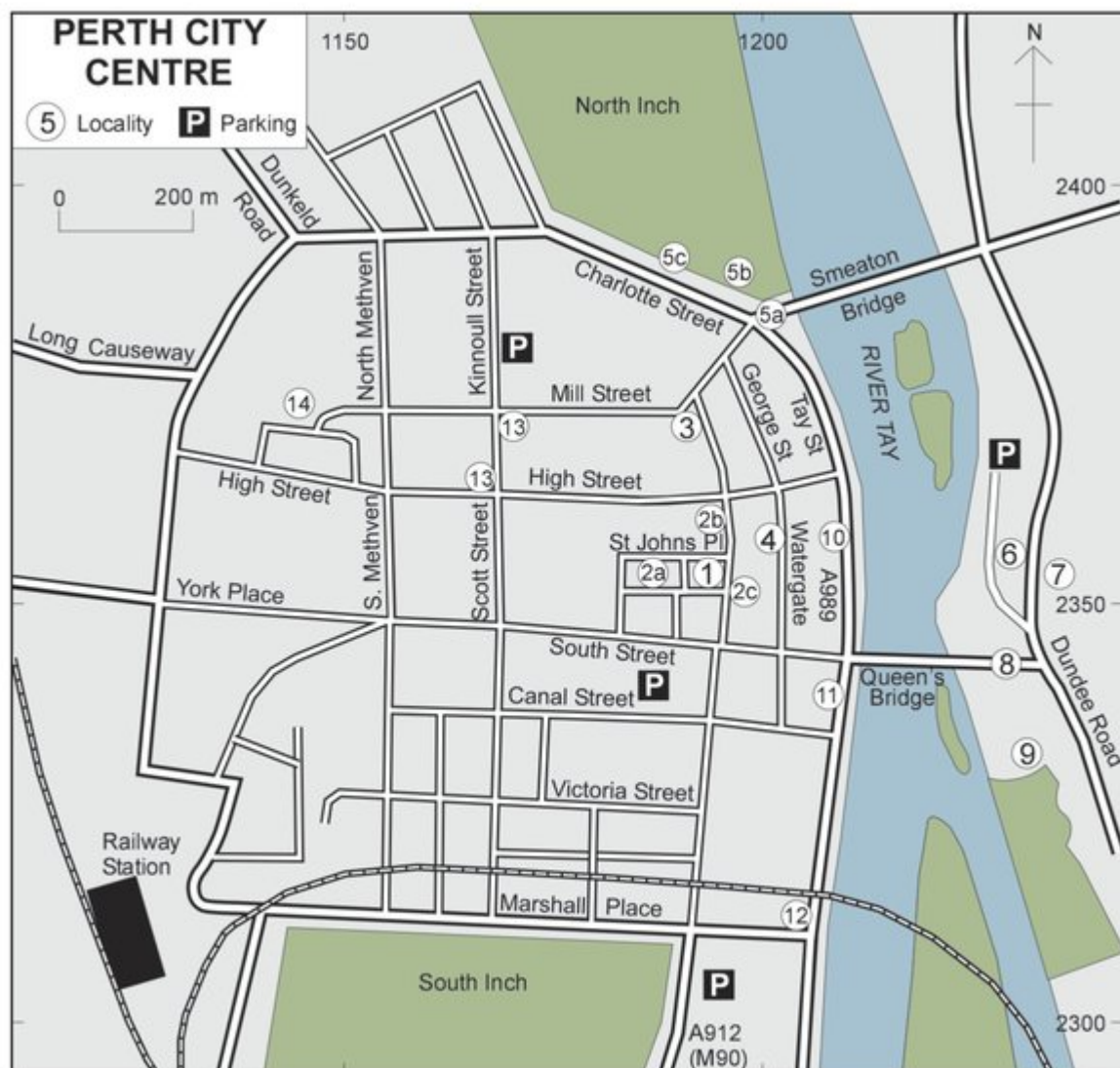
(Figure 13.1) Geological map of the area around the Keltie Water between Eas na Caillich and Bracklinn Falls, Callander, showing localities for Excursion 13. Adapted from Francis et al. (1970, fig. 9).



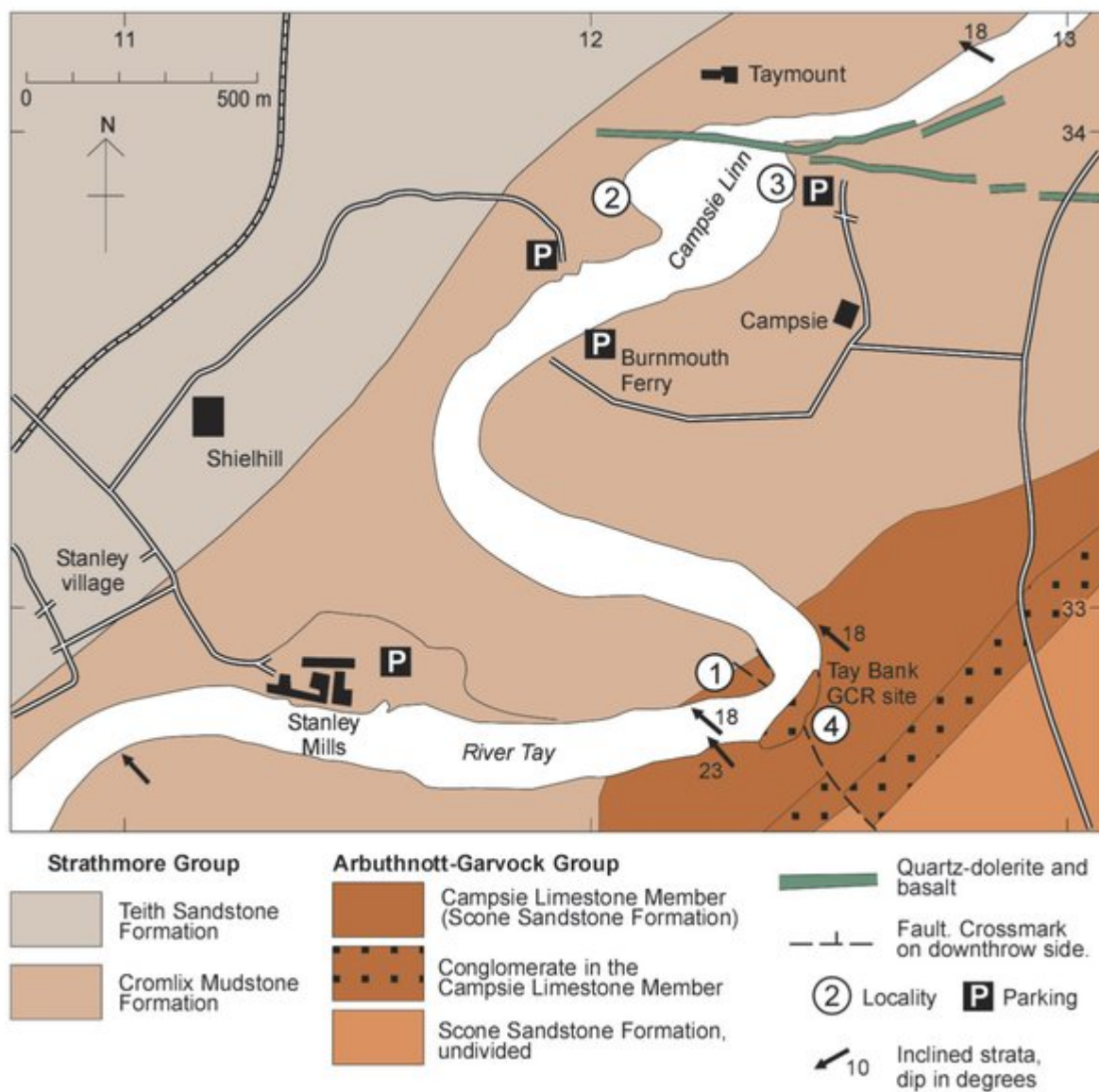
(Figure 14.1) Geological map of the area around Craig Rossie, showing localities for Excursion 14.



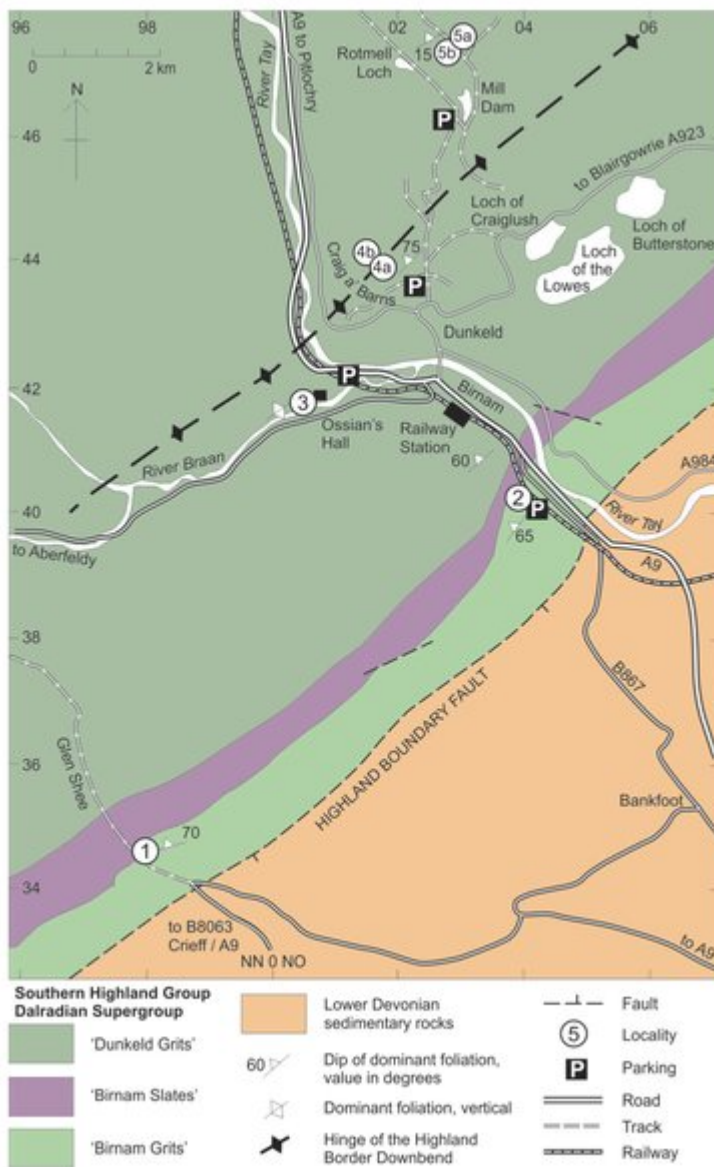
(Figure 15.1) Geological map of the area around Perth, showing localities for Excursion 15. Adapted from Fortey et al. (1998, fig. 4).



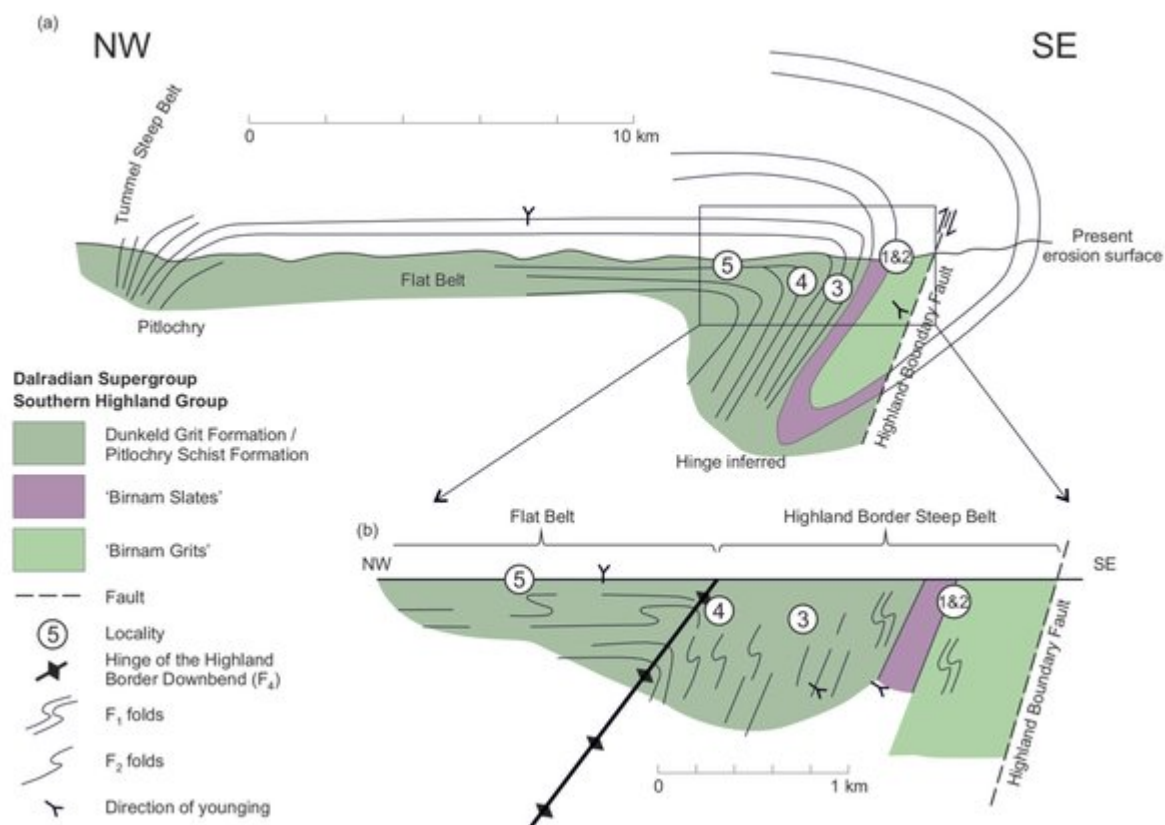
(Figure 16.1) Perth city centre locality map.



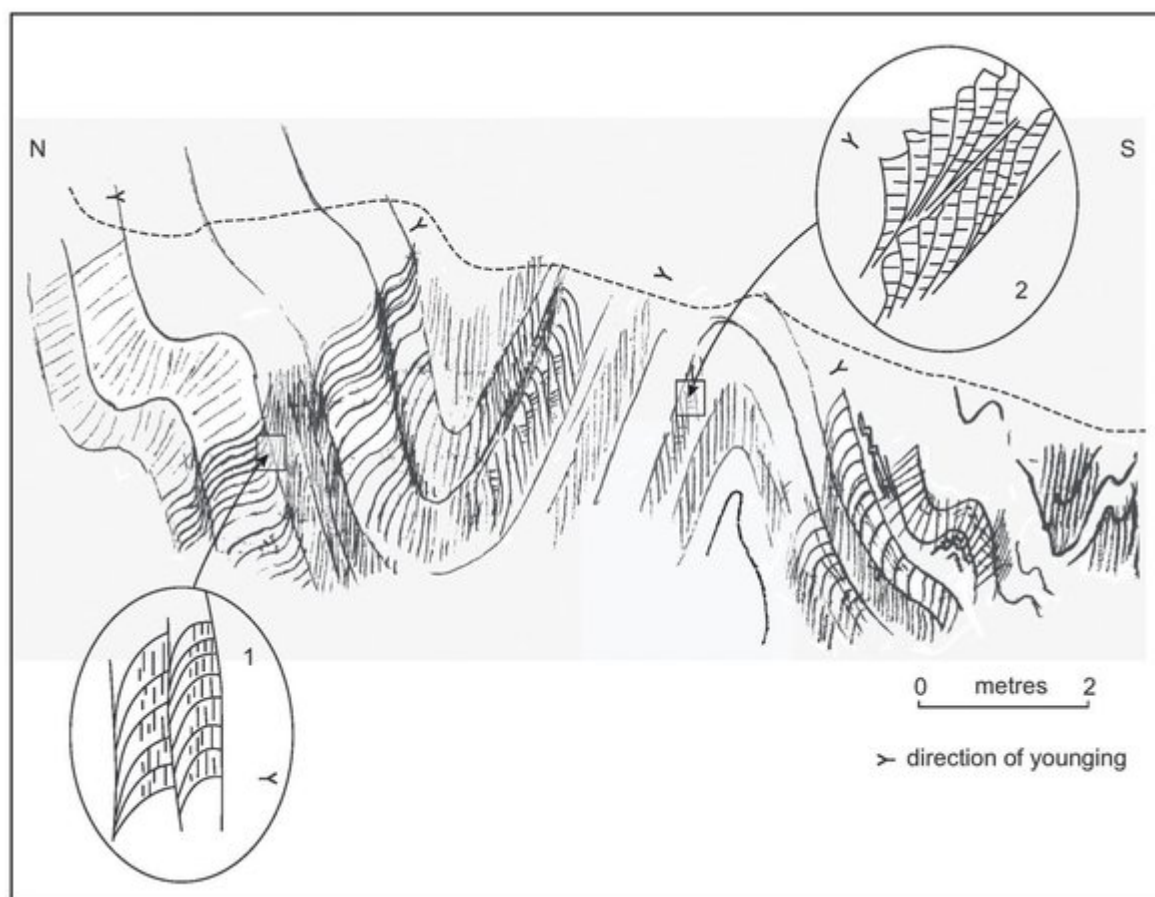
(Figure 17.1) Geological map of the area around the River Tay at Stanley, showing localities for Excursion 17.



(Figure 18.1) Geological map of the Highland Border area around Dunkeld and Little Glen Shee, showing localities for Excursion 18.



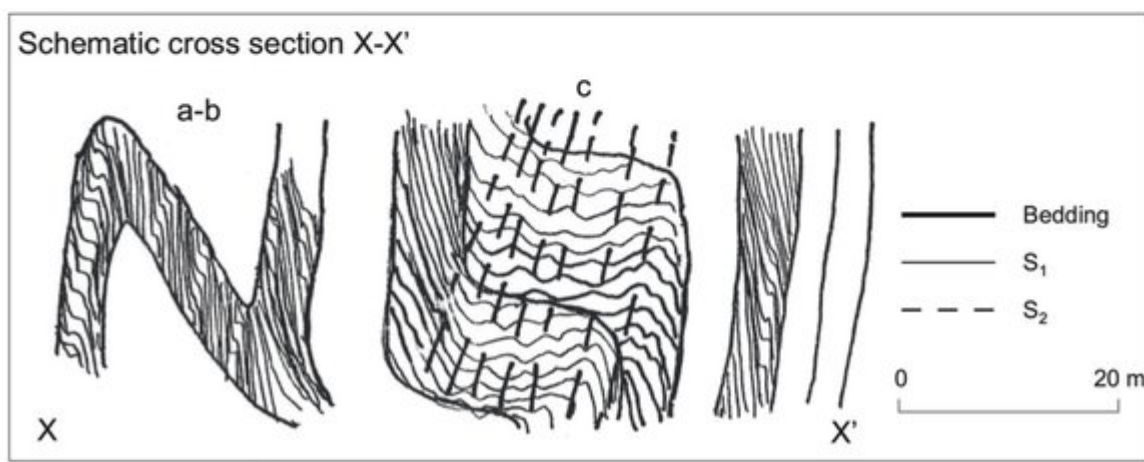
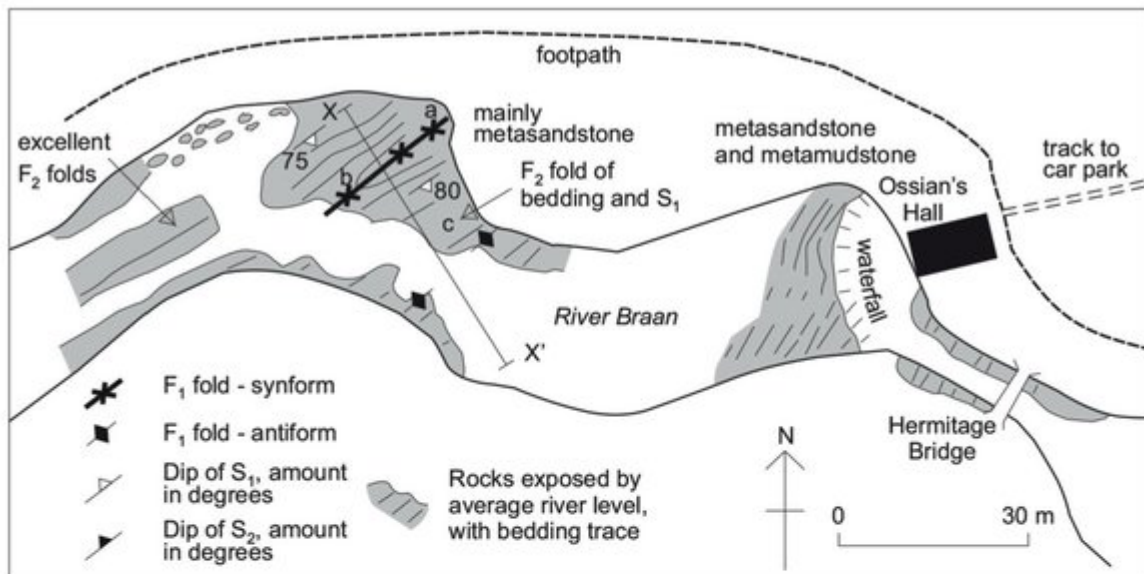
(Figure 18.2) (a) Schematic cross-section through the Tay Nappe from Pitlochry to Dunkeld, showing relative positions of localities for Excursion 18; (b) Detailed geology in relation to major features of the structure. Adapted from a drawing by Philip Rose in Tanner et al. (2013, fig. 24).



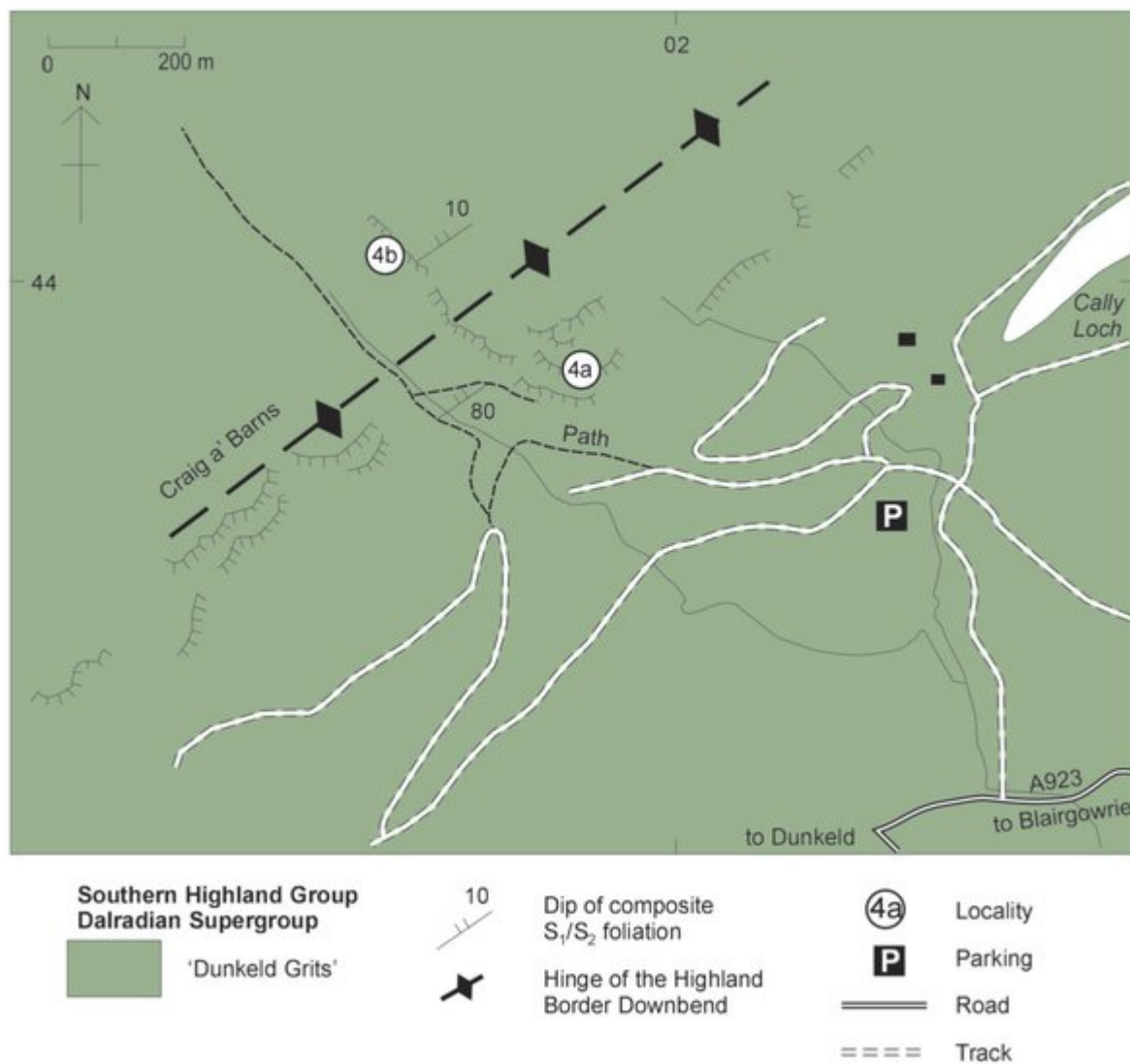
(Figure 18.3) Details of downward-facing  $F_1$  folds close to the downbent hinge zone of the Tay Nappe at Little Glen Shee, Locality 18.1, [\(Plate S.1\)](#). [Fanning of the S cleavage around minor folds and its refraction reflecting the original grain size are clearly shown. Insets show generalised detail of relations between gross bedding, the S spaced cleavage and re-orientated bedding lamination. Adapted from Tanner et al. \(2013, fig. 25\).](#)



(Plate S.1) Downward-facing  $F_1$  folds close to the downbent hinge zone of the Tay Nappe in Dalradian rocks at Little Glen Shee. See [\(Figure 18.3\)](#).



(Figure 18.4) Detailed geological map and cross-section, showing relationships between D1 and D2 structures at The Hermitage, Locality 18.3.



(Figure 18.5) Route map and major structures at Craig a' Barns, Locality 18.4.



*(Frontispiece 1) Stirling Castle from the Knott.*



*(Frontispiece 2) View SE from Kinnoull Hill of Kinnoull Tower perched on top of cliffs of Lower Devonian lavas (Ochil Volcanic Formation). The gentle windings of the Tay estuary and adjacent Holocene raised estuarine terraces that form part of the Carse of Gowrie are the highlight of this much visited viewpoint. The Ochil Hills (also Lower Devonian volcanic rocks) form the southern back drop.*



*(Plate S.2) Lower Devonian volcaniclastic conglomerate at cave east of Dumyat summit. See Excursion 5.*



*(Plate S.3) Trough cross bedding in Lower Devonian sandstone, A9 road cutting at Crossgates, Perth.*



*(Plate S.4) Lower Carboniferous Ballagan Formation mudstones with beds of dolostone (cementstone) in Banton Burn. See Excursion 11.*



*(Plate S.5) Trap featuring in Lower Carboniferous Clyde Plateau Volcanic Formation, north side of Gargunnock Hills.*



(Plate S.6) Disconformity between Kirkwood Formation and the overlying Lawmuir Formation. Outlines of clamp kilns in foreground; Lewis Hill Quartz-dolerite Sill forms crags in background. See Excursion 2.



(Plate S.7) Meadowhill opencast coal site (Clackmannanshire), Lower Coal Measures, now infilled.



*(Plate S.8) Meadowhill opencast coal site showing Langfauld Fault, separating Middle Coal Measures (left), from Passage Formation (right). (Plate 5.9) (opposite page, middle) Quartz-dolerite of the Midland Valley Sill-complex with overlying Upper Limestone Formation, Kilsyth.*



*(Plate S.9) Quartz-dolerite of the Midland Valley Sill-complex with overlying Upper Limestone Formation, Kilsyth.*



*(Plate S.10) (opposite page, below) Late Carboniferous quartz-dolerite dyke, showing right-lateral stepped contact and horizontal columnar joints, River Tay east bank, Campsie Linn. See Excursion 17.*



*(Plate S.11) Drumlin sculpted from glacial till at Clackmannan Tower, 500 m west of Clackmannan town; Holocene raised Carse Clay in foreground.*



*(Plate S.12) Terminal (push) moraine at Drumdhu Wood, Callander. See Excursion 8.*



*(Plate S.13) Perth Old City Hall, built of Lower Devonian sandstone from Leoch Quarry, West Dundee. See Excursion 16.*



*(Plate 1.1) Locality 1.8. Corner of Murray Place and King Street, former Bank of Scotland; Upper Limestone Formation sandstone from Polmaise Quarry.*



(Plate 1.2) Locality 1.10. 61 King Street, former Clydesdale Bank; red Permian sandstone from Locharbriggs.



(Plate 1.3) Locality 1.13. City wall at Back Walk in blocks of local quartz-dolerite. Bedrock of same quartz-dolerite seen at pavement level.



(Plate 1.4) Locality 1.18. Stirling Highland Hotel – the Old High School; Lower Limestone Formation sandstone from Raploch Quarry.



(Plate 2.1) Locality 2.1. Colonial coral (*Siphonodendron* sp.) in Todholes Limestone, Lawmuir Formation.



(Plate 2.2) Locality 2.4. Coarse-grained volcaniclastic detritus in Kirkwood Formation.



*(Plate 2.3) Locality 2.5. Waterfalls in the Bannock Burn, formed by the Bannock Burn White and Touchadam limestones, Lawmuir Formation.*



*(Plate 3.1) Locality 3.1. Musselband above the Upper Drumgray Coal in Westquarter Burn.*



*(Plate 3.2) Locality 3.2. Cross-bedded sandstone with sharp base upon bedded siltstone associated with the Upper Drumgray Coal, Bantaskine Quarry.*



*(Plate 3.3) Locality 3.4. Evidence of ground instability due to shallow coal workings; house with restraining horizontal and vertical metal straps, near Bellsdyke roundabout.*



*(Plate 3.4) Locality 3.4. Major mining subsidence hollow (below sea level) filled with brackish water, near former Barony Pit.*



*(Plate 4.1) Locality 4.1. Base of quartz-dolerite sill in River Avon.*



*(Plate 4.2) Locality 4.5. Adit to Castlecary Limestone, just upstream in River Avon from Union Canal Aqueduct.*



*(Plate 4.3) Locality 4.6. Weir built on sandstone at base of Passage Formation above Castlecary Limestone, River Avon, downstream of Union Canal Aqueduct.*



*(Plate 4.4) Locality 4.6. Passage Formation strata with thin coal seam, River Avon, downstream of Union Canal Aqueduct.*



*(Plate 5.1) Locality 5.1. Wolf's Hole Quarry, in Scone Sandstone Formation overlain by youngest known lava flow (feldspar-phyric basalt) of the Ochil Volcanic Formation.*



*(Plate 5.2) Locality 5.5. Stirling University campus; volcaniclastic conglomerate of Ochil Volcanic Formation; notice notch in cliff, of possible beach origin.*



*(Plate 5.3) Locality 5.7. Talus (scree) of microgranodiorite sill intruded into the Ochil Volcanic Formation.*



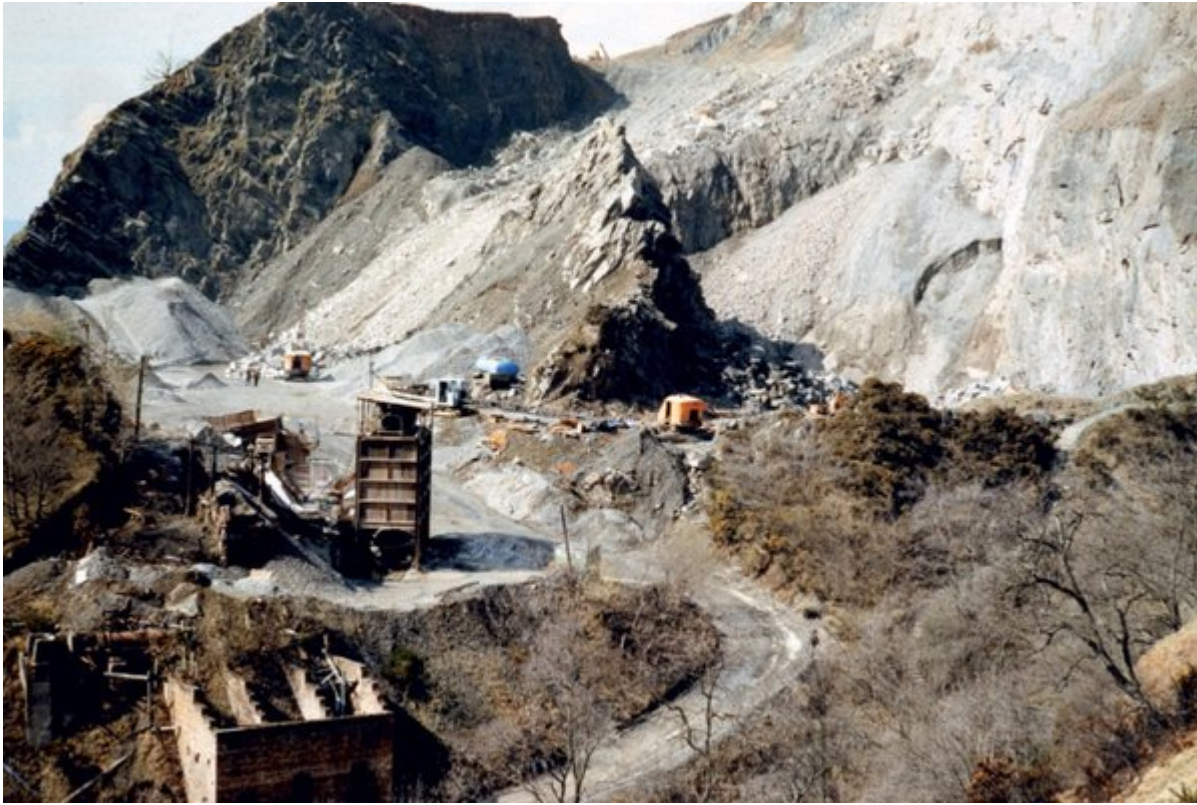
*(Plate 5.4) Locality 5.10. Ochil Volcanic Formation lavas and conglomerates showing trap-like step featuring, from Logiealmond.*



*(Plate 6.1) View north across the Devon valley towards the West Ochil Fault-scarp. Alva Glen (left) and Silver Glen (right) lie on either side of the pointed hill (The Nebit).*



*(Plate 6.2) Locality 6.2. Adit to the 'Silver Chamber' in east bank of Silver Burn.*



*(Plate 7.1) Locality 7.4, Castle Craigs Quarry, Tillicoultry. Historic view towards the west of the quartz-dolerite (Midland Valley Sill-complex) in West Ochil Fault plane, with Ochil Volcanic Formation strata to right.*



*(Plate 7.2) Locality 7.6. Gorge along line of fault in the Tillicoultry Burn, and old mill dam.*



*(Plate 8.1) Locality 8.2. Roman Camp Esker, Loch Lomond Stadial age, Callander.*



*(Plate 8.2) Locality 8.3. Drumdhu Wood terminal moraine, Loch Lomond Stadial age. (Photo: M. Hawkins)*



*(Plate 8.3) Locality 8.8. Glaciofluvial gravels, Late Devensian age, Laighhills Park, Dunblane.*



*(Plate 8.4) Locality 8.13. Glen Eagles U-shaped valley, looking south.*



*(Plate 9.1) Locality 9.1. Sandstone resting erosively on red mudstone, Kinnesswod Formation, Gargunnock Burn.*



*(Plate 9.2) Locality 9.2. Quarry exposure of nodular bed of calcrete, Kinnesswood Formation.*



*(Plate 9.3) Locality 9.3. Ballagan Formation mudstones with dolostone beds, Gargunnock Burn.*



*(Plate 9.4) Locality 9.5. Downie's Loup Sill (trachybasalt), underlain by Clyde Sandstone Formation, Gargunnoch Burn.*



*(Plate 10.1) Locality 10.2. Basal hawaiite flow of the Lower North Campsie Lavas resting on well-bedded ash-fall lapilli tuffs, Cammal Burn, Fintry.*



*(Plate 10.2) Locality 10.7. Early Carboniferous blocky agglomerate in Kilewnan Burn, Dunmore, Fintry.*



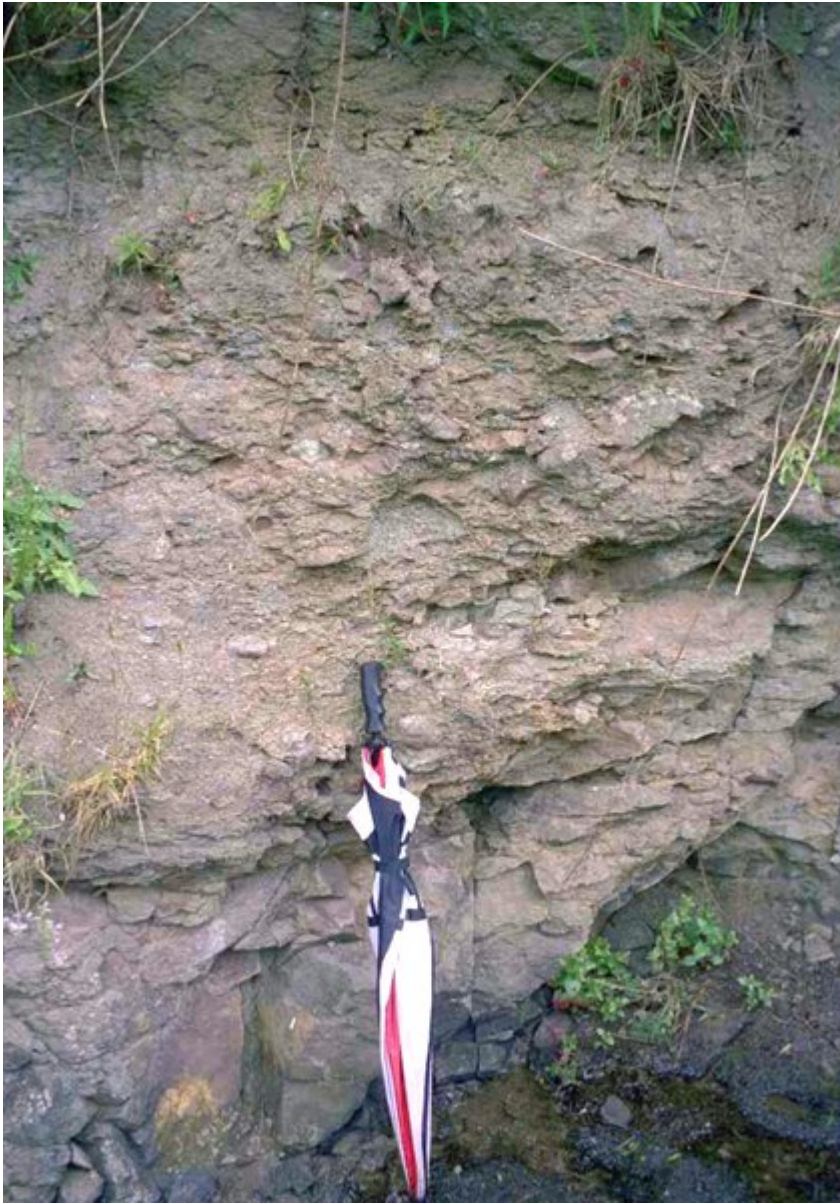
*(Plate 10.3) Locality 10.9. Columnar jointing in basalt sill under summit of Dunmore, Fintry.*



*(Plate 11.1) Locality 11.3. Basal basalt lava of the Clyde Plateau Volcanic Formation (Drumnessie Lavas), overlying red decomposed pyroclastic rocks (seen to the right of the figure) and with basaltic dyke forming face of waterfall in Banton Burn.*



*(Plate 11.2) Locality 11.8. Volcaniclastic breccia, bank of River Carron.*



*(Plate 11.3) Locality 11.14. Kirkwood Formation conglomerate and siltstone, Garvald Burn.*



*(Plate 11.4) Locality 11.16. Weathered pillows (?). Garvald Burn.*



*(Plate 12.2) Locality 12.6. Microgranite sill in Keltie Water, at inverted contact between the lower part of the Keltie Water Grit Formation (upstream, left) and the Keltie Limestone and Slate Member (downstream, right).*



*(Plate 12.3) Locality 12.8. Highland Boundary Fault in west bank of Keltie Water. See text for detail.*



*(Plate 12.1) Locality 12.5. Load casts on inverted beds of Keltie Water Grit Formation, Keltie Water.*



*(Plate 13.1) Locality 13.1. Vertical beds of conglomerate and sandstone in the Ruchill Flagstone Formation, bridge over the Keltie Water, Eas na Caillich.*



*(Plate 13.2) Locality 13.1. Waterfall and gorge in Craig of Monievreckie Conglomerate Formation interbedded in Ruchill Flagstone Formation at Eas na Caillich.*



*(Plate 13.3) Locality 13.3. Steeply dipping overturned red mudstones and sandstones of the Ruchill Flagstone Formation beside forest track on east side of Keltie Water.*



*(Plate 13.4) Locality 13.3. Glacial till and overlying boulder gravel, Keltie Water west bank.*



*(Plate 13.5) Locality 13.4. Vertical beds of sandstone and conglomerate (Ruchill Flagstone Formation) at Bracklinn Falls, Keltie Water.*



*(Plate 14.1) Locality 14.1. Rhyodacite with brecciation and mineralisation, Pairney Quarry.*



*(Plate 14.2) Locality 14.1. Rhyodacite with flow folds (centre) and green xenolith of rotted igneous rock, top left of notebook, Pairney Quarry.*



*(Plate 14.3) Locality 14.3. Craig Rossie scarp and talus (scree).*



*(Plate 14.4) Locality 14.7. Craig Rossie viewed towards the SW, showing major landslides; note esker in foreground.*



*(Plate 15.1) Locality 15.2. Kinnoul Hill viewpoint – Ochil Volcanic Formation, North Tay Fault scarp and view eastwards towards Tay estuary.*



*(Plate 15.2) Locality 15.4. Trough cross-bedding and calcrete nodules in Scone Sandstone, River Tay, Scone Palace.*



*(Plate 15.3) Locality 15.5. Bedded sandstone and mudstone dipping under andesitic lava flows of the Ochil Volcanic Formation, Friarton Quarry.*



*(Plate 15.4) Locality 15.5. Detail of loose block showing subangular to well-rounded masses of fine-grained igneous material within a matrix of green silty sandstone—peperitic texture as a result of injection of magma into wet, unconsolidated sediment, Friarton Quarry.*



*(Plate 16.1) Locality 16.1. St John's Kirk; sandstones from various quarries in Scone Sandstone Formation.*



(Plate 16.2) Locality 16.2c. Former Bank of Scotland; blonde Carboniferous sandstone.



(Plate 16.3) Locality 16.5a. Smeaton Bridge; sandstone from Scone Sandstone Formation, Quarrymill.



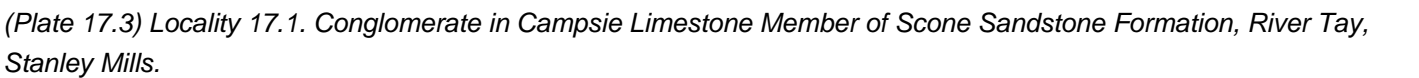
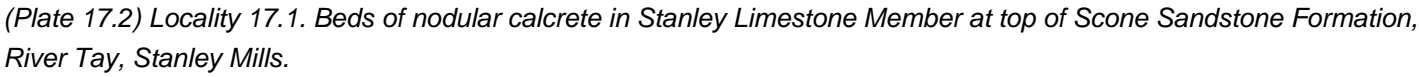
*(Plate 16.4) Locality 16.11. Wall of demolished former town jail; quartz-dolerite from Lamberkine Quarry.*



(Plate 16.5) Locality 16.13 Sandeman Building; red Permian sandstone, Locharbriggs, Dumfries.



(Plate 17.1) Locality 17.1. Desiccation cracks in Cromlix Mudstone Formation, River Tay, Stanley Mills.





*(Plate 17.4) Locality 17.2. Late Carboniferous quartz-dolerite dyke, showing right-lateral stepped contact with discoloured baked Cromlix Mudstone (right), River Tay west bank, Campsie Linn.*



(Plate 18.1) Locality 18.1. Refraction of  $S_1$  spaced pressure-solution cleavage on the steep NW limb of a synform (far left on [\(Plate S.1\)](#) and [\(Figure 18.3\)](#)), Little Glen Shee. The cleavage fans around the minor folds and is at a higher angle to the bedding in the coarser grained beds. The curvature indicates grading towards finer grain size, and hence younging, to the left. Thus the folds in [\(Plate S.1\)](#) are downward facing.



(Plate 18.2) Locality 18.3a. Characteristic  $F_2$  folds of spaced  $S_1$  cleavage in metasandstone at The Hermitage.



(Plate 18.3) Locality 18.3c. Lozenge-shaped microlithons' formed by  $S_2$  spaced pressure-solution cleavage (top left to bottom right) cutting a folded earlier,  $S_1$  spaced cleavage in metasandstone, The Hermitage.



(Plate 18.4) Locality 18.5a SE-verging  $F_4$  minor folds of composite  $S_1/S_2$  foliation in schistose metasiltstone in the Flat Belt, NW of the Highland Border Downbend, Deuchary Hill.

Table S.1	
Lower Devonian Lithostratigraphy	
Group	Formation
Stratheden	Stockiemuir Sandstone
Unconformity	
Strathmore	Teith Sandstone
	Cromlix Mudstone
Arbuthnott–Garvock	Scone Sandstone
	Craig of Monievreckie Conglomerate
	Ochil Volcanic

(Table S.1) Lower Devonian Lithostratigraphy.

Table S.2	
Carboniferous Lithostratigraphy	
Group	Formation
Scottish Coal Measures	Scottish Middle Coal Measures Scottish Lower Coal Measures
Clackmannan	Passage Upper Limestone Limestone Coal Lower Limestone
Strathclyde	Lawmuir Clyde Plateau Volcanic Kirkwood
Unconformity	
Inverclyde	Clyde Sandstone Ballagan Kinnesswood

(Table S.2) Carboniferous Lithostratigraphy.

Table 10.1
Characteristics of proximal and distal basaltic sequences
<b>Proximal</b>
– fragmental rocks form high proportion of sequence
– blocks, scoria bombs and spatter usually present
– thick units of chaotic, coarsely fragmental rock common
– thickly stratified sequences of tuffaceous material common, usually incorporating blocks and bombs
– lava flows commonly compound and highly vesicular
– lava texture relatively coarse grained with ophitic clinopyroxene
– extensive bright red steam oxidation common in fragmental deposits close to conduit
– irregular minor basaltic intrusions common in sequences close to vents
– major columnar jointed basaltic intrusions commonly associated with conduit systems
– veins of intrusive tuffisite occasionally present in sequences adjacent to conduits
– sills commonly intruded in sedimentary strata beneath base of volcanic pile
<b>Distal</b>
– lava flows form high proportion of sequence
– blocks, scoria bombs and spatter always absent
– coarse fragmental deposits only thinly developed on upper flow surfaces
– tuffaceous material present only in thinly stratified sequences between flows
– lava flows commonly in form of simple, uniform sheets of predominantly massive character
– lava texture generally fine grained with granular clinopyroxene
– red-brown bole commonly restricted to interflow fragmental deposits
– intrusions rare and always in form of dykes

(Table 10.1) Characteristics of proximal and distal basaltic sequences

Table 11.1

Lava Members in the Eastern Part of the Campsie Block					
Lava pile sub-division	Lava member	Dominant lava type	Eruptive source	Maximum thickness (m)	Seen at Locality
10	Craigdouffie Lavas (10C)	various	local	15+	
	Garvald Lavas (10D)	various	local	50+	B5, 7, 8, 12
9	Kilsyth Hills Lavas (9B)	fAOB/fH	WCVC	200+	
	Denny Muir Lavas (9C)	fAOB/fH	WCVC	85+	
	Gargunnoch Hills Lavas (9D)	fAOB/fH	WCVC	90+	A4
6	Langhill Lavas (6B)	M	?	35	B1
5	Upper North Campsie Lavas (5A)	BH/H	NC/GGLVS	215	
	Upper South Campsie Lavas (5B)	H	SCLVS	60	
4	Overton Lavas (4D)	fH/M	?	35	
3	Lower North Campsie Lavas (3A)	H	NCLVS	70	
	Lower South Campsie Lavas (3B)	AOB/BH	SCLVS	135	
	Faughlin Lavas (3C)	H/M	?local	35	
	Tappetknowe Lavas (3D)	H/M	?local	40	A4
2	Laird's Loup Lavas (2B)	fBH/fH	?SCLVS	65	
	Carron Bridge Lavas (2C)	fBH/fH	?	50+	B2, 3
1	Drumnessie Lavas (1A)	AOB	SCLVS	60	A3

## Abbreviations:

f – feldspar-phyric

AOB – alkali olivine basalt

BH – basaltic hawaiite

H – hawaiite

M – mugearite

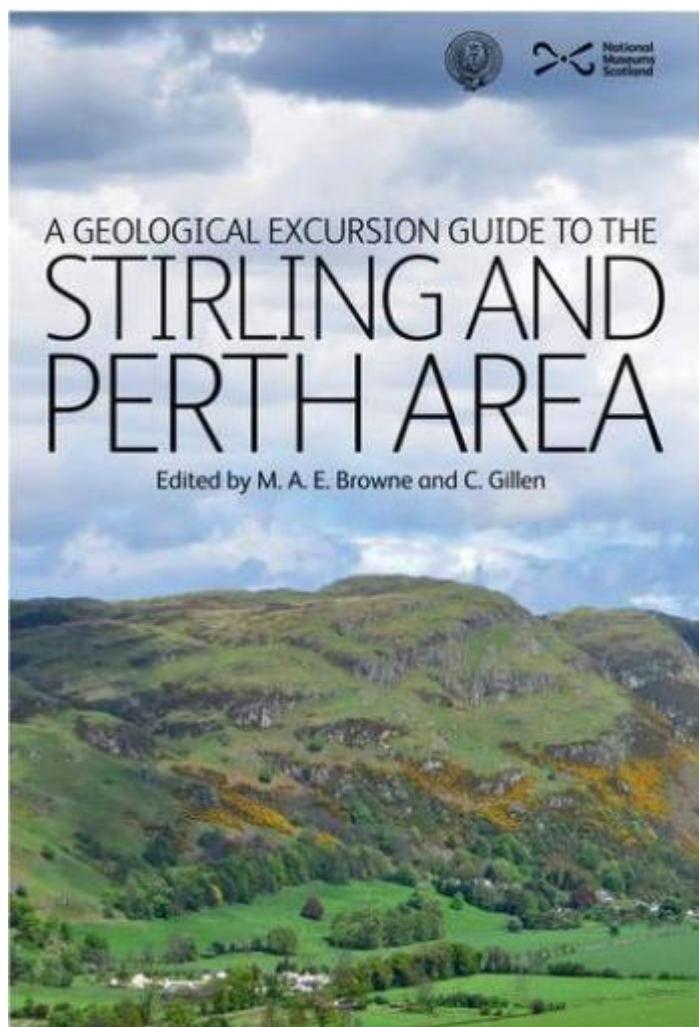
NCLVS – North Campsie Linear Vent System

GGLVS – Gonachan Glen Linear Vent System

SCLVS – South Campsie Linear Vent System

WCVC – Waterhead Central Volcanic Complex

(Table 11.1) Lava Members in the Eastern Part of the Campsie Block.



*Front cover.*