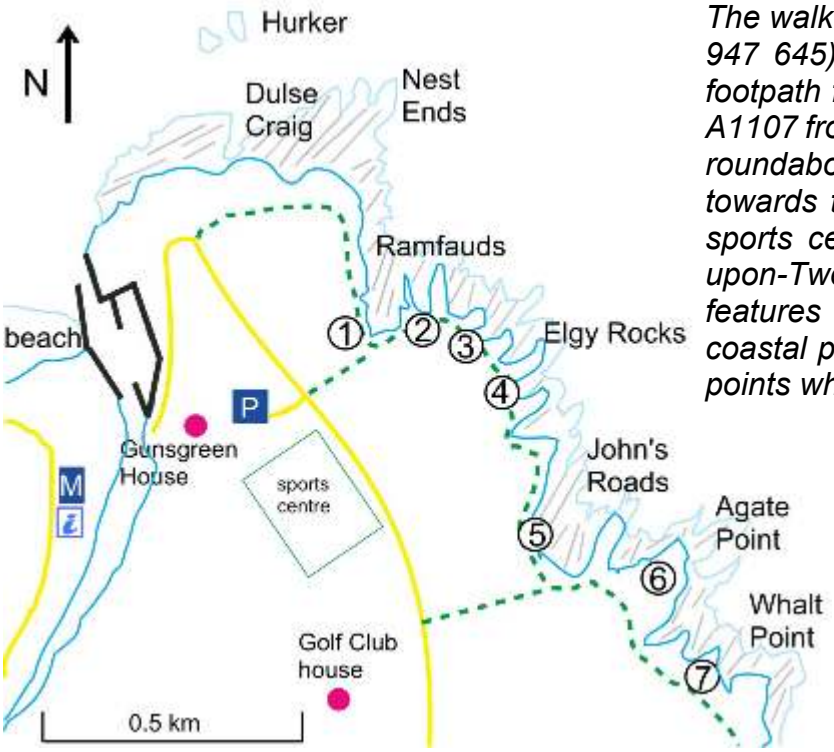
EYEMOUTH'S FOLDED GREYWACKES

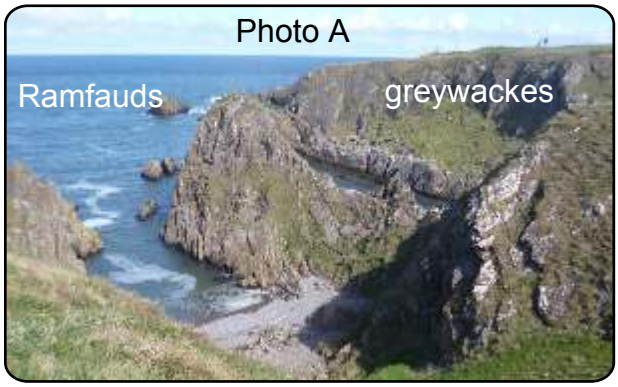
On this walk you can enjoy spectacular scenery along the Berwickshire coast and see evidence that the 430 million year old rocks of southern Scotland were formed in a deep ocean.



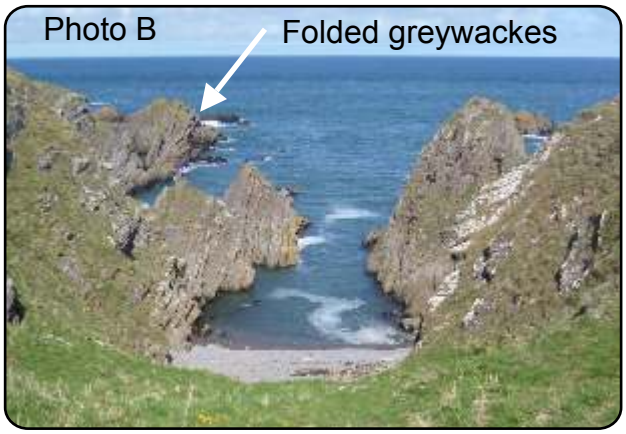
The walk starts at a car park to the east of Eyemouth (NT 947 645) and takes you along the cliffs on the coastal footpath for about a mile. To reach the car park take the A1107 from the A1 towards Eyemouth and turn right at the roundabout by Eyemouth High School. Follow the road towards the sea and turn left into the car park after the sports centre. There are frequent buses from Berwick-upon-Tweed to Eyemouth (235/253). You can see all the features on this walk at high tide but take care on the coastal path which is slippery after rain. There are many points where there is a steep drop into the sea.

After enjoying the view from the car park across Eyemouth Bay to the town and the cliffs of Eyemouth Fort, cross the road to the footpath across the Golf Course which takes you to the cliffs. You will find binoculars useful. The numbers on the map are places where you can stop and look at features of geological interest.

The cliffs between Eyemouth and Burnmouth are composed of sedimentary rocks called **greywackes** and **mudstones**. Greywackes (pronounced 'greywackies') are a type of **sandstone**, but they are composed of fragments of rock as well as grains of **quartz** found in more typical sandstones. For greywackes to contain rock fragments, there must have been mountains nearby from which **volcanic** rock fragments were weathered, eroded and transported by rivers into a nearby sea where they were deposited.

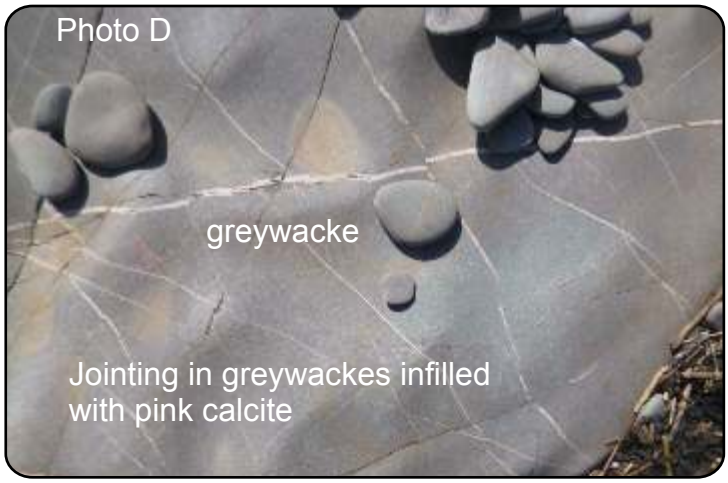


As you reach the cliffs, turn to the right along the coastal path. (1) You can see down into the cove called Ramfauds (Photo A). The **beds** of greywacke are sloping (**dipping**) steeply towards the west and vary in thickness from 10-100 cm. Careful study shows that they are folded into sharp folds like hairpins (Photo B). As you walk beyond Tee 6 you can see finely bedded mudstones to the left of the footpath. *Follow the red or green marker posts around the golf course and watch for flying golf balls.*

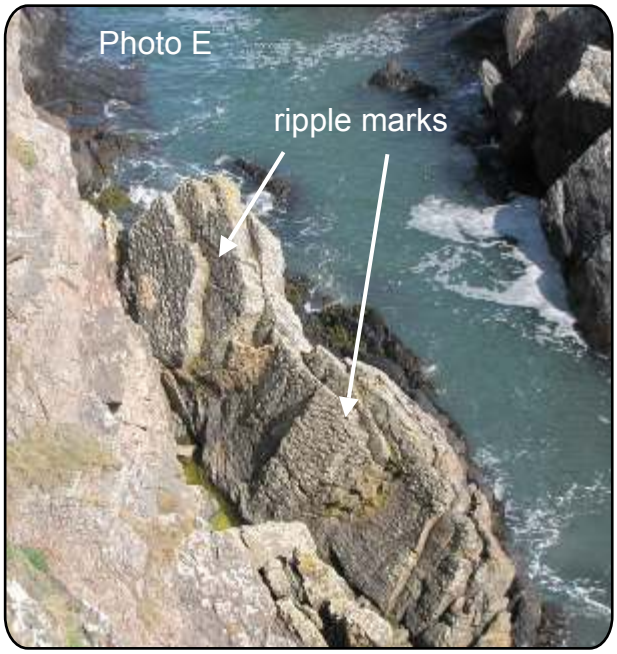


430 million years ago (the **Silurian period**), mountains on the continent of **Laurentia** formed the areas which are now Scotland, Scandinavia, northern Ireland and eastern North America. The deep ocean (**Iapetus Ocean**) to the south of the mountains was filling with mud and rock sediments at the same time as being squeezed under Laurentia during a **plate collision**. As the mud and rock particles were buried by thick layers of sediment, water was driven out and the particles were squashed together. Water moved through the sediments, carrying **minerals** which cemented the particles together to produce hard rocks. In the process, the greywackes were **folded** and **faulted** under great pressure.

② The narrow inlets along this section of the coast are probably eroded along fault lines. With binoculars, you can see folding on the left of this inlet. Photo C shows the fold in detail. To have a close look at the greywackes, walk down the grassy slope into the inlet, taking care if it is wet. Look at the **bedding planes** (the surface between each bed) which are uneven and knobbly in places. Some of them are covered by a pink mineral called **calcite**, which is also seen in the joints (Photo D).



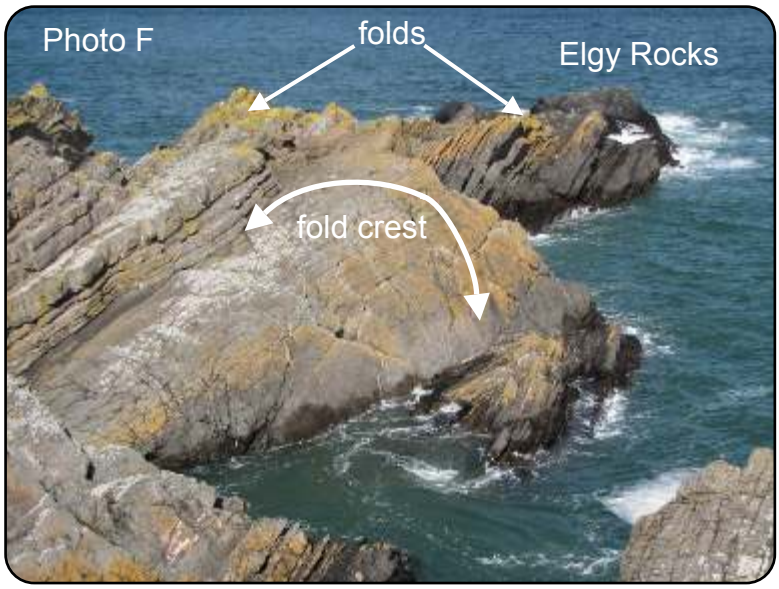
Pink calcite is characteristic of the greywackes of this age and distinguishes them from other greywackes. Geologists call rocks of this age the Hawick Group, but they are found widely across the Southern Uplands of Scotland. Calcite moves through the rocks during the burial and drying-out process which turns the wet sediments into tough rocks.



③ If you continue along the coastal footpath you will reach another narrow inlet, adjacent to the fairway and just beyond a footpath marker post, which has steeply dipping rocks with raised **ripple marks** (Photo E) on the upper sides of the bedding planes, showing that gentle currents were moving sediment back and forth on the sea bed of the Iapetus Ocean.

Continuing to the other side of the inlet and looking back at the opposite cliff, you may be able to see **flute marks** on the underside of the bedding planes. Flute marks are formed when rapid currents of water carrying sand and mud scour the sea-bed, perhaps during an underwater **turbidity flow** (see diagram on the next page). The ripple marks and flute marks are only visible when the sun shines on the bedding planes; binoculars are needed to make them out clearly.

④ A series of folds is seen near Elgy Rocks, where one fold in a thick bed of greywacke has a rounded crest (Photo F). Thinner beds are folded into tight, angular folds, shown by the arrows.



As you continue along the coastal footpath, use binoculars to find further examples of ripple marks on the greywacke beds (Photo G).

⑤ *The wide bay at the corner of the wall is John's Roads with a dramatic view along the coast.*

⑥ Beyond John's Roads is a narrow peninsula, Agate Point, stretching out to sea (Photo H). Walk along to the end of Agate Point so that you can look back at the cliffs in John's Roads and identify more folded rocks. In this area there are also many bedding planes which are rippled or have flute marks. It is not always easy to see them if they are in shadow, or if the tide is high.

TURBIDITY FLOWS AND FLUTE MARKS

During the plate collision which culminated 420 million years ago towards the end of the Silurian period, the rock fragments deposited on the **continental shelf** of the Iapetus Ocean were disturbed by earthquakes so that unstable piles of sediment tumbled down the **continental slope** into the deep sea in rapid flows called **turbidity flows** (Diagram 1). As the speed of the flow decreased the heavier rock and sand fragments were dropped first and eventually finer mud particles were deposited above when the current stopped moving (Diagram 2). Each turbidity flow created a bed of greywacke with a thin layer of mud lying above it.

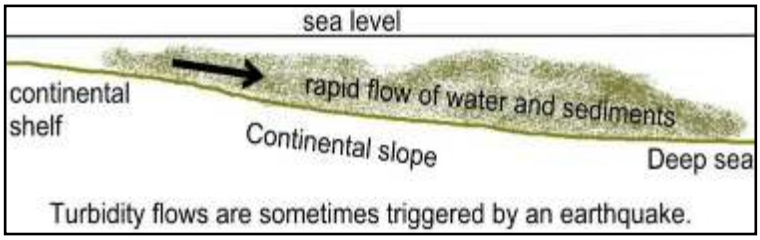


Diagram 1

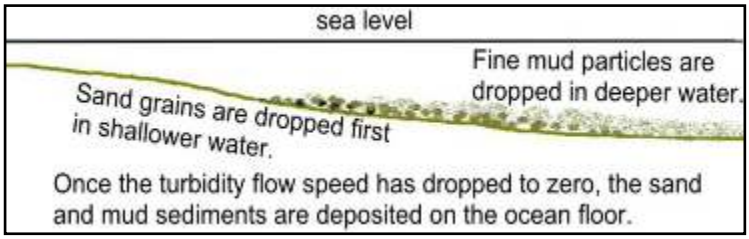
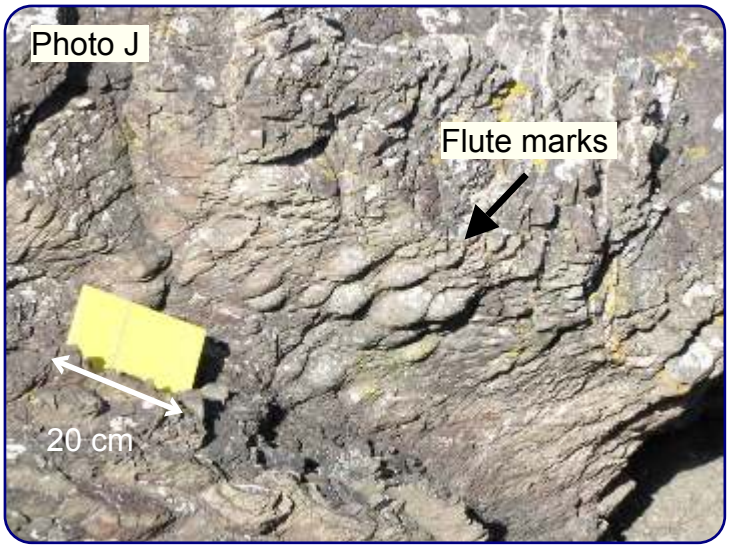


Diagram 2

Because the turbidity current was moving at great speed, probably up to 70 miles per hour, the current scoured into the sediment on the sea bed, picking it up and leaving streamlined hollows. The **flute marks** are the 'lumps' that you see, which are the infilling of the hollows with sediment deposited on the sea bed from the turbidity flow as the speed reduced (Photo J).

Continue along the coastal path, keeping to the left of the wall, until the path goes through the wall on your right. Below you, just beyond the fence post, is a rock surface covered with ripple marks, which indicate that the sand on the Iapetus Ocean sea bed was being moved by gentle currents.

⑦ *At this point, leave the coastal footpath and stay to the left of the wall around the head of a steep gully. After 10 m take the small path on the left down to some low rocks.* In front of you on a small vertical face of rock are some elongated, aligned flute marks. Photo J shows the flute marks in direct sun, but they may be more difficult to see when the face is in shadow.



You can return to the car park along the coastal footpath or take the footpath at John's Roads, then turn right onto the road and walk back to the car park along the pavement.

USEFUL REFERENCE BOOKS

Scottish Borders Geology - An excursion guide 1993 A.D.McAdam, E.N.K.Clarkson & P.Stone

Northumbrian Rocks and Landscapes - A Field Guide 1995 (ed. C. Scrutton) Yorkshire Geological Society

USEFUL MAPS

OS 1:50,000 Landranger 67 Duns, Dunbar & Eyemouth

OS 1:25,000 Explorer 346 Berwick-upon-Tweed

British Geological Survey 1:50,000 Scotland Sheet 34 Eyemouth (Solid)