North Esk Inlier

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Route: (Map 23)

Introduction

Silurian rocks outcrop in three inliers in the Pentland Hills. The largest of these, the North Esk Inlier, forms the subject of this excursion. The others are the Bavelaw Castle and Loganlea-Craigenterrie inliers (p. 162). Silurian strata in the inliers are generally vertical though rarely gently inclined. They strike SW–NE, young NW and are overlain with angular unconformity by gently dipping Lower Old Red Sandstone greywacke conglomerates. Silurian fossils were first recorded from the Pentlands by McLaren in 1838. Since then local geologists have collected extensively from the inliers. the most prominent being Hardie and Henderson, whose large collections made last century are in the Royal Museum of Scotland. Originally the sediments were thought to be of Wenlock to Downtonian age (Peach & Horne, 1899). However, in an extensive reinvestigation of the fauna, Lamont (1947) determined ages ranging from Upper Llandovery, probably crellulata biozone, to Wenlock for the North Esk Group as exposed in the North Esk Inlier. These ages were incorporated in the third survey by the Geological Survey (Mykura & Smith in Mitchell & Mykura 1962) and are generally accepted by later workers.

The succession as given by Tipper (1976) and Robertson (in prep.) is as follows, with the localities to be visited numbered:

	metres
North Esk Group	
Henshaw Formation (?Wenlock) (16–17, 26–29)	
Red conglomerates, cross-bedded micaceous sandstones, olive green shales with one or two bands of fish fragments	730
Wether Law Linn Formation (Llandovery) (11–15, 25, 30)	
Well-laminated brown siltstones with shelly fauna	125
Poorly stratified brown sandy siltstones	45
Highly fossiliferous laminated and bioturbated yellow-brown silty mudstones	40
Cock Rig Formation (Llandovery) (10)	
Cross stratified red-brown conglomerates and sandstones	110
Deerhope Formation (Llandovery) (6–9)	
Fossiliferous blue-grey micaceous siltstones and mudstones	250
Reservoir Formation (Llandovery) (1–5, 18–24)	
Interbedded greenish sandy siltstones and mudstones	1400

The sequence represents a rapid regression from an offshore submarine fan environment (Reservoir Formation, Deerhope Formation and Cock Rig Formation) through a shallow shelf environment in which an abundant and diverse fauna existed, though changing through time (Wether Law Linn Formation) to a terrestrial environment (Henshaw Formation). The most recent bibliography of works on the fossils of the Pentland Hills is given by Clarkson & Howells (1981).

For access to the eastern part of the inlier (River North Esk and Gutterford Burn excursions) parking can be found in Carlops and the 3 km walk taken either by the east bank of the River North Esk or by the farm track to Fairliehope and to the cottage at the reservoir. Private cars may be parked near the cottage. The western end of the inlier (Lyne Water excursion) can be reached from West Linton by following the road to Baddinsgill Reservoir where car parking is provided 1 km from the reservoir. The itinerary forms the basis for one day and two half-day excursions. They are:

Excursion A. River North Esk

The object of this excursion is to study the complete stratigraphy of the Silurian rocks in the North Esk Inlier. The starting point is at the south-west end of the North Esk Reservoir, the total walking distance is approximately 8 to 10 km and the excursion should occupy at least five hours.

1 and 2. River North Esk: unconformity, Reservoir Formation — Lower

By following the footpath along the River North Esk it is possible to see the Lower Old Red Sandstone strata the inlier. Red conglomerates containing dominantly greywacke cobbles are interbedded with pyroxene andesites of the Carnethy group (Mykura, 1960) and are cut by minor sub-basic intrusions. The position of the unconformity (1) between gently south-east dipping Old Red Sandstone and vertical Silurian strata crosses the river 450 m SSE of the cottage but is not exposed. To the north lie the oldest Silurian sediments to be exposed in the inlier, grey-green muddy siltstones.

Upstream from the unconformity, a gorge (2) cut out by the old overflow channel from the North Esk Reservoir exposes the lower part of the Reservoir Formation. The interbedded siltstones fine sandstones and laminated shales are folded by recumbent sub-isoclinal F_1 folds. Two stages of folding are present in the inlier, this (the older) is only evident in the Reservoir Formation sediments.

3, 4 and 5. North Esk Reservoir: Reservoir Formation — Upper

The east bank of the reservoir (3) provides an excellent and almost complete exposure through 250 m of grey-green and red Reservoir Formation sediments. In the south-east corner of the reservoir are exposed greenish-grey and yellow-brown sandstones and siltstones, finely laminated and forming discrete beds 1 cm to 1 m thick, normally with distinct upper and lower contacts. Internal structures in these show fining-up sequences from massive, relatively coarse bases, through ripple and convolute lamination, occasionally to bioturbated tops. Sedimentary structures indicate palaeocurrents flowing from the east. Rounded mud clasts and the enigmatic fossil Dictyocaris are common here in the siltstones but the beds are otherwise unfossiliferous. Some 50 m north of the south-east corner of the reservoir there is a somewhat disturbed zone following which the beds abruptly change to a fine red mudstone, devoid of fossils, but with occasional sandstone bands in its upper part, extending beyond the north-east corner.

The sediments are folded by an open F_2 (kink) fold, only recognised by subtle changes in the strike of the strata. Fold closures show slickensiding and beds are badly fractured; these are not associated with displacement and there seems no evidence for major faulting as suggested in the past (Mykura & Smith. 1962).

The north bank of the reservoir (4) provides an excellent section through higher sediments in the Reservoir Formation. At the eastern end of this large outcrop is exposed an F_1 fold closure, plunging south-west similar to folds at (2). Faults trending 1500 cut the strata, all with downthrows to the east of up to 3.5 m.

In the north-west corner of the reservoir (5) the Fairliehope–Gutterford igneous intrusion is exposed. This 2–4 m thick intrusion is folded by both F_1 and F_2 folds, is only seen below the Silurian–Old Red Sandstone unconformity, and must be pre-Old Red Sandstone in age. The rock is a highly altered (chloritised) sub-basic diorite. Intruded sediments show baked contacts. Above the intrusions, in predominantly fine-grained sediments, rare smooth-shelled brachiopods (*Lissatrypa atheroidea*) occur.

6 and 7. River North Esk: Deerhope Formation — Lower

The Deerhope Formation overlies the Reservoir Formation. The top of the Reservoir Formation is marked by the last thick siltstone unit showing internal structures, and this bed is exposed in the River North Esk (6). On the hillside to the east above the contact, fine grey-brown laminated shales, typical of the Deerhope Formation, show the first elements of a poor shelly fauna.

Upstream, in patchy exposures, this fauna and flora of algae, corals, crinoids, brachiopods, bivalves, gastropods, nautiloids and trilobites becomes common. A large cutting in the east bank (7), in red shales, is particularly fossiliferous.

8. Deerhope Burn: Deerhope Formation, Deerhope Coral Bed

Better exposures of the formation are found at the type locality along the lower reaches of the Deerhope Burn. The Deerhope Formation is predominantly green and purple shales containing, in some places, a rich shelly fauna. Interbedded are thin siltstone horizons, in which the fauna is more concentrated. Several such siltstones in a side-stream are known collectively as the Deerhope Coral Bed. Good exposures of the overlying Cock Rig Formation and the highly fossiliferous lower member of the Wether Law Linn Formation can be studied higher up this valley, but return to the North Esk to continue the succession.

9. River North Esk: Deerhope Formation — Upper

A large cutting in the river exposes a considerable thickness of siltstones near the top of the Cock Rig Formation, which forms beds 5–10 cm thick. These show tool marks indicating palaeocurrents from the east, and lineations on the bedding planes due to erosive current scour. Fossils are concentrated in lags at the bases of some of the siltstone layers. The fauna is dominated by bivalves, gastropods, corals, crinoids and chonetid brachiopods (Lamont. 1954).

10. River North Esk: Cock Rig Formation

The contact between the Deerhope and the overlying Cock Rig Formations is well exposed only in the Deerhope Burn. It can also be located in the North Esk section by a change in sediment type, where blue-grey mudstones and siltstones give way to yellow-brown medium grained sandstones and interbedded conglomeratic horizons. The Cock Rig Formation is well exposed on the east bank and also in the quarry on the west bank. The conglomerates contain clasts of granite, porphyry, sub-basic lava, quartzite, red and black chert, and fine-grained sediment in poorly graded cycles up to 25 cm thick. Cross-bedding, showing a variety of current directions is well preserved. Towards the top of the Formation is a largely transported benthic fauna made up of crinoid ossicles, the brachiopod *Isorthis mackenziei* and the bivalve *Leptodesma*.

11, 12 and 13. Wether Law Linn: Wether Law Linn Formation–Lower and Middle Members

The abrupt change from red sandstones to the green, highly bioturbated sandy mudstones marks the start of the Wether Law Linn Formation. Patchy hillside outcrops on the south side of Wether Law Linn allow the contact to be located. The lowest member of the formation, well-exposed on the south bank of the burn contains abundant *Skenidiodes lewisii*. *Cyrtia exporrecta*, *Dicoelosia verneuiliana* and subsidiary *Eoplectodonta penkillensis*, *Leptaena* aff. *purpurea* and the rugose coral (1) *Streptelasma* sp. Above a 20 cm white clay band representing the sudden deposition of volcanic ash, this fauna was replaced by a new and rich assemblage dominated by *Eoplectodonta penkillensis*. The brachiopods *Visbyella visbyensis* and *Leptaena* aff. *purpurea* together with the trilobites *Acernaspis sufferta* and *Encrinurus expansus* (other trilobites are less common) are numerous at the base of this assemblage but decrease in numbers up the succession. Correspondingly there is an increase in abundance of the gastropods *Gyronema* (1) *salteri* and *Liospira* (1) *simulans*, the bivalve *Synek* (?) sp., and the inarticulate brachiopods *Lingula* sp. and *Trimerella* cf. *visbyensis*. Gradually brachiopods similar to those of the topmost Cock Rig and lowermost Wether Law Linn Formations return at the top of the Lower Member. The fauna above the *Eoplectodonta* assemblage is best seen in a series of cuttings at (12) in the River North Esk.

The Middle Member of the Wether Law Linn Formation forms a large outcrop on the north bank of Wether Law Linn (13). These are yellow-brown laminated siltstones and fine sandstones, characterised by marked spheroidal weathering. The

sparse fauna of cephalopod and graptolite remains is almost totally lacking in benthic elements.

14 and 15. Henshaw Burn: Wether Law Linn Formation-Upper Member

The Upper Member of the Wether Law Linn Formation is exposed (14) in a number of outcrops where the Henshaw Burn merges with the River North Esk. These are brownish well-laminated uniform siltstones and mudstones and contain a rather sparse restricted fauna dominated by varying elements through the succession. Up-section there are the nuculoid bivalve *Praearca kosoviensis*, the gastropod *Spirina antiquata*, the brachiopod *Pentlandella pentlandica* and ultimately the gastropod (?) *Liospira simulans*.

In a shallow trench (15) the contact between marine Wether Law Linn Formation and the overlying fluviatile-terrestrial Henshaw Formation is exposed. Pyrite-bearing fossiliferous silty mudstones grade into yellow, then red mudstones. Above these is a marked change to reddened grits of the Henshaw Formation. Strong evidence of contemporaneous leaching and precipitation is clear.

16. River North Esk: Henshaw Formation-Igneous Conglomerate

Conglomerates of the lower Henshaw Formation are well exposed on both sides of the River North Esk. This is the 'Igneous Conglomerate' and contains clasts, up to cobble-size, of granite, porphyry, trachyte, sub-basic lava, siltstone and mudstone in bedded units of up to 1 m thick. Overlying these coarse conglomerates are reddened medium-grained sandstones sh- — quartzite conglomerate

An exposure of a 1.5 m thick bed of the 'Quartzite Conglomerate' is exposed here which may be correlated with quartzite conglomerates found in the other Midland Valley Silurian inliers. This conglomerate is markedly different from the Igneous Conglomerate containing approximately 70% quartzite clasts.

To return, follow the river bank to the reservoir. Alternatively join the Carlops–Balerno footpath which passes the cottage at the south-west corner of the reservoir.

Excursion B Gutterford Burn

The object of this excursion is to study several famous localities in the Gutterford Burn within the Reservoir Formation. The starting point is also the cottage at the south-west end of the North Esk Reservoir.

18. Reservoir Formation — Lowest Beds

Good exposures of the Reservoir Formation, noted in Excursion A along the east bank (3) and north bank (4) of the North Esk Reservoir, continue up the Gutterford Burn which flows into the north-east corner of the reservoir. Purple and green finely laminated silty shales are interbedded with discrete beds 1 cm to 1 m thick, of siltstone and fine sandstone, sparsely fossiliferous. The stream runs roughly parallel to the strike allowing individual beds to be followed for long distances.

19. Reservoir Formation — graptolite beds

Purple and grey mudstones further upstream have yielded rare specimens of the smooth-shelled brachiopod *Lissatrypa atheroidea* and of several species of graptolites. The fauna is dominated by *Monoclimacis vomerinus* (s.l.) possible *M. crenuiala* (sensu Elles & Wood) with occasional *Monograptus priodon* and *M. spiralis* and up to three species of dendroid graptolites. Precise identification is difficult but the fauna indicates a pre-Wenlock age for the Reservoir Formation.

20. Reservoir Formation–Gutterford Burn Limestone

Some siltstone to fine sandstone beds higher in the formation have thin basal lags of crinoid ossicles. One such bed which has a rich fossil content making it a highly calcareous siltstone, is known as the Gutterford Burn Limestone. Its

outcrop can only be found with difficulty high on the eastern bank of the valley. It is a 25 cm thick lag deposit containing abundant broken corals and bryozoans, disarticulated brachiopods and bivalves, together with gastropods, trilobites, ostracods and crinoid ossicles draped over internal sedimentary structures.

21. Reservoir Formation–Eurypterid Bed

The next large outcrop upstream is the site of the Eurypterid Bed. These arthropod bearing laminated siltstones are dominated by stylonurids (Waterston. 1979) and contain one of the most extensive eurypterid faunas in the world. As a result of extensive excavations by Laurie (1892. 1899) the bed is now buried beneath a large pile of debris, but occasional fragments of the siltstones, along with abundant *Dictyocaris*, are to be found in the scree.

22. Fairliehope–Gutterford Intrusion

In the next large outcrop the sediments are cut by the Fairliehope-Gutterford Intrusion. It is necessary to examine the outcrop closely to differentiate igneous rock from baked siltstone. The intrusion is folded by tight F1 folds three separate outcrops in the Gutterford Burn, formerly taken to be three separate intrusions. The intrusion is pre-Old Red Sandstone in age, since the body is affected by Silurian folding. From a position high on the north bank of the stream these tight F_1 folds can be seen to be themselves folded by younger more open F_2 kink folds of the kind exposed on the east bank of the reservoir (locality 3).

23 and 24. Reservoir Formation — starfish beds

Two starfish localities have been recorded high in the Gutterford Burn. The first (23) is on the north bank 100 m downstream from the wall across the burn and the second

(24) on the south bank 50 m upstream from the wall, is the classic starfish bed of Peach and Horne (1899). The common starfish *Crepidosoma wenlocki* is found in fine micaceous silty shales with relatively rare brachiopods *Lissatrypa atheroidea*. *Clorinda*, hyolithids, cephalopods and the echinoid *Aptilechinus caledonensis*.

To return, it is easiest to follow the path high on the east bank of the burn back to the reservoir.

Excursion C. Lyne Water

The object of this excursion is to examine the Wether Law Linn Formation and to study the various alluvial facies in the terrestrial Henshaw Formation which are better developed than in the River North Esk. The starting point is the bridge at the north-east corner of the Baddinsgill Reservoir. The walking distance is approximately 4 km and should occupy at least 3 hours.

25. Baddinsgill Reservoir: Wether Law Formation — Upper Member

Strata of the Upper Member of the Wether Law Linn Formation crop out 150 m beyond the bridge, in the small side stream that flows into the reservoir. The yellow-brown muddy siltstones contain *Pentlandella pentlandica* and (?)*Uospira simulans*. On the south side of the stream a vertical fault throws the mudstones to the south, up against Lower Old Red Sandstone conglomerates. Contact with the Henshaw Formation near the bridge on the north bank of the reservoir is not here exposed.

26. Baddinsgill Reservoir: Henshaw Formation — igneous conglomerate

Along the north shore of the reservoir the Igneous Conglomerate is interbedded with thick beds of red medium-grained sandstones. The well-rounded hematite-stained pebbles of granite, porphyry, trachyte, sub-basic lava and fine-grained sediments form beds up to 50 cm thick. Moving along the shore of the reservoir the red sandstones become dominant. These contain isolated pebbles and thick pebble horizons, mainly composed of quartzite. Trough cross-bedding is poorly developed.

27. Lyne Water: Henshaw Formation — Lyne Water Fish Bed

Above the red sandstones grey-green muddy siltstones are developed, displaying dessication cracks. On the east bank of the Lyne Water, 25 m north of the sheepfold, is the Lyne Water Fish Bed. These yellow-brown and grey laminated siltstones contain rare small broken fish fragments, mainly *Ateleaspis tessellata*, with some *Lasanius problematicus* and *Birkenia elegans*, as well as the crinoid *Pisocrinus campana* and worm tubes, probably representing a minor marine incursion.

Overlying the fish-beds are red medium-grained sandstones with well-developed trough crossbeds and quartzite pebbles, well-exposed since the Lyne Water runs along strike.

28. Lyne Water: Henshaw Formation, unconformity

Red trough crossbedded medium-grained sandstones form the highest Silurian sediments exposed in the inlier. Gently northward dipping Lower Old Red Sandstone conglomerate is exposed above the Silurian-Old Red Sandstone unconformity.

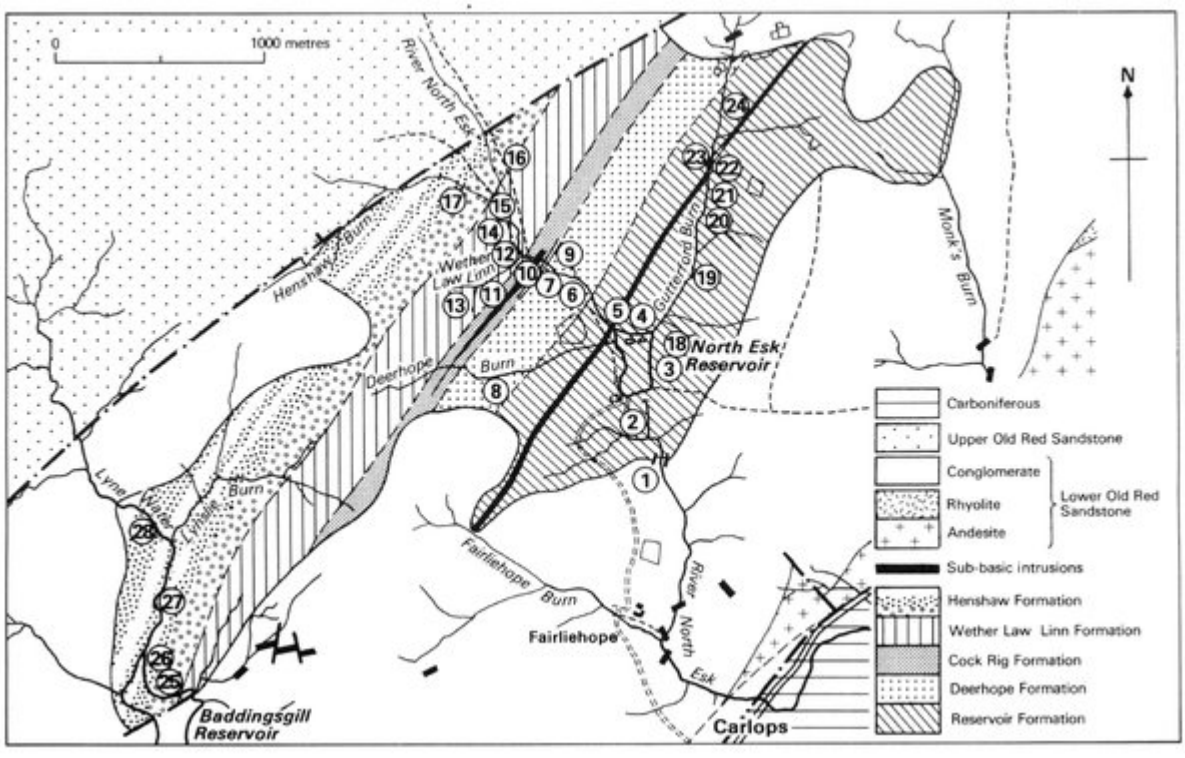
29. Lynslie Burn: Henshaw Formation — Lyne Water Fish Bed

Retrace one's steps and proceed up the Lynslie Burn. Red sandstones give way to interbedded red siltstones and shales. Low amplitude ripples indicate some palaeocurrent directions. Near the junction with the Lynslie Burn there is a further outcrop of the Lyne Water Fish-Bed, formerly regarded as a separate higher fish bed, the Lynslie Burn Fish Bed (Mykura & Smith, 1962).

30. Lynslie Burn: Wether Law Linn Formation — Lower Member

Nearer the head of the Lynslie Burn on the north bank is a good fossil-collecting locality in the Lower Member of the Wether Law Linn Formation (locality 11). To return it is easiest to descend the valley back to the reservoir.

References



(Map 23) North Esk Inlier.