East Dunbartonshire Geodiversity Audit

Volume 2 - Appendices

Geology and Landscape Scotland Programme

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Front cover

Central image: View south-east towards Bishopbriggs from an escarpment of Craigmaddie Muir Sandstone close to the Auld Wives' Lifts.
Above image: Mineral growth and striations on a fault plane, Blairskaith Quarry.
Lower image: Glaciofluvial cobbles and pebbles of various lithologies, Inchbelle Quarry.
Right image: Fossils from the Lower Limestone Formation at Blairskaith Quarry.
Left image: Columnar jointing in a basaltic volcanic plug at Craigangawn Quarry.

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Volume 2 - Appendices

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Figure 6: Dictionaries entry screen 116

Appendix 1 Site photographs and descriptions

EDC 1: Twechar Quarry, Twechar

Photo 1: View looking NE from the tavern car park into the disused quartz-microgabbro quarry at Twechar.

Photo 2: Looking NNW at a part of the quarry face which displays the top of the igneous intrusion. The lower ⅔ of the face shows sub vertical jointing formed within the intrusion as the molten rock cooled, the upper ⅓ shows gently the dipping strata of the overlying sedimentary sequence. As the contact between the two rock types is parallel to the layering in the sedimentary strata, the intrusion is termed a ‘sill’.

EDC 1: Twechar Quarry, Twechar

Photo 3: A network of quartz and calcite veins within the quartz-microgabbro. Looking N.

Photo 4: Sub horizontal slickensides developed along a fault plane within the quartz-microgabbro. Looking NE.

Photo 5: Well developed vertical columnar jointing has formed perpendicular to the top and base of the sill. Snow is resting on the top of some crudely polygonal columns. Looking E.

EDC 2: Castle Hill Quarry, Twechar

Photo 6: Information board by Historic Scotland describing the archaeological remains at Bar Hill Roman Fort on the Antonine Wall. View looking SE

Photo 7: Although the source of the stone used to build the Roman fort is unknown, it is likely to have been quarried locally. View looking W

Photo 8: Quarry face on the southern side of Castle Hill. Note the massive nature of the quartz-microgabbro intrusion. Looking N

EDC 2: Castle Hill Quarry, Twechar

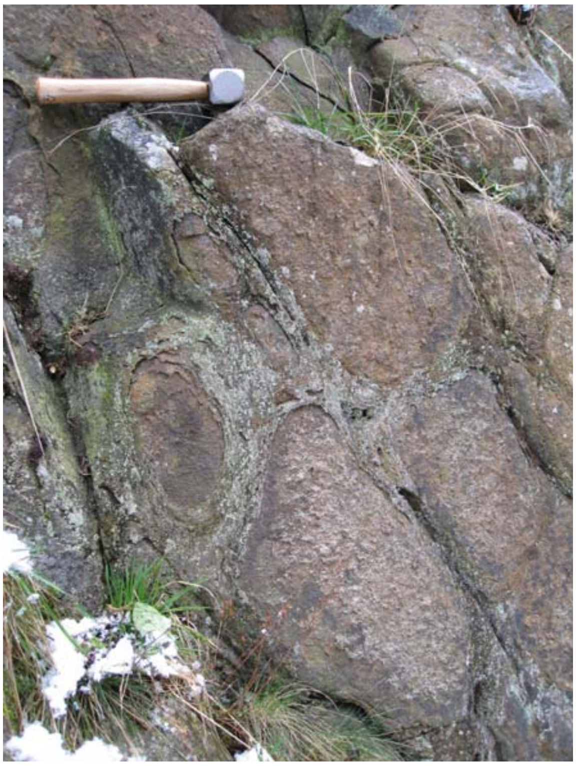

Photo 9: Good examples of spheroidal or 'onion-skin' weathering can be seen in the quartz-microgabbro.

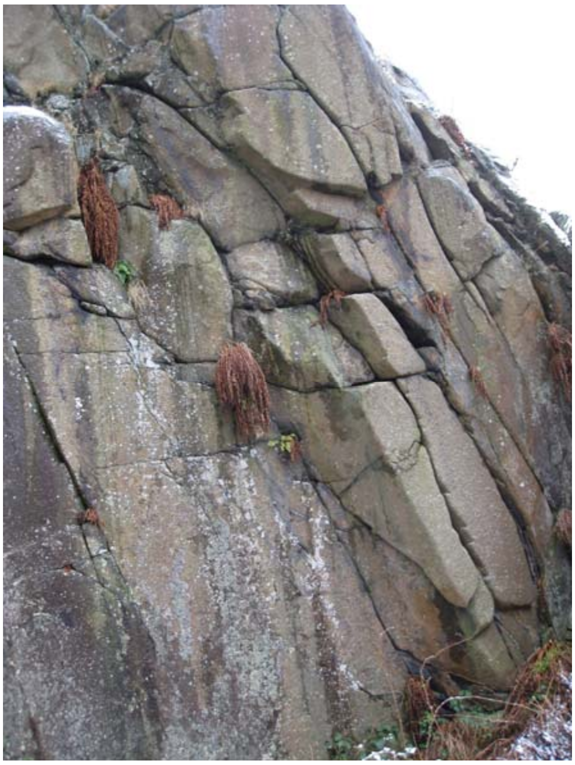

Photo 10: Widely spaced jointing in the quartz-microgabbro suggests that the quarry is located within the middle part of the intrusion which cooled slowly. Quarry face is approx 5m high. Looking NE

Photo 11: The resistance of igneous material to erosion means that it often forms high ground; Castle Hill is a typical example. The extensive views from the top of Castle Hill across the Kelvin valley are likely to be a primary reason for the Antonine Wall and the Iron-Age fort being positioned here.

EDC 3: Board Craigs Quarry, Twechar

Photo 12: Part of the quarry face exposing the quartz-microgabbro sill at Board Craigs. Looking SW

Photo 13: Well-developed sub-vertical columnar jointing in the quartz-microgabbro. Looking SSE

Photo 14: Rusty-coloured weathering of the quartz-microgabbro, resulting from the oxidation of the iron-rich minerals. Looking SSE.

EDC 3: Board Craigs Quarry, Twechar

Photo 15: Example of biological weathering where tree roots have exploited the joints in the quartz-microgabbro. As the roots grow and thicken, the blocks of rock are pushed apart and finally fall away from the face leaving the roots exposed. Looking S

Photo 16: Looking NNW from the escarpment formed by quarrying of the igneous intrusion over Twechar village to the snow-capped Kilsyth Hills in the distance.

EDC 3: Board Craigs Quarry, Twechar

Photo 17: Panorama over Twechar village allowing interpretation of the landscape features on both a local and regional scale. The snow-capped Kilsyth Hills and Campsie Fells in the distance are made up of volcanic rocks belonging to the Clyde Plateau Volcanic Formation. These igneous rocks are as a rule hard wearing and resistant to erosion, so that when our present-day landscape was being sculpted during the last ice-age they resisted erosion resulting in high ground. Conversely, the Kelvin Valley is largely underlain by relatively soft sedimentary rocks from the Clackmannan Group, which were preferentially eroded by the ice and now form low ground which is used by the River Kelvin.

EDC 4: Lenzie–Torphichen Dyke, Kirkintilloch

Photo 18: Looking SE from the footbridge over the Bothlin Burn. Claddens Dyke forms the high ground immediately left of the burn. The weir probably utilises a natural step in the burn where it passes over the more resistant igneous rock.

Photo 19: Small exposure on the north side of Lenzie–Torphichen Dyke. This igneous intrusion has a sub-vertical sheet-like form, and trends east-west for many kilometres across East Dunbartonshire. The intrusion cuts across the surrounding layers of sedimentary strata, and is termed a ‘dyke’. Looking SE.

EDC 4: Lenzie–Torphichen Dyke, Kirkintilloch

Photo 20: The dyke forms a natural barrier both above and below the ground. Topographically it forms a linear ridge across the countryside (as can be seen in the photograph), and below the surface it forms a barrier to the flow of water. View looking E.

Photo 21: Detail of the igneous intrusion, showing an exposure of well jointed quartz-microgabbro at the edge of the dyke. Here the molten rock chilled quickly when it came into contact with the surrounding colder 'country' rock', producing many internal fractures as it cooled and contracted. Looking N.

EDC 4: Claddens Dyke, Kirkintilloch

Photo 22: Degraded exposures of the dyke to the right of the track; probably the remains from a quarry which was formally located here. Note the ongoing construction work. Looking E.

Photo 23: Exposures of Lenzie–Torphichen Dyke adjacent to the construction work. Looking SE.

EDC 5: Meltwater Channel, Cadder

Photo 24: View looking SW across the meltwater channel, located northeast of Cadder.

Photo 25: Looking SE across the ‘U’-shaped base of the meltwater channel.

EDC 5: Meltwater Channel, Cadder

Photo 26: Panorama along part of the meltwater channel. Young crops and low sunshine often highlight such landforms within agricultural fields. The channel, which was cut by glacial meltwater, has been mapped out by geologists and is thought to be over 2km long.

EDC 6: Bardowie Loch, Bardowie

Photo 27: View looking NNW across Bardowie Loch from the village located to the southeast. The loch is surrounded by large rounded drumlins which were sculpted as glacial ice advanced across the area from the west to the east.

Photo 28: Looking ESE from the north shore of Bardowie Loch towards the sailing club.

EDC 6: Bardowie Loch, Bardowie

Photo 29: Shallow water along the northern edge of the loch has formed a wetland habitat for a variety of flora and fauna. Looking WSW.

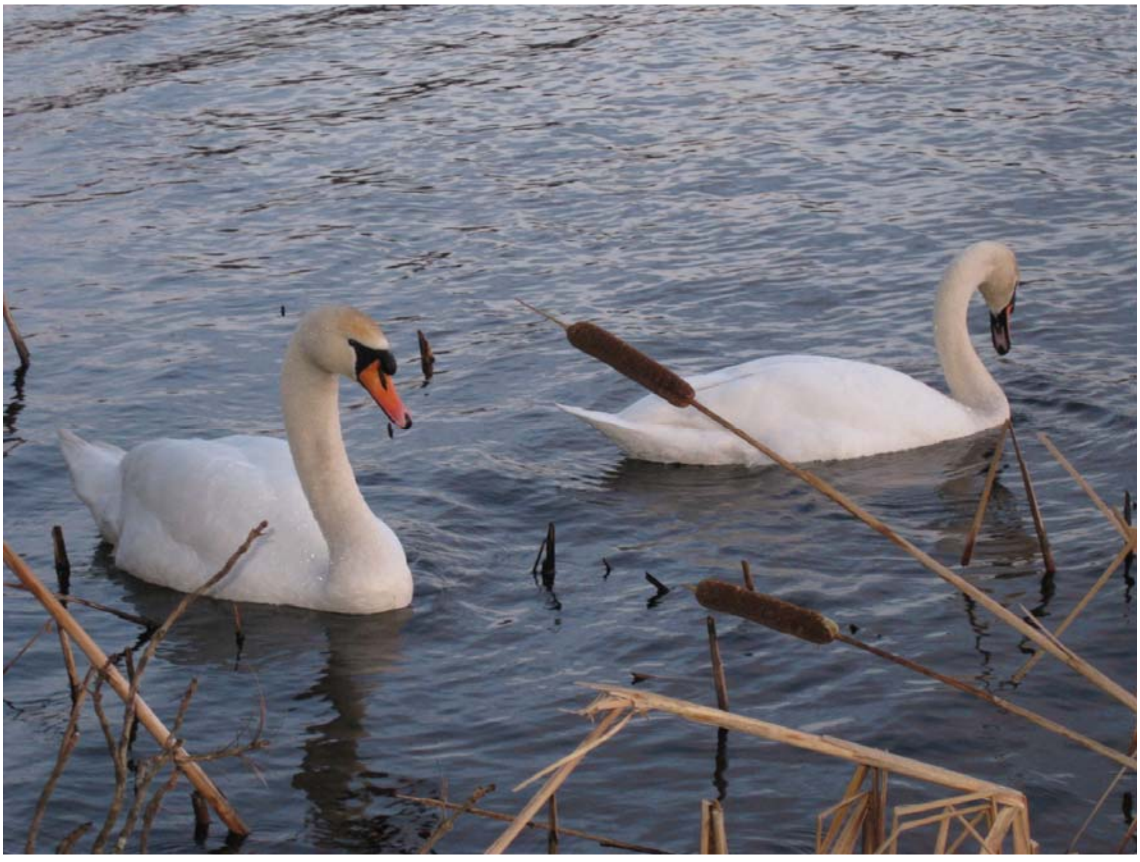

Photo 30: Swans on the loch. Looking S.

EDC 7: River Kelvin Meanders, Bearsden

Photo 31: Looking SW across a meander in the River Kelvin. The foreground contains fine-grained sediment deposited in the slow-moving inside curve of the meander. In contrast, the outside of the meander is subject to erosion and the far bank in the photograph displays the resulting small river-cliff.

Photo 32: A channel bar has formed in a prominent meander of the River Kelvin, creating an eddy in the waterflow (the water in the small channel to the left is flowing upstream). Looking E.

EDC 7: River Kelvin Meanders, Bearsden

Photo 33: Looking SW across a meander in the River Kelvin.

EDC 8: Kilmardinny Loch, Bearsden

Photo 34: View SW across Kilmardinny Loch. A good network of footpaths and seating encourages local residents and visitors to enjoy this geomorphological feature.

Photo 35: Shallow water at the edge of the inter-drumlin loch provides a wetland habitat for a variety of flora and fauna. Looking NNE from the western shore.

EDC 8: Kilmardinny Loch, Bearsden

Photo 36: Panorama across Kilmardinny Loch from the southeast shore.

EDC 9: Craigdhu Burn, Bearsden

Photo 37: Craigdhu Burn channelled underground. Looking SE.

Photo 38: Craigdhu Burn re-emerging. Looking WSW.

Photo 39: View W along the course of Craigdhu Burn which is now piped underground. Previous geological maps have recorded exposures of sedimentary rocks belonging to the Limestone Coal Formation containing 'Lingula' shell fossils, but these have now been landscaped and lost.

EDC 10: Manse Burn, Bearsden

Photo 40: General view looking ESE along the western end of the Manse Burn site.

Photo 41: Exposure of glacial till in the banks of the Manse Burn, at the western end of the site.

EDC 10: Manse Burn, Bearsden

Photo 42: Gently dipping sedimentary strata belonging to the Limestone Coal Formation, exposed in the base and banks of the Manse burn. Looking ESE.

Photo 43: Outcrop of black mudstones, part of the Limestone Coal Formation. Looking NE across the Manse Burn.

EDC 10: Manse Burn, Bearsden

Photo 44: Close-up of the exposed section of organic-rich black mudstones. Looking NE

Photo 45: Fossil shell fragments revealed when layers of the black mudstone are split apart. For many people, especially children, finding a fossil plant or animal that no person has ever seen can be a special experience.

EDC 10: Manse Burn, Bearsden

Photo 46: Iron-rich water issuing from the rocks into the burn. Looking SW

Photo 47: Abundant mudstone fragments recently turned over, probably by fossil hunters. Looking WNW.

Photo 48: Uncontrolled over-collecting of fossils, either by amateurs who store finds in their own private collections or professionals who sell finds to private collectors, could be the biggest threat to the geology of the Manse Burn site. Looking N.

EDC 11: West Mugdock Quarry, Mugdock Country Park

Photo 49: Site map for Mugdock Country Park, located at the visitor centre (northern part of the park).

Photo 50: Thickly-bedded sandstone units in West Mugdock quarry in the southern part of Mugdock Country Park. Looking S

Photo 51: Massive, coarse-grained 'gritty' sandstone containing scattered white and pink rounded quartz pebbles. Typical exposure of the Douglas Muir Quartz Conglomerate Member. Looking S.

EDC 11: Mugdock Quarry, Mugdock Country Park

Photo 52: Panorama of the southern part of Mugdock Quarry, showing the main sandstone faces now partially overgrown. The sandstone from this quarry was used to construct buildings in Milngavie. Most towns and villages in the area are likely to have obtained building stone from local quarries. Differences in the sandstones from quarry to quarry have resulted in buildings throughout the district having slightly different character. Today, stone for repairs is often imported from large quarries which is a poor match to the original quarry source. It is becoming increasingly important to record and where possible safeguard the remaining stone resources at historic quarry sites.

EDC 11: Mugdock Quarry, Mugdock Country Park

Photo 53: Information board located at the western end of Mugdock Loch, opposite Drumclog Moor car park. Looking SE

Photo 54: Close-up of the information board. There is no mention of geology/geomorphology despite this being a primary factor in the location, design and construction of the reservoir.

EDC 12: Barraston Quarry, Barraston Farm

Photo 55: Panorama across the old workings of Barraston Quarry, now partly flooded. Unfortunately only small degraded exposures remain and access is difficult through dense woodland which reduces the potential value of the site.

EDC 12: Barraston Quarry, Barraston Farm

Photo 56: View WNW along the flooded part of Barraston Quarry

Photo 57: Burnt shale waste piles are found to the north of the quarry. Looking NW

EDC 12: Barraston Quarry, Barraston Farm

Photo 58: An ironstone band forms a resistant horizon within the layers of laminated black mudstones, creating a lip for a small waterfall. Looking SW

Photo 59: Section through laminated black mudstones with several rusty-coloured ironstone bands. Looking SW

EDC 12: Barraston Quarry, Barraston Farm

Photo 60: The main face at the western end of the quarry, comprising a series of degraded sections through black mudstones. Looking SW.

Photo 61: A superb example of a striated (glacially scratched) boulder, found in the burn entering Barraston quarry from the northwest. It has probably been washed out of a glacial till deposit. Looking SE.

EDC 13: Blairskaith Quarry, Blairskaith

Photo 62: Panorama across Blairskaith Quarry from the northern edge. This former brick clay pit exposes the Blackhall Limestone and adjacent black mudstones of the Lower Limestone Formation.

EDC 13: Blairskaith Quarry, Blairskaith

Photo 63: Small-scale faulting is highlighted by an offset ironstone band with a thick sequence of laminated black mudstones. Looking NE.

Photo 64: Ironstone nodules of various sizes can be found lying around the quarry, weathered out of the rock face. Most of these are of iron-carbonate composition and some show ‘septarian’ structures (internal shrinkage cracks infilled with mineral precipitate, usually calcite).

EDC 13: Blairskaith Quarry, Blairskaith

Photo 65: A fallen block displaying desiccation cracks. The network of ridges on the surface represent infilled cracks which formed as a layer of mud dried out when the sediments were originally deposited.

Photo 66: A fallen block displaying a variety of fossils.

Photo 67: Pale coloured ‘coprolites’ (fossilised faecal pellets) within dark mudstones, each containing shiny black fish scales. The size and composition of the coprolites suggests that they are likely to have come from a large predator such as a shark.

EDC 13: Blairskaith Quarry, Blairskaith

Photo 68: Fallen block of fossiliferous 'crinoidal' limestone. Most of the fragments visible to the eye are small crinoidal columns which weather proud of the fine-grained lime matrix. The presence of crinoidal fragments suggests that this limestone was formed in fully marine conditions.

Photo 69: Fallen block displaying a good example of 'stigmaria', the fossilised root of a tree. The tiny round holes scattered across the surface of the root are thought to be where smaller rootlets were attached.

Photo 70: Fallen block displaying relatively rare examples of 'Ulodendron majus', fossilised fragments of tree bark. The central circular to oval depressions are thought to represent the scars where branches or cones were attached.

EDC 14: Auld Wives' Lifts, Craigmaddie Muir

Photo 71: View looking NW across the sandstone blocks which form the Auld Wives' Lifts, with the Strathblane Hills in the background.

Photo 72: The Auld Wives' Lifts are composed of three large sandstone blocks that sit in a natural amphitheatre on Craigmaddie Muir. The origin of the feature is unclear; some people believe the blocks may have been positioned by man, whilst others think it is the result of nature. Looking NE.

EDC 14: Auld Wives' Lifts, Craigmaddie Muir

Photo 73: Looking SE across a quarried sandstone face.

Photo 74: Looking NE at a sub-vertical cylindrical drill hole from the extraction of the sandstone

Photo 75: One of many thick-bedded sandstone units which has been worked in the area. It is thought that the stone was mainly used for building local dry-stone walls, dragged across the moors by horses pulling wooden sledges. Some records also suggest it was used for millstones. Looking N.

EDC 14: Auld Wives' Lifts, Craigmaddie Muir

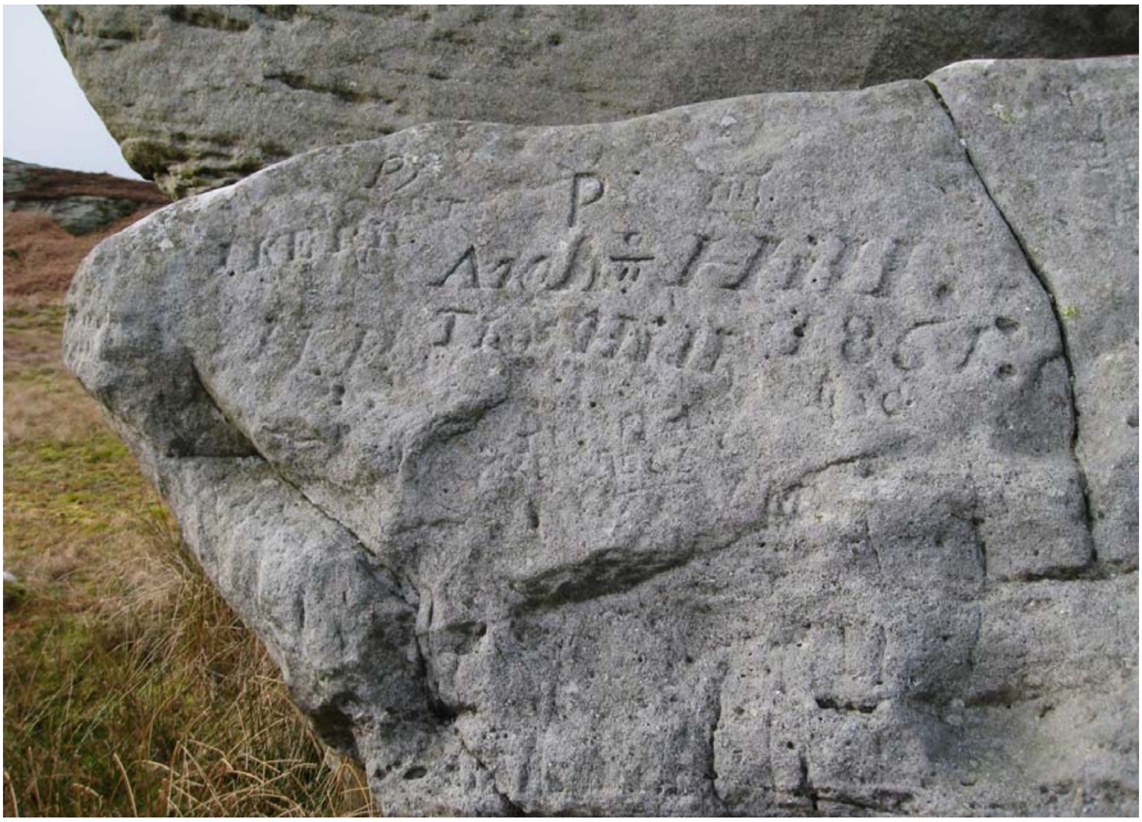

Photo 76: Graffiti carved into the sandstone blocks making up the Auld Wives' Lifts. Names, initials, dates and pictures can be seen dating back at least two centuries, although it is thought that some of the carvings date from much earlier. Looking NW.

Photo 77: Laminations at an angle to the main layering within a sedimentary rock is known as cross-bedding. The lowermost unit of sandstone in the photograph shows an example of this sedimentary structure, which results from the action of the river currents which carried and then deposited the sand grains millions of years ago.

EDC 14: Auld Wives' Lifts, Craigmaddie Muir

Photo 78: Part of the sandstone escarpment which surrounds the Auld Wives Lifts. The rock face is one of the few in the area which appears to be naturally weathered, without any signs of having been worked. Looking NW.

Photo 79: Above and behind the main rock escarpment, sandstone is exposed at the surface in a number of places across Craigmaddie Muir. Several of these surfaces have been smoothed and display abundant parallel scratches/grooves known as glacial striae. These were formed by boulders trapped in the bottom of a glacier which were dragged across the landscape as the ice sheet advanced forwards. The orientation of the striations can therefore be used to indicate the direction of the ice flow. On Craigmaddie Muir glacial ice moved from the NW to the SE.

EDC 14: Auld Wives' Lifts, Craigmaddie Muir

Photo 80: Panorama from the sandstone escarpments close to the Auld Wives' Lifts. The cultivated fields are located on an elongated ridge called a drumlin, sculpted by ice which advanced towards the SE. There is also a smaller 'parasitic' ridge along the near (northern) side of the drumlin. Drumlins vary in size; this example is approximately 700m by 300m.

EDC 15: Gallow Hill, Milton of Campsie

Photo 81: Panorama of Gallow Hill illustrating the undulating form of the sand and gravel mound. The volcanic Kilsyth Hills are in the distance to the NW. The sand and gravel was deposited at the end of the last ice-age by meltwater streams issuing from glaciers retreating in a northwest direction towards the main Highland ice-sheet. The name Gallow Hill comes from a site to place gallows, and it is recorded that as late as 1639 Lord Kilsyth hanged one of his servants here.

EDC 15: Gallow Hill, Milton of Campsie

Photo 82: Gravel point-bar forming on the inside of a meander in the Galzert Water. A river-cliff can be seen forming on the opposite side where water the bank has been undercut. Looking SW.

Photo 83: Cobbles transported downstream lodged against a larger boulder on the point bar are stacked up in the direction of river flow in a process known as imbrication. This example of a modern-day sedimentary process, can help geologists to determine the 'palaeo' flow direction in ancient sedimentary rock deposits. Looking NW.

EDC 16: Finniescroft Wood, Lennoxtown

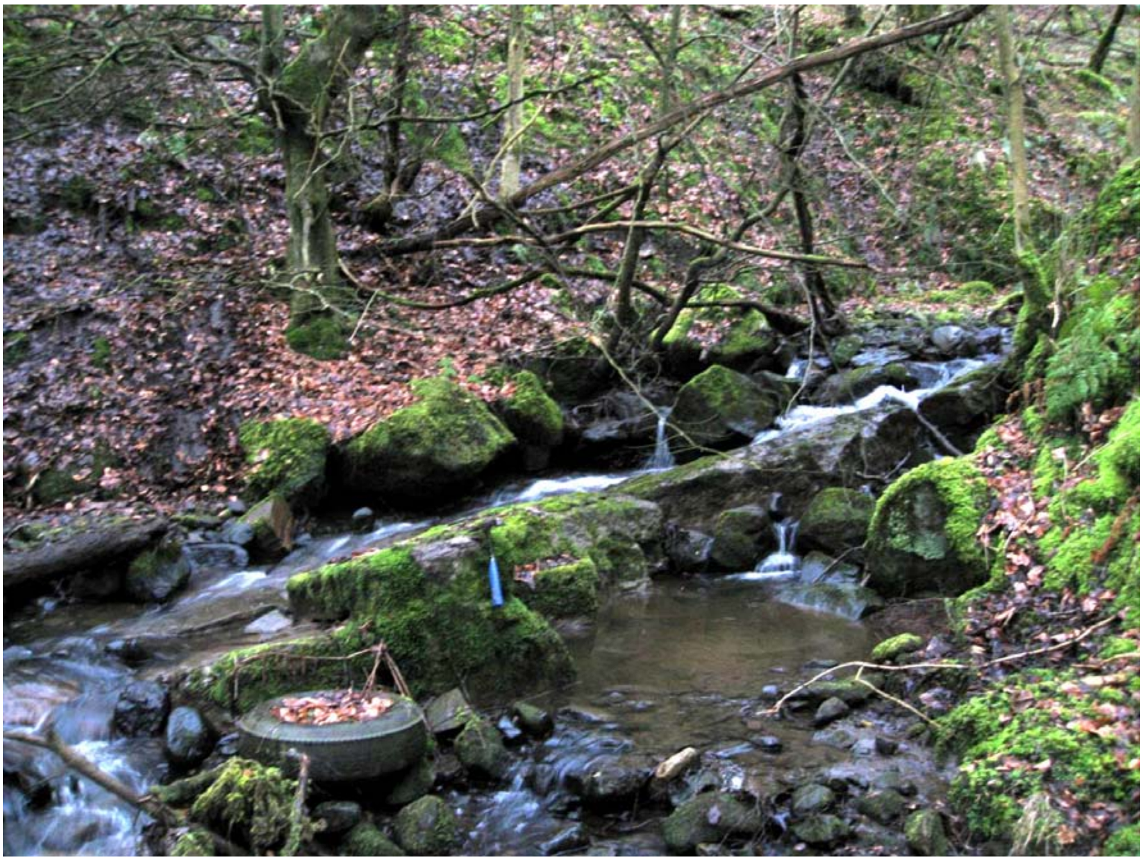

Photo 84: Beds of crinoidal limestone outcropping in the stream. Looking SW.

Photo 85: A more resistant limestone bed forms a small waterfall in the stream. Looking WSW.

Photo 86: Iron-rich water issuing from the bank-side. Looking SSE

EDC 17: Pattie’s Bughts, Craigend Muir

Photo 87: Looking SSW up the trackway leading from Pattie’s Bughts quarry (on the horizon) to Craigend Farm and the railway beyond. The quarry is thought to have supplied stone for the construction of the railway.

Photo 88: Fallen block displaying an excellent example of the fossilised plant root ‘stigmaria’. The pitted surface represents where individual rootlets were attached.

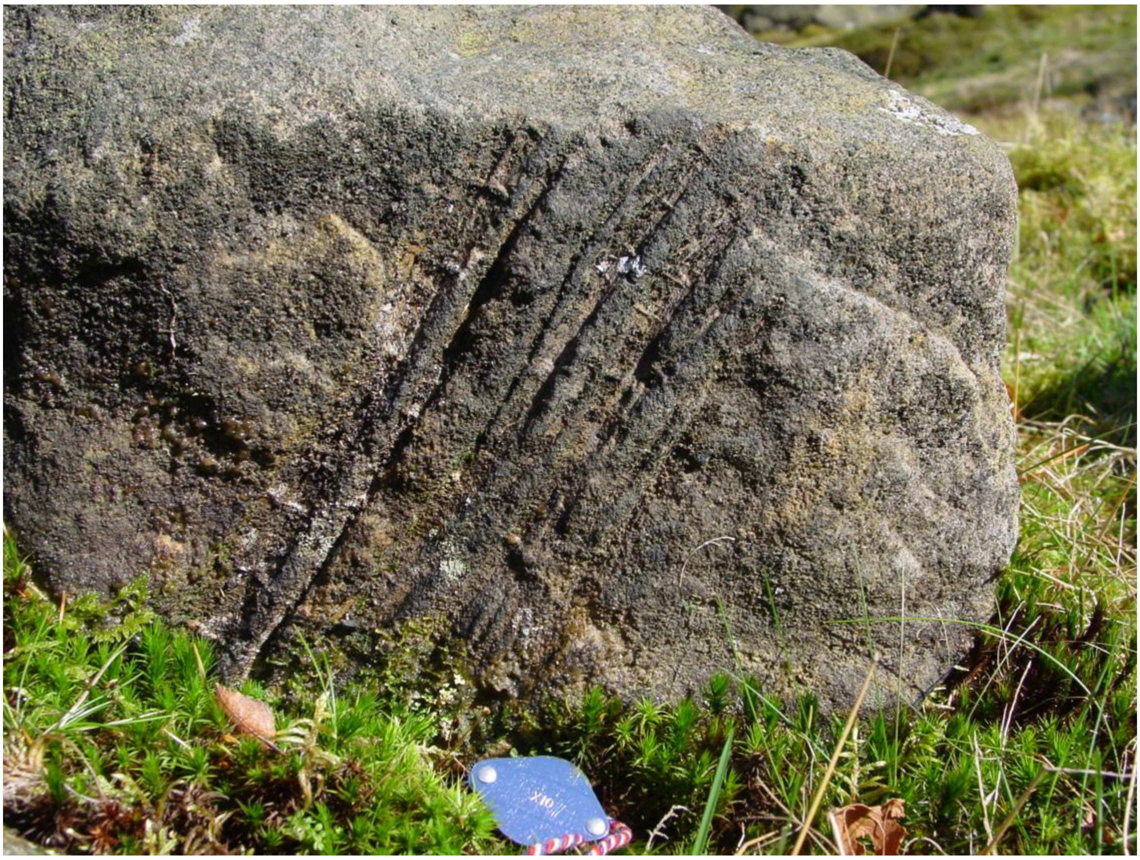

Photo 89: A fallen block displaying an example of Lepidodendron, a fossilised tree trunk. The markings on the stone are the equivalent of the bark on a modern-day tree.

EDC 17: Pattie's Bughts, Craigend Muir

Photo 90: View from the edge of the quarry looking NW to the Strathblane Hills. The remains of buildings in the foreground probably represent a workmen's hut or similar, built from waste quarry material.

Photo 91: Thick-bedded sandstone units, up to 4 m high, would have provided a good sized block of sandstone for making building stone. Many of the discarded blocks on the quarry floor show plant fossils. Looking NW.

EDC 17: Pattie's Bughts, Craigend Muir

Photo 92: Road bridge over the old Blane Valley Railway line. Stone for the bridge was likely sourced from Pattie's Bughts Quarry.

Photo 93: Detail of the sandstone masonry used to build the road bridge over the railway. Looking WNW.

EDC 18: Crow Road, Lennoxtown

Photo 94: Looking W across to one of the largest landslips near Sloughmuclock. On retreat of the glaciers, steep unstable slopes were left along the southern slopes of the Campsie Fells. In places these have collapsed to form major landslides.

Photo 95: Looking NE at a major landslip on the southern slopes of the Campsie Fells. The cliff-like backwall of the landslide is within the lava flows of Carboniferous age that make up the Clyde Plateau Volcanic Formation. Mounds of fragmented fallen rock lower down the slope can clearly be seen. The Crow Road can be seen along the bottom of the photograph.

EDC 18: Crow Road, Lennoxtown

Photo 96: Close-up of large angular blocks of basaltic lava scattered across the hillside resulting from the catastrophic landslide. The slopes are now largely vegetated, suggesting there has been no recent movement. Looking NNE towards the backwall scar higher up the hillside.

Photo 97: Small outcrop of 'Lennoxtown essexite' on the southern slopes of the Campsie Fells. The distinctive appearance and rare occurrence of this rock type makes this an important geological locality in the UK. The geographical extent of the essexite, suggests that the intrusion represents a volcanic plug. Looking N towards the backwall of the landslide.

EDC 18: Crow Road, Lennoxtown

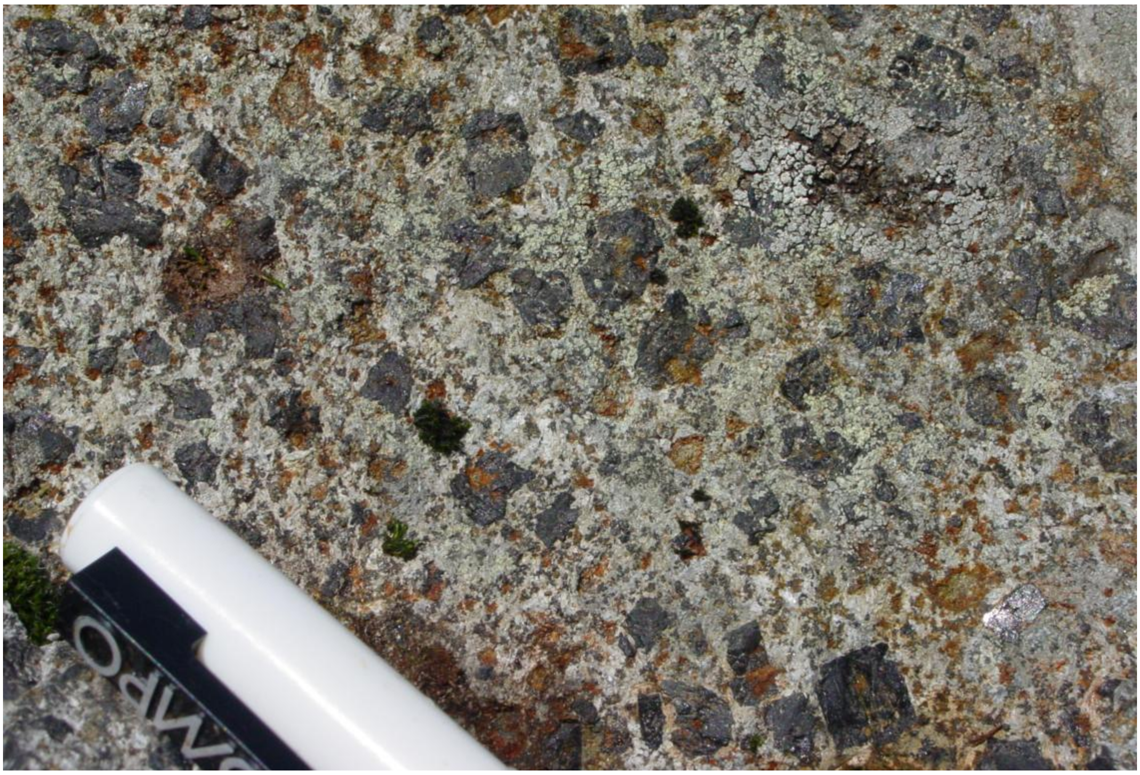

Photo 98: Close-up of the surface of a weathered outcrop of Essexite, showing a 'porphyritic' texture with large (up to 16mm) black augite crystals standing out from a fine-grained, pale-coloured groundmass which is dominantly composed of plagioclase feldspar.

Photo 99: Essexite has proven to be a valuable aid to identifying the direction of ice movement during the last ice age. As ice advanced over the outcrop, pieces of essexite were frozen to the base of the glacier and carried for some distance before being then dropped 'downstream' of their origin. Due to the distinctiveness and rarity of essexite, boulders found across the landscape can be linked back to this site, and the direction of ice movement determined. Fragments of this rock have been found as far as 20km to the east, confirming that the main movement of ice from the Loch Lomond area was towards the east, and that there must have been a major glacier travelling eastwards from Blanefield, through Lennoxtown towards Kilsyth and Falkirk, scouring the valley into the shape we see today. Looking S.

EDC 19: Campsie Glen, Clachan of Campsie

Photo 100: Close-up of the map / information board located at the bottom of Campsie Glen. The glen is regarded as a classical geological locality; it is one of only 2 sites in East Dunbartonshire published in the Glasgow Geological Society Excursion Guide for the area, and was undoubtedly visited by geologists in the early 1900's. The board highlights the natural and cultural history of the area, but unfortunately there is no geological information about how the rocks have influenced the shape of the landscape, the different geological features visible in the Glen, or how the existence of certain rock types were fundamental for local industries. The formation of the Glen is related to the retreat of glaciers back towards the Highlands, when vast amounts of meltwater caused massive erosion and the formation of gorges such as that seen today at Campsie Glen.

Photo 101: View looking NE across the remains of a rectangular 'bleach pool', associated with the former textile industry which developed as a result of the alum works near Lennoxtown. The industry existed in this area due to the presence of alum shale as part of the local geology.

EDC 19: Campsie Glen, Clachan of Campsie

Photo 102: The lower part of the Campsie Glen is underlain by the Ballagan beds, composed of dark coloured mudstones alternating with beds of cementstone (muddy dolomitic limestone). Here the beds are cut by a pale-coloured, carbonated igneous dyke, the line of which is displaced by a fault, tilting the Ballagan beds to a steep angle. Ten metres upstream, away from the fault, the Ballagan beds can be seen in both river banks at a low angle. Looking W.

Photo 103: A prominent waterfall in the burn is caused by the presence of doleritic dyke which forms a resistant barrier compared to the more easily eroded sedimentary rocks downstream belonging to the Ballagan Formation. At low water the structure of the dyke reveals a complex story of multiple intrusions. Looking W.

EDC 19: Campsie Glen, Clachan of Campsie

Photo 104: At the confluence with the Aldessan Burn the upper part of the Ballagan Formation can be examined; the pale-coloured cemenstones can clearly be seen alternating with the darker mudstone layers. Approximately 20m higher up the sequence these sedimentary rocks are overlain by lava flows belonging to the Clyde Plateau Volcanic Formation. Looking WNW.

Photo 105: Looking through the trees, towards the skyline, a larger waterfall can be made out. This has formed where the Aldessan Burn flows over the lowermost lava flows of the Clyde Plateau Volcanic Formation. Looking NW.

Photo 106: A sign warning walkers that the upper part of the Campsie Glen is susceptible to rockfalls. Continuing weathering and erosion of the steep unstable slopes makes the glen a risk to those who venture beyond this point. Looking NE.

EDC 19: Campsie Glen, Clachan of Campsie

Photo 107: View looking E from the confluence of the Aldessan Burn. The lower two-thirds of the valley side is composed of sedimentary rocks belonging to the Ballagan Formation. The craggy upper part of the slope displays the lowermost 3 or 4 lava flows of the Clyde Plateau Volcanic Formation. The flows, each several metres thick, form a series of rocky ribs along the valley sides. The flows are often separated by a grassy ledge where softer material has been eroded away.

Photo 108: Close-up of a series of elongate hollow ‘vesicles’ within a basaltic lava flow of the Clyde Plateau Volcanic Formation. When magma is erupted the molten rock often contains gas bubbles which, on contact with the cold air, become ‘frozen’ in the rock before they can escape. These are known as vesicles.

EDC 20: Cowies Glen, Milton of Campsie

Photo 109: An example of the sedimentary sequence seen in Cowies Glen, through the Lower Limestone Formation. Looking SE.

Photo 110: Close-up of fossilised ripples found on the upper surface of a layer of sandstone, exposed in the Waltry Burn.

Photo 111: A fault exposed in the western bank of the burn. The line of the fault, which cuts through steeply dipping strata, can be seen running from the top right to the bottom left of the photograph. Movement must have occurred along this fracture in the rocks to bring together the black mudstones visible ‘beneath’ the fault and the sandstones ‘overlying’ the fault. The iron-rich staining seeping out of the fault zone shows that fluid movement preferentially occurs through fractures in the rocks. Looking SW.

EDC 20: Cowies Glen, Milton of Campsie

Photo 112: A sub-horizontal bed of sandy limestone in the Lower Limestone Formation forms a small waterfall near the confluence of Burniebrae Burn and Spouthead Burn. Looking NE.

Photo 113: An outcrop of coal from the Upper Limestone Formation, exposed in the bank of Cowies Glen. Coal was an important resource in the past and few places still exist where it can be found naturally occurring at the surface. Looking NW.

EDC 20: Cowies Glen, Milton of Campsie

Photo 114: Close-up of a limestone bed containing small light-coloured fossil crinoid fragments. Black pen top for scale.

Photo 115: Warning signs in the upper part of Cowies Glen. Looking NE.

Photo 116: Warning signs in the upper part of Cowies Glen. Looking NE.

EDC 20: Cowies Glen, Milton of Campsie

Photo 117: Exposure of glacial till in the bank of the Waltry Burn, typically fine-grained containing a scattering of pebbles, cobbles and boulders. This material has been transported, deposited and over-ridden by moving glacial ice. Despite covering large areas of East Dunbartonshire there are few places where a good section through till can be observed. Looking E.

Photo 118: Where the burn cuts through more resistant sandstone beds, the water has cut a narrow channel and a series of rapids have formed. A ‘pot-hole’ has also developed, carved out by the scouring and grinding effect of trapped pebbles as they are rotated in a swirling eddy of water. Looking ENE.

EDC 21: Burniebrae Burn, Shields Farm

Photo 119: View from Shields Farm looking NNE up to the waterfalls in Burniebrae Burn. The lower ground is underlain by sedimentary rocks belonging to the Lower Limestone Formation and Limestone Coal Formation. The higher ground is underlain by more resistant igneous rocks belonging to the Clyde Plateau Volcanic Formation. The waterfall is located on a fault which separates the two units.

Photo 120: A series of smaller waterfalls have formed as the burn flows across the Limestone Coal Formation, highlighting variations in the underlying sedimentary rocks. The formation consists of a series of sedimentary cycles, consisting mainly of mudstones, siltstones and sandstones. The more resistant sandstone beds form the caps to the waterfalls. Looking N.

EDC 21: Burniebrae Burn, Shields Farm

Photo 121: A typical sedimentary cycle in the Limestone Coal Formation seen in the bank of the Burniebrae Burn. The cycles, which average between 5 and 10m thick, usually consist of soft black mudstones at the base, passing upwards into siltstones and sandstones (generally the thickest unit). Looking NE.

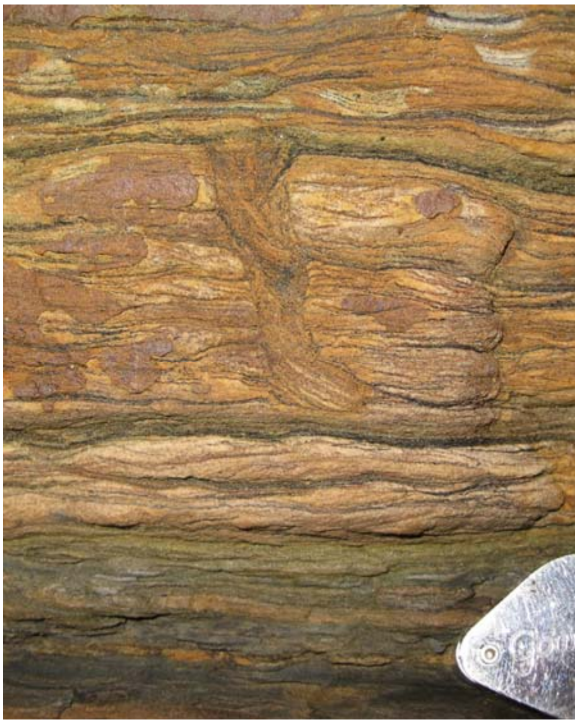

Photo 122: Close-up of a sub-vertical burrow, in fine-grained horizontally laminated sandstone. This illustrates where an animal has moved through the unconsolidated sediment soon after deposition, disrupting the ripple laminations.

Photo 123: A fallen block from the Limestone Coal Formation, showing the impression of a tree branch, probably Lepidodendron, indicating the presence of substantial vegetation during the time of deposition.

EDC 21: Burniebrae Burn, Shields Farm

Photo 124: Panorama of the southern edge of the basaltic rocks making up the Clyde Plateau Volcanic Formation, represented by the waterfall. Looking NE.

EDC 21: Burniebrae Burn, Shields Farm

Photo 125: Close-up of mineralised joints (thin white infilled cracks) near the fault which separates the sedimentary rocks of the Lower Limestone Formation and the igneous rocks of the Clyde Plateau Volcanic Formation.

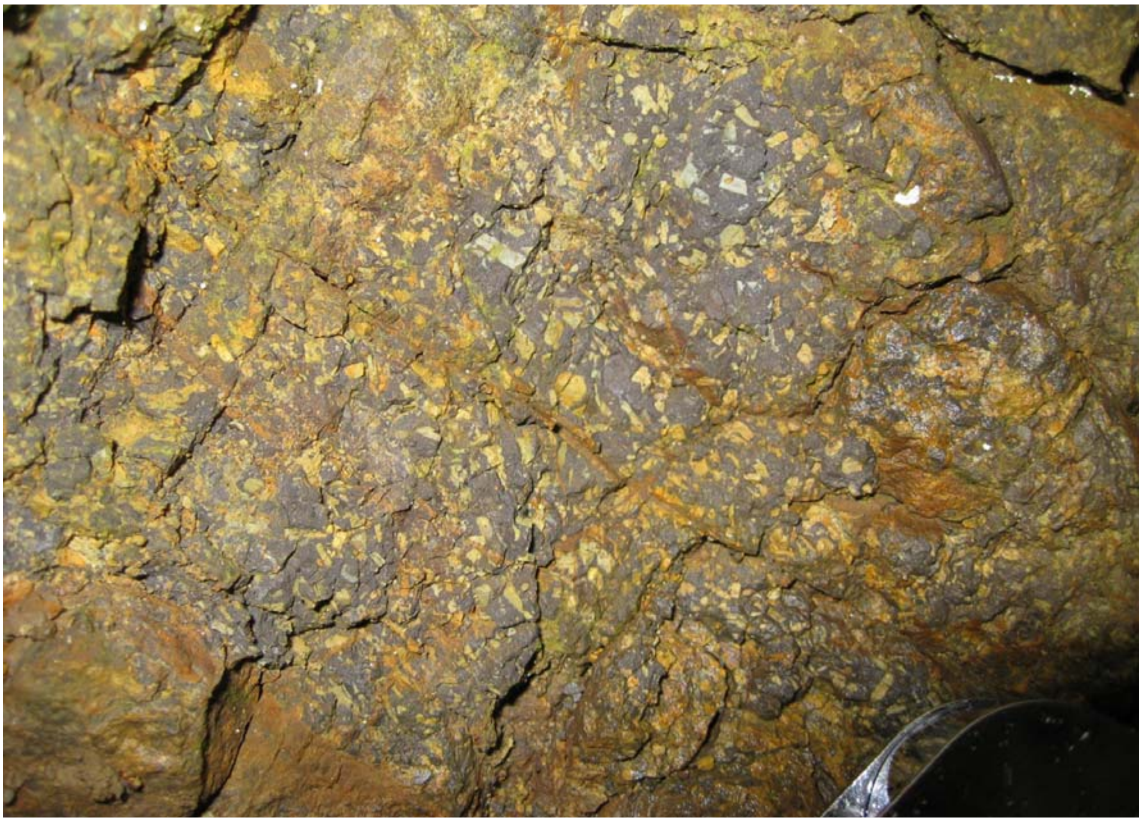

Photo 126: Close-up of volcanic tuff, displaying fine-grained ash (purple) and crystals (white) which were ejected from a volcano. Found in the banks of BurnieBrae Burn near the waterfall.

EDC 21: Burniebrae Burn, Shields Farm

Photo 127: Sequence of black mudstones overlying the Top Hosie Limestone. The limestone forms a ledge at the base of the weir. Note that this sequence is stratigraphically the same as that at Manse Burn where the fossil sharks were discovered. Looking E.

Photo 128: Close-up of the black mudstone which overlies the Top Hosie Limestone. The patchy yellow staining, seen when the rocks are split along bedding planes, is caused by the presence of sulphur minerals.

EDC 22: Spouthead Burn, Spouthead Farm

Photo 129: View looking N up the Spouthead Burn. The waterfall in the foreground is caused by a more resistant sandstone bed within the Lower Limestone Formation sedimentary sequence. The main waterfall in the distance is formed from an igneous intrusion

Photo 130: Close-up of the fine-grained, pale-coloured felsite which is found at the main waterfall in the Spouthead Burn. The felsite forms one of a number of igneous intrusions in the area.

EDC 22: Spouthead Burn, Spouthead Farm

Photo 131: The felsite intrusion forms a prominent scarp along the hillside. Looking N.

EDC 22: Spouthead Burn, Spouthead Farm

Photo 132: A cementstone bed from the Ballagan Formation can be observed in the burn above the waterfall. Looking NNE.

Photo 133: Basaltic rocks belonging to the Clyde Plateau Volcanic Formation, found in the upper part of the Spouthead Burn.

EDC 23: Douglas Muir Quarry, Milngavie

Photo 134: Quarried cliff displaying a section through the Douglasmuir Quartz-Conglomerate Member (basal Lawmuir Formation). The east wall section shows mudstone beds and a lower percentage of conglomerate to sandstone, with lenticular bedding. Looking ENE.

EDC 23: Douglas Muir Quarry, Milngavie

Photo 135: Quarry face displaying a section through the Douglasmuir Quartz-Conglomerate Member (basal Lawmuir Formation). Note the conspicuous channel base in the mid-upper face, east wall near north end (view from north).

Photo 136: Quarry face displaying a section through the Douglasmuir Quartz-Conglomerate Member, basal Lawmuir Formation. East wall section showing more persistent mudstone beds and lower percentage of conglomerate to sandstone. Note lenticular bedding.

EDC 23: Douglas Muir Quarry, Milngavie

Photo 137: Quarry face in the Douglasmuir Quartz-Conglomerate Member (basal Lawmuir Formation), showing mainly sandstone deposited on mudstone and conglomerate. View east of remnant west wall, closer detail of section.

Photo 138: Close-up of loose blocks showing rounded clasts of white and pink vein quartz and quartzite up to 6 cm in diameter. Blocks have come from the Douglasmuir Quartz-Conglomerate Member.

EDC 23: Douglas Muir Quarry, Milngavie

Photo 139: Large fossil tree found at conveyor section of the quarry, now in garden at site offices. Fossil is located within the Douglasmuir Quartz-Conglomerate Member.

Photo 140: Former quarrying in the Douglasmuir Quartz-Conglomerate Member (basal Lawmuir Formation), showing heather and exposed rock restoration, with former quarry faces marked by blocks.

EDC 24: Roman Baths, Bearsden

Photo 141: View across the remains of the Roman bath-house at Bearsden. Viewed from west side.

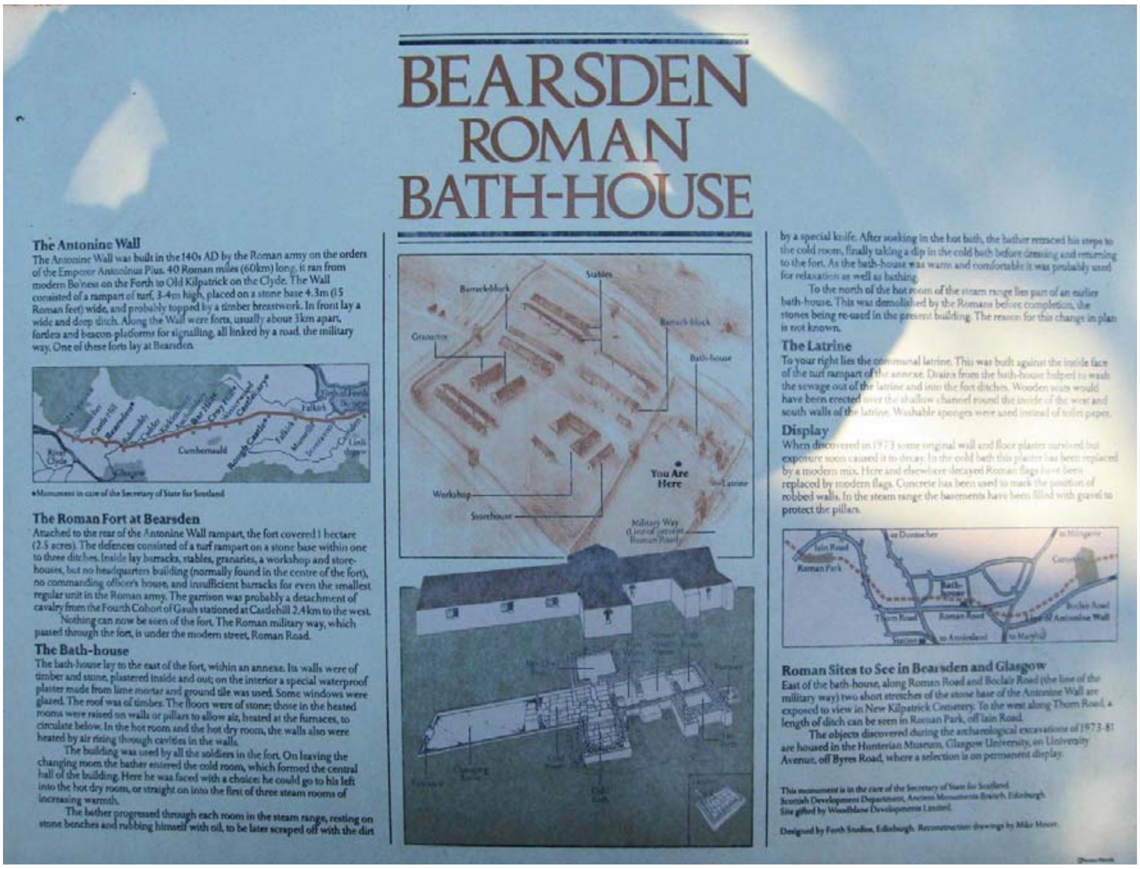

Photo 142: Existing interpretation board at the Roman bath-house. There is no mention of the materials used for building.

EDC 24: Roman Baths, Bearsden

Photo 143: View across the stone remains of the Roman bath-house. The buildings appear to have been constructed mainly from local Carboniferous sandstones.

Photo 144: Close-up of the original flagstone paving at the Roman bath-house, which displays fossilised ripples.

EDC 25: Linn of Baldernock, Blairskaith

Photo 145: Outcrops in the Branziet Burn show that microgabbro sills have intruded between the sedimentary rocks belonging to the Lower Limestone Formation forming a series of waterfalls, or 'linns'. The waterfall section displays a sub-horizontal sill at the top (approx 3m thick), beneath which are cavities from abandoned workings where the Baldernock Limestone has been mined. Underneath the limestone lie layers of sandstone, limestone and black shales. Looking NNE.

Photo 146: Close-up of brown tufa deposits on the lower lip of the waterfall. Calcium carbonate deposits form as lime-rich waters plunge over a cliff. The water is aerated and carbon dioxide is released, resulting in the water becoming supersaturated with calcite which consequently precipitates as calcium carbonate onto the rocks below.

EDC 25: Linn of Baldernock, Blairskaith

Photo 147: View from inside the old 'stoop and room' workings located behind the waterfall. Limestone was an important resource in Central Scotland and even thin seams were often mined. The Baldernock Limestone is about 1-1.5m thick. The 'stoops' (pillars) supporting the roof can still be seen, while the limestone was extracted from the 'rooms'. The mine extends a short way beneath the sill and is well preserved, but wet and muddy underfoot. Entering the mine should not be encouraged.

Photo 148: View inside the limestone mine, showing a variety of cave formations or speleothems. These are formed as acidic water dissolves small amounts of limestone rocks, as it flows through cracks or joints into a cave. As the water comes into contact with the air, the carbon dioxide escapes and the water can no longer hold as much dissolved calcium. The excess calcium is precipitated on the cave walls, floor and ceiling. Speleothems form very slowly, taking around 50 years for 1cm of material. Examples of speleothems in the mine include stalactites, stalagmites, draperies, rimstone dams and cave pearls. Most of these features are at an early stage in their development and appropriate conservation must be applied to protect them.

EDC 25: Linn of Baldernock, Blairskaith

Photo 149: Stalagmites are probably the best known cave formations. They are upward-growing mounds deposited as calcite is forced out of the water by agitation as a droplet hits the floor. Their shape is determined largely by drip rate, ceiling height, cave atmosphere conditions, and the carbonate chemistry of the drip water. Many stalagmites can be dated due to the presence of naturally occurring radioactive isotopes which has allowed dating of associated paleontological and archaeological finds, as well as holding a record of past climates.

Photo 150: 'Draperies' can be seen on some overhanging surfaces in the mine where surface tension has allowed calcite-rich solutions to cling to a wall or sloping ceiling as they stream slowly downward. The supersaturated solutions deposit a thin trail of calcite, which, hanging slightly lower than the surrounding surface, becomes a preferential route for continued flow, and so develops into slender, delicate sheets.

Photo 151: Delicate 'soda straws' can be found hanging from much of the mine roof. They have formed as water seeps down from the surface and drops to the floor, leaving a tiny deposit of dissolved calcite on the ceiling. This deposit is in the shape of a ring which, as more water droplets come through, forms a small, hollow tube which hangs from the ceiling. In time, this will develop into a much larger stalactite.

EDC 25: Linn of Baldernock, Blairskaith

Photo 152: A rare and beautiful example of a cave pearl nest. 'Cave pearls' are concretions found in shallow cave pools, which form when water dripping into the pool loses carbon dioxide and precipitates calcite. Unusually, these pearls are not cemented onto the pool floor, which may be due to vibrations in the pool caused by the dripping water. Excess precipitate has formed a cup or nest around the pearls.

Photo 153: The shape, size and colouring of cave pearls differs from one cave to another. However, they all have a similar concentric internal structure, which is formed as calcite continuously precipitates around a nucleus. The 'pearls' collected in the mine appear to have a piece of dark-coloured gravel at their core which is surround by white calcite. These examples are between 0.5cm and 2cm in diameter. The roundness typical of cave pearls is due to the uniform growth of the pearl.

EDC 25: Linn of Baldernock, Blairskaith

Photo 154: Superb examples of rimstone dams (or gours). These are mineral barriers, usually of calcite which pond streams or shallow pools in caves.

Photo 155: Rimstone dams usually form where there is a slope underground with a flow of water, which creates a series of steps or terraces over the surface, or can form many tiny micro-gours on horizontal surfaces.

Photo 156: Crystallization of a gour begins to occur at the air/water/rock interface. The turbulence caused by flow over the edge of the ridges may contribute to the outgassing or loss of carbon dioxide from water, resulting in precipitation of mineral on this edge.

EDC 26: Craigangawn Quarry, High Craigton

Photo 157: View looking WSW towards the main quarry face which displays a complete section through the neck of a volcanic vent. The vent, of Lower Carboniferous age, may have been a source of the local Clyde Plateau Volcanic Formation lavas and cuts through fine ash and basaltic rocks of a similar age. This site is of particular importance as it not only displays the material found both within and outside the vent, but also illustrates the geometry of the vent. The educational value of the site would be greatly enhanced by the removal of the trees at the base of the section which obscure the best views (such as the one above) of the funnel-shaped neck of the vent. Otherwise the site is accessible and remarkably well exposed.

EDC 26: Craigangawn Quarry, High Craigton

Photo 158: View looking ENE from the top of the main quarry face showing the safe and accessible nature of the site. From here views can be seen across Strath Blane to the hills beyond, and of the 'trap' topography in the Clyde plateau Volcanic Formation lavas behind the site, on the lower slopes of the Kilpatrick Hills.

Photo 159: View looking NNW across the main quarry face which exposes the agglomerate within the volcanic vent. In the distance, to the right of the picture, a basaltic plug displays well-developed columnar jointing.

EDC 26: Craigangawn Quarry, High Craigton

Photo 160: Outcrops of porphyritic basalt which are thought to represent a volcanic plug adjacent to the main vent. Looking NNE.

Photo 161: Well developed, curved columnar jointing in the porphyritic basalt forming the volcanic plug. The fractures form as the hot magma internally contracts on cooling. The joints generally develop perpendicular to the top of the magma body. Looking NNE.

Photo 162: Close-up the porphyritic basalt making up the volcanic plug. The very dark grey surface is freshly exposed and shows the true nature of the rock. The lighter brown surfaces are characteristic of a weathered basic igneous rock, as the iron- and magnesium-rich minerals in the rock oxidise.

EDC 26: Craigangawn Quarry, High Craigton

Photo 163: View of the main quarry face, displaying the agglomerate which infills the volcanic vent. The vent material is not well cemented and is constantly falling. Care should be taken close to the face.

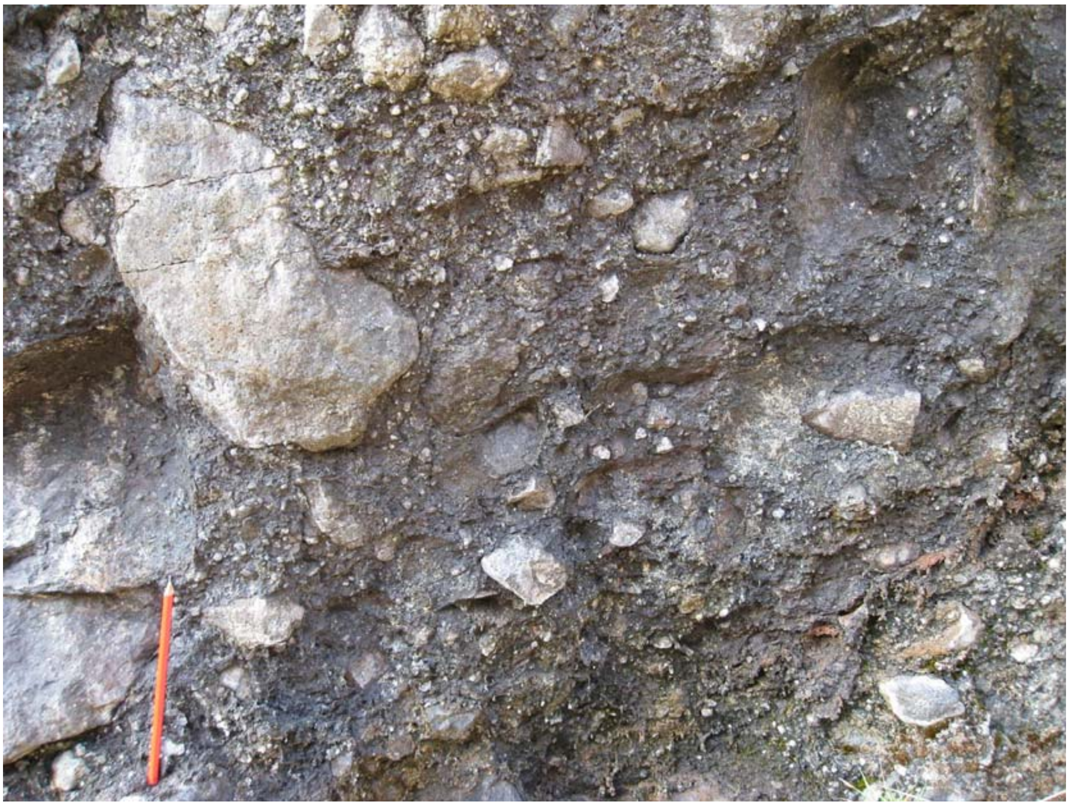

Photo 164: Close-up of the poorly sorted vent agglomerate, containing boulders up to 2 m in size.

EDC 27: East Mugdock Quarry, Mugdock Country Park

Photo 165: Panorama of one of the larger quarries in the Mugdock Country Park, which displays a thick sandstone unit from the Lawmuir Formation overlain by an igneous sill of late Carboniferous to early Permian age. Looking E.

EDC 27: East Mugdock Quarry, Mugdock Country Park

Photo 166: The contact between the thick sandstone unit belonging to the Lawmuir Formation and the overlying microgabbro sill is indicated by a ledge. Looking N.

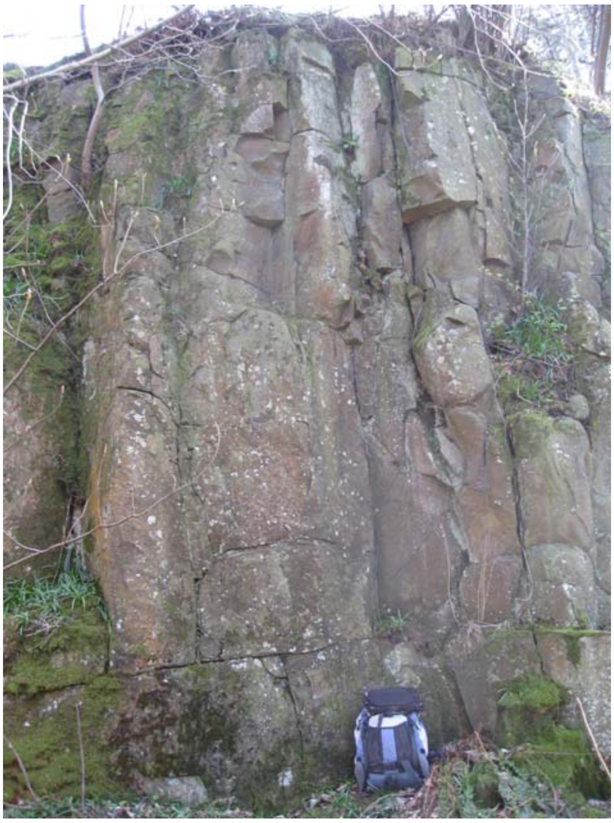

Photo 167: Vertical columnar jointing has formed within the sill as the magma cooled and contracted.

Photo 168: Spheroidal weathering of the microgabbro blocks making up the sill.

EDC 27: East Mugdock Quarry, Mugdock Country Park

Photo 169: A path leading away from the quarry overlooking the reservoir. The sandstone has been chiselled away to leave a smooth vertical face. Looking NW.

Photo 170: Close-up of the chisel marks on the surface of the sandstone cliff

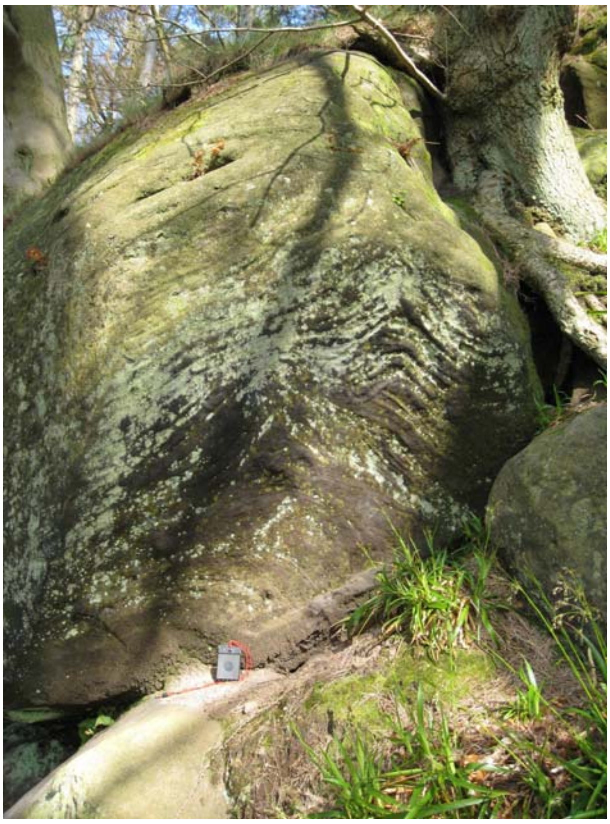

Photo 171: Close-up of convolute bedding displayed in some of the sandstone blocks adjacent to the path

EDC 27: East Mugdock Quarry, Mugdock Country Park

Photo 172: House lying between the reservoir and the sandstone quarries likely to have been constructed of local sandstone from the Lawmuir Formation, showing how the local geology has been used as a resource.

Photo 173: The gauge basins at the northern tip of the reservoir are likely to have been constructed using locally quarried sandstone. The reservoir is popular with walkers, runners and bikers and an additional interpretation board explaining the geology of the area and how it has been used for locating, designing and constructing the reservoir could be well received.

EDC 28: Baldernock Mill, Baldernock

Photo 174: View looking SSW taken from just south of Baldernock Mill. The river cliff exposes a jointed alkali microgabbro sill of late Carboniferous to early Permian age which intrudes sedimentary strata of the Lawmuir Formation.

Photo 175: Close-up of the contact between the microgabbro sill and the underlying sedimentary rocks. Microgabbro, as with most igneous rock, is relatively resistant to erosion and here displays few joints which could be exploited by weathering agents, resulting in an overhang. In contrast, the underlying sedimentary rocks are fine-grained and thinly bedded, and easily eroded by flowing water. The ledge forming near the water level contains a bed of crinoidal limestone. Note the step in the base of the intrusion (towards the left-hand edge of the picture) this may be referred to as ‘transgression’, where a flat intrusion moves up from one level to a different level in the country rock.

EDC 28: Baldernock Mill, Baldernock

Photo 176: A millstone lying against the side of Baldernock Mill, which was used when the building was a grain mill (pre 1875) before it was turned into a saw mill. The source of the stone is unknown, although there are records which suggest that the sandstones of Craigmaddie Muir were exploited for millstones.

Photo 177: Baldernock Mill, built from local sandstone during the16th century, included a brick kiln in the basement for drying the grain before milling. The present wheel, seen above, is 18ft in diameter with 48 steel buckets.

Photo 178: The water supply for Baldernock Mill came from a dam 250yds upstream; running through a tunnel beneath the road to reach the mill, seen above. The mill was largely restored in the 1970's after falling into disrepair.

EDC 29: Inchbelle Quarry, Kirkintilloch

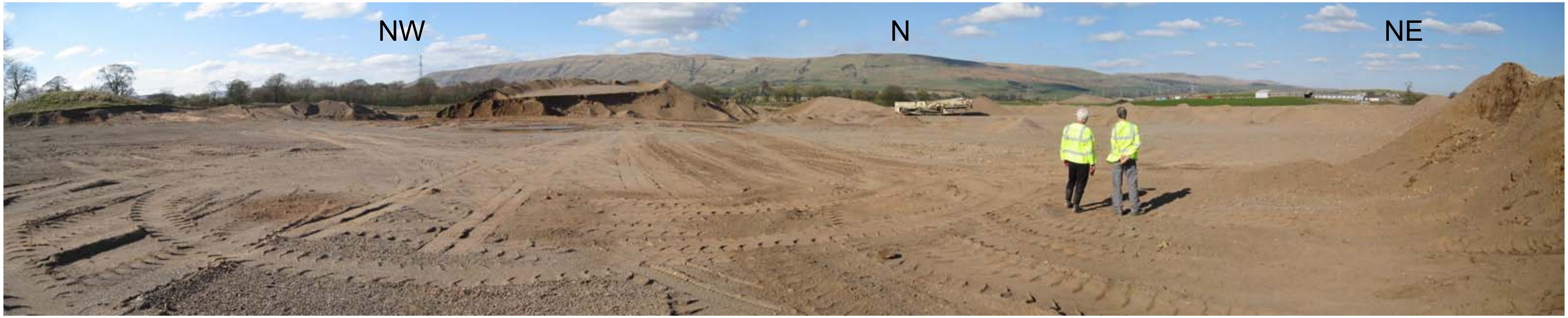

Photo 179: Panorama across the active area of the quarry, with the Campsie Fells and Kilsyth Hills in the distance. The quarry is exploiting the glaciofluvial sand and gravels belonging to the Broomhouse Formation. Across the area the deposit is only a few metres thick and is generally composed of gravels overlying a unit of sand.

Photo 180: The contact between the gravel and underlying sand unit can be clearly seen in small sections at the north-eastern edge of the quarry (partly infilled). The sand is generally medium- to coarse-grained and displays very gently dipping layers to the east. These layers are seen to be truncated by the erosive base of the gravels. Approx 70 cm of gravel is seen in this section, and the ill-defined bedding suggests a transport direction towards the east. Looking NW.

EDC 29: Inchbelle Quarry, Kirkintilloch

Photo 181: Exposures in the upper gravel unit, seen along the north eastern edge of an area which is partly infilled. The section displays up to 4 m of sandy gravel. Looking ENE

Photo 182: Close-up of the gravel unit seen in the figure above. The gravels are fairly poorly sorted, generally ranging between 5 cm and 15 cm in diameter mixed with medium- to coarse-grained sand. All the clasts are rounded to well rounded and are of various lithologies. Looking NNW.

EDC 29: Inchbelle Quarry, Kirkintilloch

Photo 183: Exposure in the lower sand unit at the southern edge of the active quarry (the upper gravel unit has been removed). On this visit approximately 1m of bedded medium- to coarse-grained sand with fine gravel was exposed. Looking east.

Photo 184: Close-up of the lower sand unit, displaying the structure in the sand. The cross-sets suggest an easterly transport direction. Looking south.

EDC 29: Inchbelle Quarry, Kirkintilloch

Photo 185: View looking ENE towards Bar Hill. As the sand and gravel is only a few metres thick here, areas become worked-out fairly quickly. The quarry owners, thinking ahead, have plans to expand to the area southeast of Inchbelle Farm (middle distance). The superficial geological map suggests there are further sand and gravel deposits here. Worked areas will be landfilled or landscaped accordingly, although will probably leave no exposures for future reference.

Photo 186: Areas previously quarried are now being infilled, and remaining sections at the edges will be permanently covered. Preserving these sections would allow people to see a rarely exposed part of the stratigraphy, which is part of the glacial history of the area. Looking SE.

EDC 30: Craigen Glen, Upper Carlestoun

Photo 187: Fine-grained, yellowish sandstone unit, approximately 1-1.5 m thick ,in the Lawmuir Formation. Beneath this lies approximately 2 m of mudstone, seen in burn below. Looking SE.

Photo 188: Close up of the fine-grained, yellowy ochreous weathered sandstone, containing plant fragments and trace fossils.

EDC 30: Craigen Glen, Upper Carlestoun

Photo 189: View upstream of the lower waterfall in 2-4 m of bedded grey mudstones belonging to the Lawmuir Formation. Looking NW.

Photo 190: Thin limestone bands (approximately 10 cm thick) and nodules in the bedded grey mudstones of the Lawmuir Formation. Looking NE.

EDC 30: Craigen Glen, Upper Carlestoun

Photo 191: View looking SW from a bing of burnt mudstone at the mouth of Craigen Glen towards the old workings.

Photo 192: Close-up of the burnt mudstone on a bing from workings of ?Hurlet Coal etc.

EDC 30: Craigen Glen, Upper Carlestoun

Photo 193: Possible adit beneath a 1.5 m exposure of yellow fine-grained sandstone belonging to the Lawmuir Formation. Looking ENE.

Photo 194: New fencing above the lower waterfall in Craigen Glen makes access to the geology difficult.

EDC 31: Wilderness Plantation, Buchley

Photo 195: View looking westwards across the former sand and gravel pit and landfill site at Wilderness Plantation.

EDC 31: Wilderness Plantation, Buchley

Photo 196: View towards main section of the Wilderness Till Formation overlying the Cadder Sand and Gravel Formation. Access to the site is not easy; the section is degraded and slips into stagnant pools beneath. Despite this, it is a very important site, showing the relationship between these units, and with some clearing of the main face could be improved greatly. Looking SW.

Photo 197: View along the main face which since being actively quarried has become degraded. Only the reddish consolidated glacial till of the Wilderness Till Formation is visible towards the top of the section, the underlying deposits of the Cadder Sand and Gravel Formation can no longer be seen. Looking WSW.

EDC 31: Wilderness Plantation, Buchley

Photo 198: Small exposure of sand near the base of the quarry face, thought to belong to the Cadder Sand and Gravel Formation which underlies the Wilderness Till Formation. Typically such deposits of sand make good dwelling places for rabbits. Looking east.

Photo 199: View along the main face. The reddish consolidated glacial till belonging to the Wilderness Till Formation is visible in the upper part of the section. The degraded slope below the exposure is steep and slippery. Looking East.

EDC 31: Wilderness Plantation, Buchley

Photo 200: The Wilderness Till Formation is a hard, reddish brown, sandy, silty glacial till with isolated boulders and smaller stones. Note the inclined shear joints dipping to the west in this part of the section. The material was laid down beneath the ice sheet which covered the area during the Dimlington Stadial, approximately 27,500-13,500 years before present. At its maximum the ice is thought to have been over 1 km thick in Central Scotland. Looking south.

Photo 201: Close-up of the Wilderness Till Formation, showing fractures in the over-consolidated glacial till.

Photo 202: Close-up of the Wilderness Till Formation, showing the nature of the matrix of the glacial till; sandy with scattered gravel.

EDC 32: Cawder Quarry, Cadder

Photo 203: Panorama across the former sand and gravel quarry at Cawder, which formerly exploited the Cadder Sand and Gravel Formation. No exposures of these sediments are known today.

EDC 33: Bishopbriggs No2 Gravel Pit, Torrance

Photo 204: View looking SE towards the former faces at the southern edge of Bishopbriggs No 2 sand and gravel pit. Records, from the time when the pit was active, describe a section 40 foot high, consisting of “sand, with fine gravel near the top and silt layers towards the base”. These sands are thought to have a deltaic origin and have therefore been assigned to the Ross Formation. The deltas formed during deglaciation; as the ice retreated westwards down the Kelvin Valley meltwater issuing from the remaining glaciers on higher ground transported and deposited large volumes of sediment. Cross-sets previously described in this pit confirm an easterly transport direction for the sands. The meltwater flowed into the ice-dammed ‘Lake Kelvin’, which no longer exists, and the sands were deposited in deltas located at the edge of the lake.

EDC 34: Baldow Glen, Lennoxtown

Photo 205: View towards the bing at the former colliery at Newlands from the car park on the gated road. Looking east.

Photo 206: Close-up of the bing at the former colliery at Newlands.

EDC 34: Baldow Glen, Lennoxtown

Photo 207: Snatch quarry for track bases. The quarry is in sandstone with siltstone and mudstone beds belonging to the Lower Limestone Formation above the Blackhall Limestone. View looking southeast towards the small section displaying a fault.

Photo 208: Close-up of a small eastward trending fault in the snatch quarry, cutting through sandstone with siltstone and mudstone beds of the Lower Limestone Formation.

EDC 34: Baldow Glen, Lennoxtown

Photo 209: Small stream section displaying mudstones overlying a thin coal seam on top of seatclay with backfill of old workings to the left. The units are likely to be the Hurlet Coal and the Alum Shale. The sedimentary sequence is thought to belong either to the top of the Lawmuir Formation or basal part of the Lower Limestone Formation.

Photo 210: Close-up of laminated mudstones overlying a thin coal seam with closely spaced cleat on seatclay; possibly representing the Hurlet Coal and Alum Shale.

EDC 34: Baldow Glen, Lennoxtown

Photo 211: Stream outcrop of bedded crinoidal limestone. Blackhall Limestone, Lower Limestone Formation.

Photo 212: Close-up of the bedded crinoidal limestone. White flecks are crinoidal fragments. Blackhall Limestone, Lower Limestone Formation.

Photo 213: Small river bank section through mudstones with reddish brown ironstone beds, Lower Limestone Formation above the Blackhall Limestone.

EDC 35: Glenwynd, Blairskaith Muir

Photo 214: Circular depression likely to have formed from the collapse of a mine shaft or similar mining feature.

Photo 215: Abandoned sandstone lined 2m diameter shaft.

EDC 35: Glenwynd, Blairskaith Muir

Photo 216: Small adit and waterfall with crinoidal limestone in foot below part of Balgrochan Beds, Lawmuir Formation. The waterfall lip is possibly Baldernock Limestone or hard sandstone from immediately below this unit.

Photo 217: Faulted (easterly trend and southerly downthrow) base of larger waterfall in sandstone with mudstone on crinoidal limestone in hanging wall; Balgrochan Beds, Lawmuir Formation.

EDC 35: Glenwynd, Blairskaith Muir

Photo 218: Loose block displaying load casts ('pillows') in sandstone, found near the circular ?shaft collapse.

Photo 219: Section in new drainage ditch revealing dark grey glacial till (Wilderness Till Formation) with one large boulder, southwest of Newlands.

EDC 36: Torrance Meanders (River Kelvin)

Photo 220: Aerial view of three remnant meanders, abandoned when the River Kelvin channel was artificially straightened.

Appendix 2 Carboniferous Lithostratigraphy

INTRODUCTION

East Dunbarton lies in the Midland Valley of Scotland between the Highland Boundary Fault to the north and the Southern Upland Fault to the south. The Midland Valley is considered to be a displaced 'terrane' emplaced in its present relationship with the Highlands and Southern Uplands by large-scale sinistral strike-slip movement during the end-Silurian to mid-Devonian interval. Since then the Midland Valley has been a north-east- to south-west-orientated complex basin down faulted between the Highlands and the Southern Uplands.

All rocks at outcrop in East Dunbartonshire are Carboniferous in age (Map 1, Vol. 1). The oldest belong to the Tournaisian and Visean Series and consist of sedimentary and basaltic volcanic rocks. Subaerial volcanic activity was widespread in the Midland Valley in Lower Carboniferous times. A large area of basaltic lava occurs at outcrop in the Campsie Fells. Eruption of these volcanic rocks in the area ceased in the Visean, but persisted elsewhere well into the Namurian. The geological succession in East Dunbartonshire is given in Table 1, Vol. 1).

The sedimentary strata consist principally of sandstones and mudstones with relatively minor proportions of limestone, coal and ironstone. They were deposited as part of a very extensive fluviodeltaic system which occupied most of north-west Europe during the Carboniferous. Sediment was carried from Caledonian mountains to the north and deposited at or near sea level in a differentially subsiding basin. Early Carboniferous strata (Tournaisian) were deposited, in part at least, under lagoonal, lacustrine and coastal plain conditions. Cyclic sedimentation, including the deposition of seams of economically valuable coal, lasted from the Visean through the Namurian to the Westphalian (late Carboniferous). Periodic marine incursions brought about the deposition of thin but widespread limestones mainly in the late-Visean Lower Limestone Formation and in the Namurian Upper Limestone Formation. A period of uplift and erosion in the source area and within the Midland Valley brought about mainly fluvial deposition during late-Namurian Passage Formation times, temporarily replacing the fluviodeltaic processes. Marine incursions were brief and largely confined to the lower part of the formation.

Two main episodes of basaltic intrusion are known in the district. Most of the intrusive igneous rocks are quartz-microgabbros which occur as sills as well as east-west dykes. The sills are a major component of the **Midland Valley Quartz-microgabbro Sill-swarm** (formerly known as the Midland Valley Sill-complex), which is part of the North Britain Late-Carboniferous Tholeiitic Suite. The Sill-swarm was intruded at around 305 million years ago, at the very end of the Carboniferous Period and underlies some 1920 km^2 of the eastern Midland Valley. The suite is generally accepted as being of late Westphalian to Stephanian age. There are no extrusive equivalents.

Alkali-microgabbro sills, probably contemporaneous in age to Visean and Namurian volcanic rocks, are present. These basic sills are assigned to the **Scotland Carboniferous – Permian Alkaline Suite** (formerly referred to as the Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite). They were intruded into sediments that were still wet and at least partially unlithified. They are similar to the volcanic rocks in chemical composition.

Various small intrusive igneous bodies are intimately linked to the extrusion of the lavas of the Clyde Plateau Volcanic Formation including microgabbro, olivine basalt, trachybasalt, trachyte and felsite.

After deposition of the Carboniferous sediments, they were lithified deeply buried, lithified and then folded and faulted. The Kilsyth Trough Syncline is the most prominent fold. Faulting took place particularly on east-west trends. The Campsie Fault is the most important and its presence is reflected in the landscape by the escarpment of the Campsie Fells.

Little is known of the geological history of the district during the interval between Carboniferous times and the Quaternary although it is thought that marine rocks of the era of the dinosaurs (Jurassic and Cretaceous) were probably present but subsequently destroyed by erosion. During the Quaternary the entire region was overwhelmed by glaciers, probably on more than one occasion. The overall west to east movement of the ice is recorded in the erosional effects on the higher ground and in the orientation of the elongate features in the ‘ground moraine’ as drumlin hills.

INVERCLYDE GROUP

The oldest Carboniferous rocks in the Midland Valley of Scotland belong to the **Inverclyde Group**. It comprises the **Kinnesswood**, **Ballagan**, and **Clyde Sandstone formations** These formations are characterised by sandstone with pedogenic (soil profile) carbonate concretions (calcrete) and by silty mudstones containing thin beds of dolostone (cementstone) and limestone; also the absence of carbonaceous rocks especially coal seams. They were laid down between 345m and 355m years ago (Tournaisian; Courceyan to earliest Chadian Stage). The Inverclyde Group was laid down whilst Scotland lay in low latitudes south of the Equator. At this time, the climate was generally considered to be semi-arid and seasonally wet. It is because of the semi-arid climate that the sandstone-dominated Kinnesswood Formation contains calcareous and dolomitic pedogenic (soil profile) horizons (calcrete) and the overlying Ballagan Formation is characterised by ferroan dolostone (cementstone), and evaporite (mainly gypsum).A rather discontinuous vegetational cover of the land surface was probably the norm. Neither the Kinnesswood Formation nor the Clyde Sandstone Formation occur at surface in East Dunbarton and are not further described.

The **Ballagan Formation** is characterised by grey mudstones and siltstones, with nodules and beds of ferroan dolostone (cementstone), the beds generally less than 0.3 m thick. Gypsum, and to a much lesser extent anhydrite, and pseudomorphs after halite occur. Desiccation cracks are common and the rocks frequently show evidence of brecciation. Both these features are associated with reddening of the strata. Thin sandstone beds are commonly present. Where present, the restricted fauna is characterised by the bivalve *Modiolus latus*, but ostracodes are more abundant along with Estheriids and Sprirorbids. The formation is locally absent, but between 20 m and 160 m thick.

The Ballagan Formation is interpreted as being laid down in coastal alluvial plains, lakes and marginal marine flats. These were subject to periodic desiccation with fluctuating salinity partly as a result of seawater being introduced by storm flooding events. The open sea lay to the east initially. Later it is more evident to the south of the Midland Valley of Scotland with the more marine faunas in the `cementstones' being found in the Solway Firth Basin. The lack of sulphide in the mudstones and the sourcing of the magnesium and calcium ions in the cementstones has been explained by the limited events of seawater inundation of the alluvial plains and its lakes. Argillaceous limestone is present where lakes were deep enough to avoid post-burial dolomitisation. The inundations in general left no marine faunal record but provided a strong geochemical signal in the sulphate evaporites, ferroan dolostones and Strontium isotopes. Because of the dominance of the siliciclastic component over the evaporitic, it has been concluded that the formation was laid down in a humid environment subject to drier periods of evaporation rather than a generally arid one.

STRATHCLYDE GROUP

The Strathclyde Group is a varied sequence of rocks, sedimentary and volcanic, characterised by the presence of carbonaceous beds, including coal and oil-shale. They were laid down between 345m and 326m years ago (Visean; earliest Asbian to Brigantian Stages). The group is largely fluviatile and lacustrine in origin, with a few marine incursions from time to time. The base of the Strathclyde Group is taken at the base of the Clyde Plateau Volcanic Formation (340 million years ago). Strathclyde Group strata consist of interbedded sandstone, siltstone and mudstone with common seatearths, coal seams and sideritic ironstone. Deposition of the Strathclyde Group marks a lithological change from concretionary limestone and dolostone-bearing strata typical of the Inverclyde Group to a coal-bearing sequence in which volcanic rocks may be common. The local Strathclyde Group strata are assigned to the **Clyde Plateau Volcanic**, **Kirkwood** and **Lawmuir** formations.

The palaeoclimate during deposition of the Strathclyde Group was mainly humid (coals, oil-shales and sideritic mud grade palaeosols) but the presence elsewhere in East Scotland of calcretes and calcareous mudstones (‘marls’) in the West Lothian Oil-Shale Formation point to periods of semi-arid climatic conditions through Asbian Stage times. Regular orbitally forced glacio-eustatic sea-level oscillations started abruptly around 330Ma (early Asbian) with a 100Ka periodicity and that these characterised the late Palaeozoic from then on. Prior to this time pre-Asbian climates were relatively stable with infrequent changes. Fluctuations in climate occurred during glacial sea level lowstands. It is only in the Brigantian (Raeburn Shell Bed and younger marine beds) that any marine cycles are seen in the Strathclyde Group that might be associated with such a systematic mechanism.

Palaeocurrent flow in the Strathclyde Group is generally from the north throughout and Argon/Argon ages on detrital muscovites appear to link the flow direction with a source of the detritus in Scandanavia. This source area remained a major topographic high and supplied sediment to Scotland for over 100Ma because of post-orogenic uplift and exhumation events.

The **Clyde Plateau Volcanic Formation** consists of lavas, tuffs and volcaniclastic sedimentary rocks that were produced by one, short-lived major episode of subaerial volcanic activity about 340 million years ago. The lavas are mildly alkaline and show a wide range in composition. The basic rocks are mostly hypersthene-normative with a few being silica-undersaturated nepheline-normative. The more fractionated rocks are all hypersthene-quartz-normative in composition. In the Kilpatrick - Campsie - Gargunnock blocks, the sequence is dominated by *plagioclase*-phyric hawaiites, *plagioclase*-phyric basalts are less abundant and *clinopyroxene*-phyric types are uncommon. The base of the formation is normally sharp, representing a gentle but irregular unconformity. The unit is about 400 m thick. Dykes related to this volcanic activity belong to the **Midland Valley Carboniferous to Early Permian Alkaline Basic Dyke Suite**; volcanic necks and plugs are assigned to the **Southern Scotland Dinantian Plugs and Vents Suite**.

The **Kirkwood Formation** consists of dark reddish brown to greenish grey tuffaceous mudstones and tuffs erosively overlying the basaltic lavas of the Clyde Plateau Volcanic Formation. The formation is locally intercalated with non-tuffaceous sedimentary rocks. Largely formed by the reworking of materials derived from the underlying volcanic rocks, some direct air-fall tuffs may be present. The Kirkwood Formation shows extensive subaerial weathering and lateritisation, the products of a period of intense tropical weathering. The formation is usually 15 m or so thick.

The **Lawmuir Formation** consists of a sequence of mudstones, siltstones and sandstones with rooted seatrocks, coals and limestones. In the north of Glasgow around Milngavie, the lower part of the formation is dominated by sandstone with a local development of quartz conglomerate (**Douglas Muir Quartz-Conglomerate Member**) and quartz-rich sandstone, the **Craigmaddie**

Muir Sandstone Member. In the south of Glasgow around Paisley, sandstone is interbedded with thick, poorly-bedded siltstones and mudstones (including calcareous mudstones = marls of older literature) with a few thin coals. The lower part of the formation is essentially fluviatile in origin, the facies including channel, floodplain, lake and mire. The upper part of the formation is partly arranged in cycles, with marine incursions represented by beds including thin limestones (**Dykebar**, **Hollybush** and **Blackbyre**). A lacustrine limestone (**Baldernock Limestone**) also occurs near the top of the sequence and was deposited in 'Loch Baldernock'. In East Dunbarton the Hollybush Limestone is represented by the **Craigenglen Beds** and the Blackbyre Limestone by the **Balgrochan Beds**. The formation is about 250 m thick.

CLACKMANNAN GROUP

The **Clackmannan Group** includes the **Lower Limestone**, **Limestone Coal**, **Upper Limestone** and **Passage formations**. These units are characterised by strongly cyclical sequences of sandstone, siltstone, mudstone, limestone, coal and seatearth, the presence (or absence especially of limestone) and proportions differing in each of the formations. Thus, beds of limestone are more conspicuous in the Lower and Upper Limestone formations than elsewhere, coals are most common in the Limestone Coal Formation, and sandstones and seatearths are the most prominent constituents of the Passage Formation. Depositional environments, likewise, show an underlying similarity, being related to the repeated advance and retreat of fluviodeltaic systems into an embayment of varying salinity. Scotland during the Namurian (and succeeding Westphalian) was located more or less on the Equator. Its climate was essentially tropical with extensive swampy forests (mires and 'mangrove' swamps) rapidly producing large trees that subsequently died to produce great thicknesses of peat that with time and deep burial became transformed into coal. The Lower and Upper Limestone formations contain the highest proportion of marine deposits, while alluvial deposits dominate the Passage Formation; the Limestone Coal Formation occupies an intermediate position. The base of the Clackmannan Group is taken at the base of the Lower Limestone Formation, where a cyclical sequence of marine limestone-bearing strata rests conformably on the Lawmuir Formation of the Strathclyde Group. This group is mostly Namurian in age (but ranges from late Viséan Series to early Langsettian Stage of the early Westphalian Series).

The **Lower Limestone Formation** comprises repeated upward-coarsening cycles of limestone, mudstone, siltstone and sandstone. Thin beds of seatrock and coal may cap the cycles. The limestone beds are fossiliferous and pale to dark grey in colour; most were deposited in a tropical marine environment. The mudstones (which may also contain marine fossils) and siltstones are predominantly grey to black. A few non-marine faunal beds are also known. Nodular clayband ironstone and limestone are well developed in the mudstone sequences. The sandstone is usually fine- to medium-grained and generally off-white to grey in colour., Coal seams are thin (<0.3 m) and few in number in the Lower Limestone Formation except locally. Other minor lithologies in the formation include cannel coal and blackband ironstone (interleaved mud ironstone and coal). Conspicuous beds of limestone are a distinctive characteristic of the Lower Limestone Formation. The **Hurlet Limestone** defining the base of the formation, the Inchinnan Limestone, the **Blackhall Limestone**, the Main, Mid and Second Hosie limestones and, defining the top of the formation, the Top Hosie Limestone. The rocks of the Lower Limestone Formation are the youngest Visean strata in West Lothian. They have been assigned to the Brigantian Stage. The thickness of the formation is not well constrained but in the range of 100 m to 150 m.

The formation is predominantly of lower coastal plain, shallow-water marine origin as is shown by the presence of marine fossils in the limestones and many of the mudstones. Upper coastal plain lakes are represented by the few non-marine faunal bands known. However, largely marine deltaic environments are represented by the upward-coarsening cycles and delta distributary and fluvial ones by the upward-fining cycles. The marine deltas were probably of lobate form, based on the limited occurrence of lake deposits and of seatrocks and coal seams.

The **Neilson Shell Bed** normally occurs in mudstones intercalated with and towards the top of the **Blackhall Limestone** or stratigraphically above it. The characteristic fauna of the Neilson Shell Bed, seen well, for example, at, is dominated by brachiopods including *Crurithyris urii*, gastropods including the discoidal form *Straparollus (Euomphalus) carbonarius*, common nuculoid bivalves, and orthocone and coiled cephalopods including *Goniatites*.

The **Limestone Coal Formation** comprises sandstone, siltstone and mudstone in repeated cycles. The majority coarsen upwards, but others fine upwards. The cycles are usually capped by rooted seatearth and coal (3-10% of the total succession). The siltstones and mudstones are usually grey to black, while the sandstones are usually fine- to medium-grained and off-white to grey. Coal seams are common and many exceed 0.3 m in thickness. Minor lithologies include cannel, and blackband and clayband ironstone, the latter nodular as well as bedded. Beds containing large numbers of shells (coquinas) of *Lingula* or of the non-marine bivalves *Naiadites* and *Curvirimula* occur in the fine-grained rocks, including the ironstones and cannel. Because of the form of preservation, these shells usually do not form conspicuous musselbands like those of the younger strata of the Scottish Coal Measures. Marine shells are present in some fine-grained strata but marine limestones are not a feature. The **Manse Burn SSSI** at Bearsden is world famous for its fossil fishes. They occur in the mudstones immediately overlying the **Top Hosie Limestone**. Upward-fining parts of the succession, dominated by fine- to locally coarse-grained sandstone, are widely developed. The Johnstone Shell Bed and Black Metals Marine Bands can be correlated throughout the Midland Valley, but the coal seams are not so easily correlated and retain their local names. The Limestone Coal Formation is the oldest of the three subdivisions of Namurian age in the Clackmannan Group. It includes the strata stratigraphically above the Top Hosie Limestone at the top of the Lower Limestone Formation up to the base of the Index Limestone which is the lower boundary of the Upper Limestone Formation. The strata fall within the lower part of the Pendleian Stage (E1a) of the Namurian Series. The formation is of fluvial, deltaic, coastal to marine origins with the coal seams representing extensive tropical, afforested mires and swamps. The formation is over 200m thick.

The **Upper Limestone Formation** is characterised by repeated upward-coarsening cycles comprising grey limestone overlain by grey to black mudstones and calcareous mudstones, siltstones and paler sandstones capped by seatrocks and coal. The limestones contain marine faunas and are usually argillaceous. The sandstones are generally off-white and fine- to medium-grained. The coals are usually less than 0.6 m thick. Minor lithologies present include ironstone and cannel. Upward-fining sequences of coarse- to fine-grained sandstones passing up into finer-grained rocks are also present. The base of the formation is taken at the base of the Index Limestone. The top is drawn at the top of the Castlecary Limestone where not eroded penecontemporaneously by incising river channels. The main limestones are the Index, Orchard, Calmy and Castlecary limestones. The rocks of the Upper Limestone Formation form the middle of the three Clackmannan Group units within the Namurian Series. They are assigned to the late Pendleian (E1) and Arnsbergian (E2) stages. The Castlecary Limestone at the top of the Formation lies just below the top of the Arnsbergian Stage. The formation is predominantly of shallow-water marine shelf and deltaic origin but also in part of lacustrine origin. The presence of palaeosols and coals, show that subaerial delta top and lower alluvial plain environments existed. However, the heavily bioturbated striped beds (usually thinly interbedded siltstone and sandstone) indicate that delta lobe abandonment was a common event with subsequent marine reworking of the delta top. The existence of alluvial plain environments is also confirmed by the presence of the upward-fining channel sandstone bodies. These are particularly well developed where associated with significant intraformational unconformities. Limestone and hard calcareous mudstone represent only 1% - 3% of the total lithology in this formation reflecting higher siliciclastic input and perhaps less stable shelf depositional setting. Coal seams account for no more than 3% of the succession and sandstones about 50%. The formation is about 240 m thick.

The **Passage Formation** is characterised by an alternation of fine- to coarse-grained sandstones (with some conglomerates) and structureless clayrocks (including some high-alumina seatclay and fireclay). The original stratification is believed to have been obliterated by root systems and soil-forming processes. Rootlets can be seen in the darker beds but partial oxidation as a result of the lowering of the water table has removed carbon from the variegated red, yellow and lilac mottled, pale grey coloured rocks making rootlets less obvious. The rocks are thought to be the overbank deposits of a large river system. The kaolinite clay of which the muds are composed may have been a product of tropical weathering.

Upward-fining cycles or non-cyclic sediments predominate over upward-coarsening cycles. Bedded grey and black siltstones and mudstones are also present, and beds of limestone, ironstone, cannel and coal. Marine bands, represented mainly by mudstone but also inconstant limestones and ironstones are to be found in the lower half of the unit. Marine faunas become progressively impoverished upwards. The sandstones are white, pale grey or yellow in colour and tend to occur mainly in beds which are coarse grained at the base and become finer grained upwards. The upward-fining sandstones may occur singly or as a series with the base of each resting on a scoured surface cut into the underlying beds. The coarser sandstone in the lower part of each unit may contain scattered small pebbles or angular clasts of siltstone or mudstone and even of quartz. Locally, fossilised drifted tree trunks occur in the basal parts of the thicker sandstone beds. The finer beds may be ripple laminated and include partings of siltstone and mudstone. The thinner sandstones are considered to be simple channel fills and the thicker sandstones may represent the deposits of meander belts.

The strata range in age from the upper part of the Arnsbergian Stage of the Namurian into the Langsettian Stage of the Westphalian. The post-Arnsbergian stages are thin and incomplete and faunal or microfaunal evidence for the presence of the Chokierian and Alportian stages is lacking. The top of the formation is placed at the base of the Lowstone Marine Band. Coal seams form 0% - 4% of the succession and sandstones average about 55%. A period of uplift, erosion and regression in the early part of the Passage Formation brought about a change from the deltaic conditions with major marine incursions, which prevailed during the Upper Limestone Formation, to predominantly meandering fluviatile deposition with an influx of coarse detritus from the north. The formation is around 100 m thick or less.

Appendix 3 East Dunbartonshire Data Entry

Screen shots of the BGS GeoDiversitY database. The software was loaded onto a ruggedized laptop and carried in the field to allow direct data entry. A number of screens display the various assessment criteria recorded.

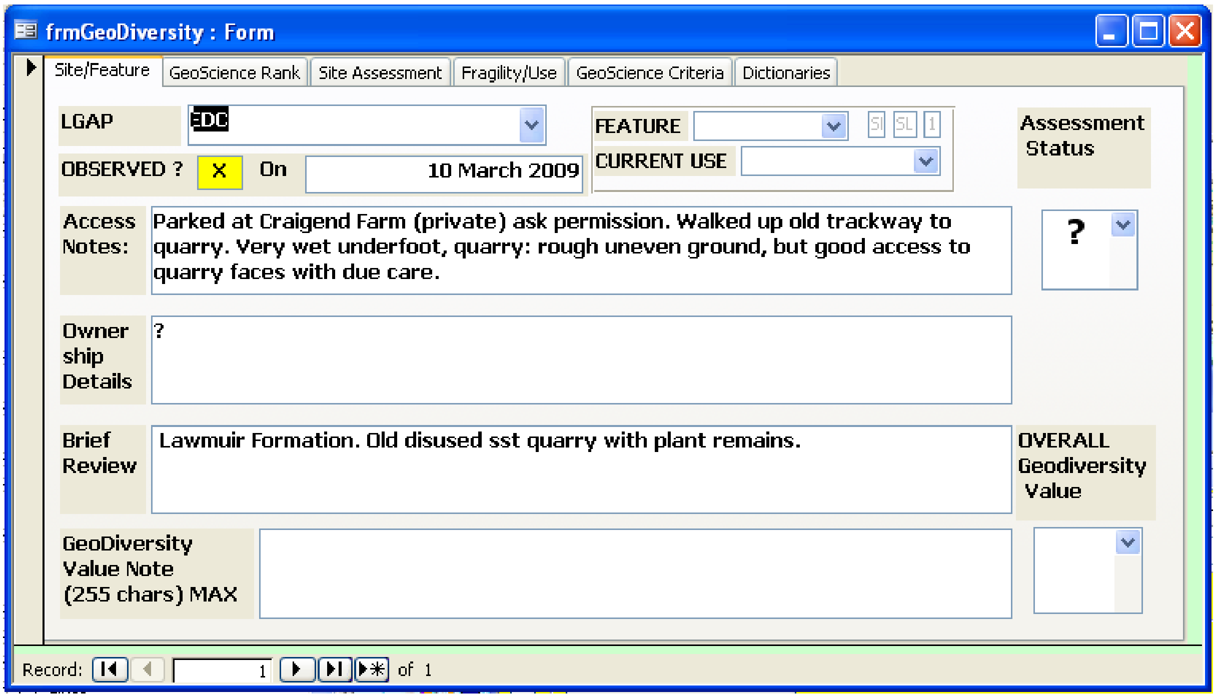

Figure 1: Site entry screen and access notes

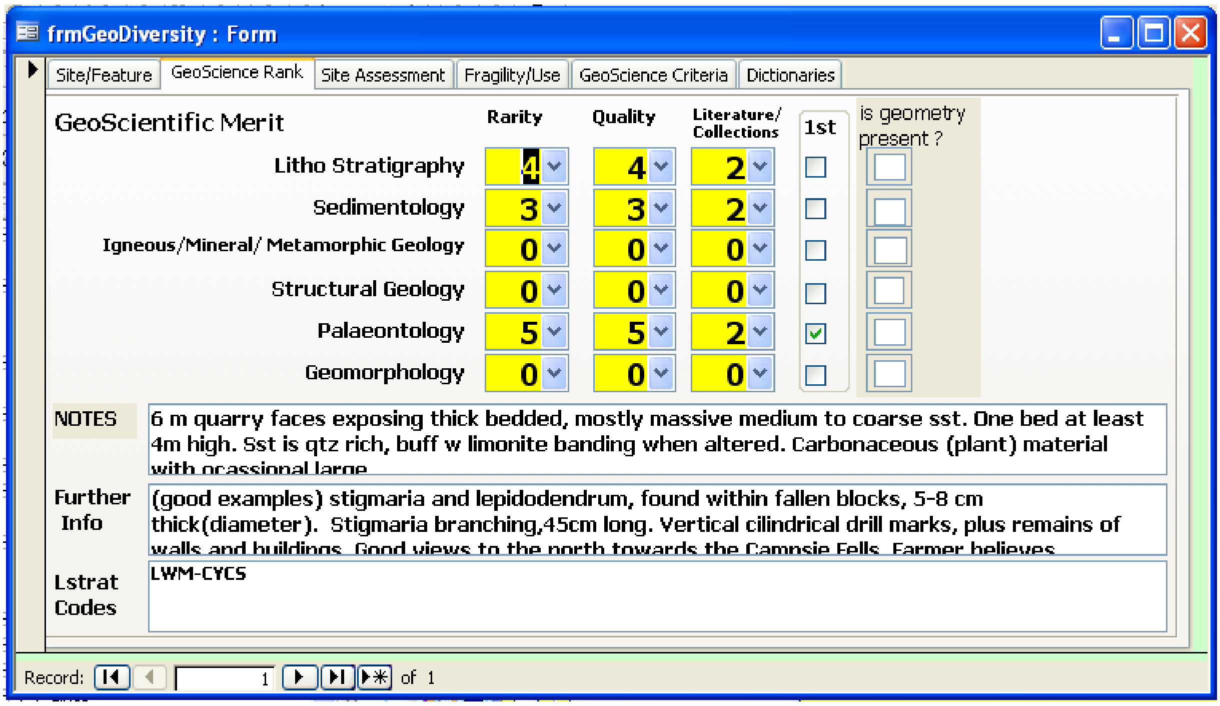

Figure 2: GeoScience Rank entry screen and site review

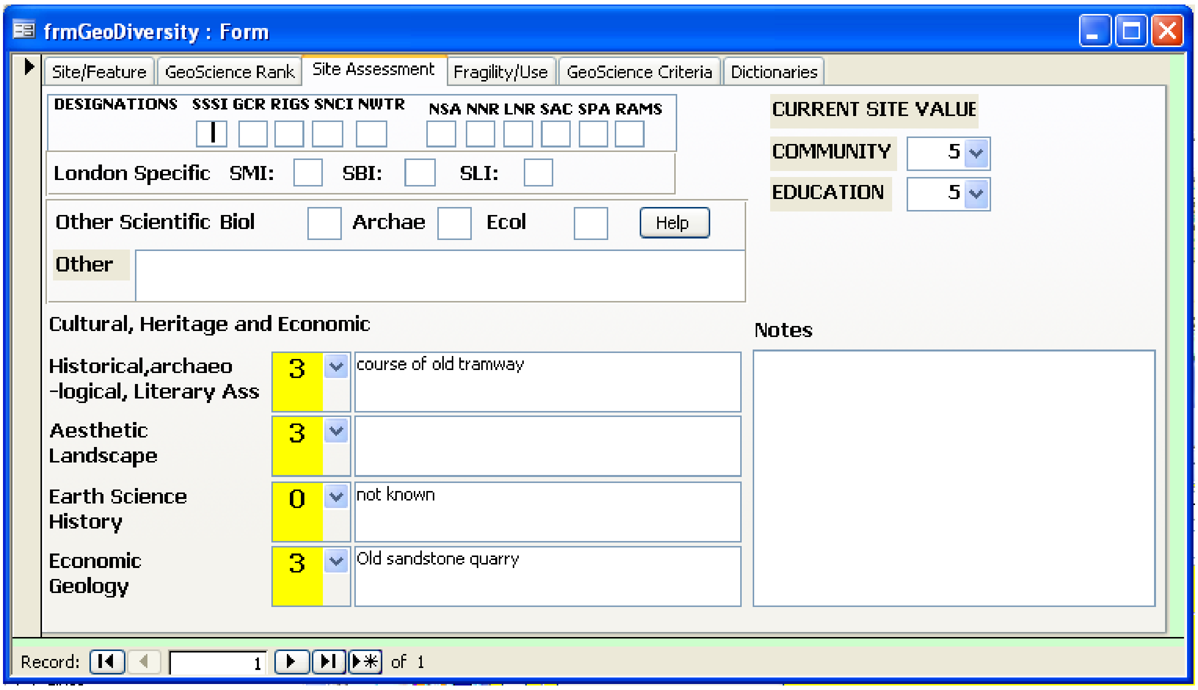

Figure 3: Site Assessment entry screen

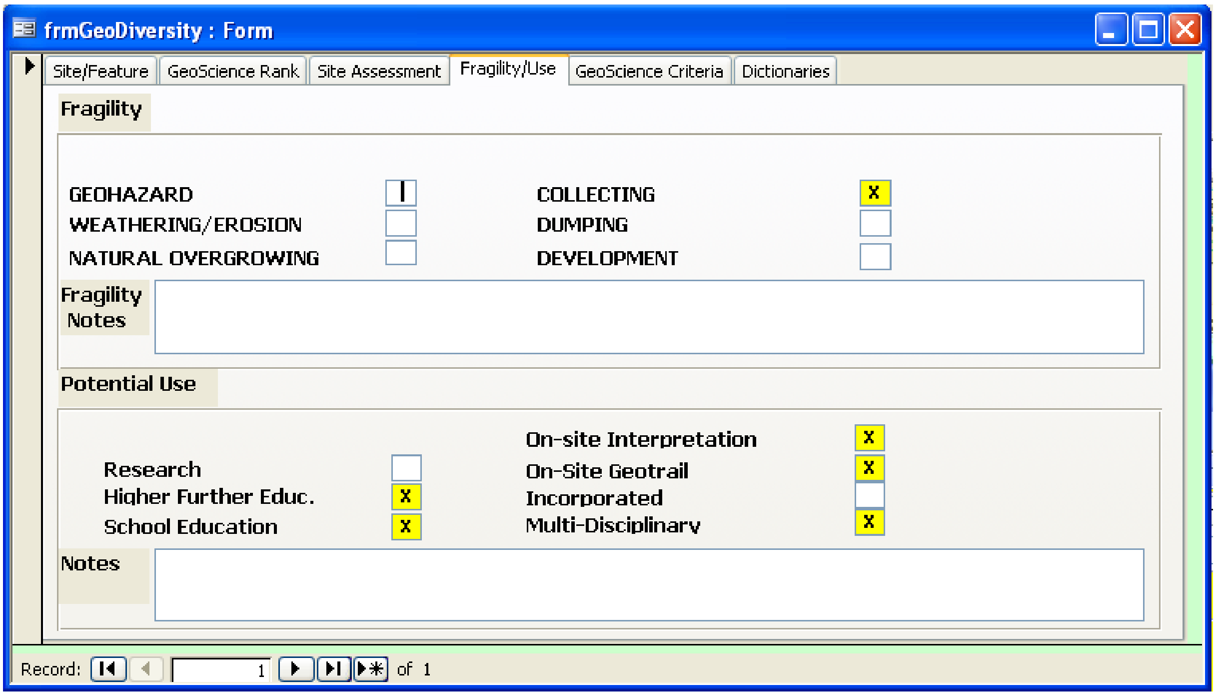

Figure 4: Site Fragility/Use entry screen

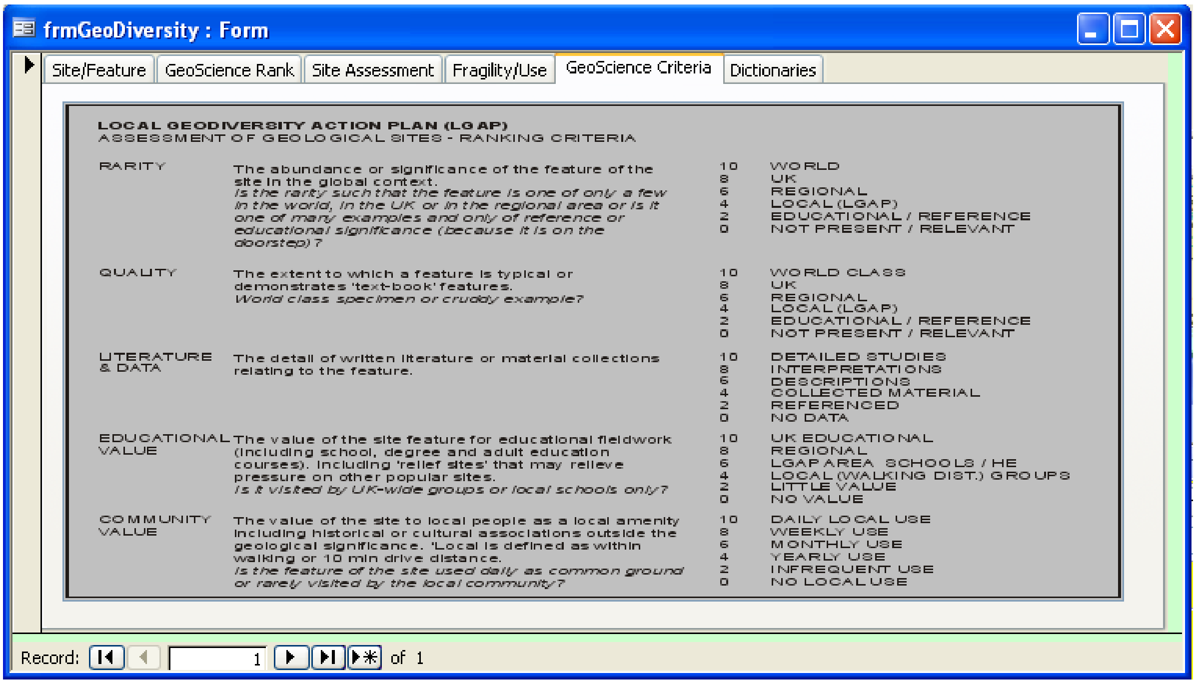

Figure 5: Site GeoScience Criteria entry screen

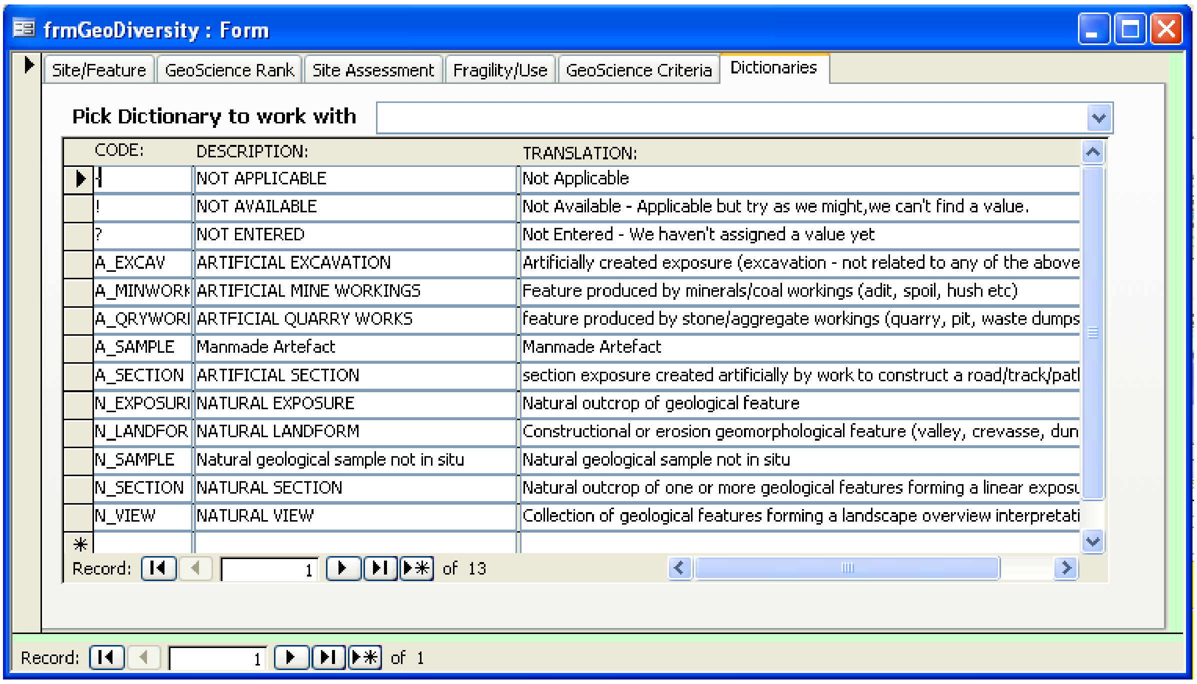

Figure 6: Dictionaries entry screen