The Story Behind the 'Wall'

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3rd July, 2008

The 'Wall' refers to the reconstructed wall on the east side of the Hillwood House walled garden on Corstorphine Hill. Like most walls it is meant to keep things out or to protect things (in this case, plants) from potential danger or destruction. Before describing the features displayed by some of the rock fragments incorporated in the wall, it is necessary to introduce some basic geological ideas.

The three great categories of rocks

Igneous. There are three main categories of rocks; igneous, sedimentary and metamorphic. In considerations of the wall (and the reason for the presence of the hill) we need only concern ourselves with two of these categories - sedimentary and igneous. Igneous rocks (often thought of as the 'primary' rocks) are derived from the hot interior of the Earth and form as a result of cooling of extremely hot material known as magma. Magma is molten material that exists at depth and only forms rocks when it is cooled if it rises into cooler places near or at the Earth's surface. This idea is now widely accepted but just over 200 years ago, it was hotly debated. The popular theory, in the past, was that igneous rocks crystallised from materials dissolved in the primitive ocean and it was through the pioneering and brilliant work of James Hutton, an 18th century Scot, that the deep and hot origin of igneous rocks was realised.

Sedimentary. The second great category of rocks is called 'sedimentary' and the wall is made up, almost exclusively of chunks of this material, cemented together for strength and durability. Sedimentary rocks are quite variable in appearance and origin but most of the rock fragments making up the wall are of one kind – clastic sedimentary rocks, such as sandstones. The word 'clastic' simple means broken and implies that such rocks are formed as a result of the breakdown of pre-existing rocks and accumulation of the fragments. Thus, in a sense, these are 'secondary' rocks for they cannot form without the existence of older rocks (such as the 'primary' igneous rocks). Just as in the walls holding up the buildings in the New Town, most of the rocks making up the garden wall are sandstones. Again, the origin of such rocks was explained by the great James Hutton, who proposed that such rocks originated as sediments like those we can observe today as layers of sand and gravel in river beds and on the shores of lakes and oceans. There is, however, a major difference between sand and sandstone. If you were to build a wall of sand (as children commonly do on the beach) it wouldn't last very long. Sandstone, on the other hand, is much more durable. How can one be transformed into the other? The main processes involved take place during and after burial – in some circumstances the surface layer (or bed) of sand may be covered over by another and another until it is deep beneath the surface. The weight of overlying sediment causes compaction – the grains are jostled and crushed against each other and, at the same time, there may be precipitation of cements from water in the pore spaces of the sediments. The most common natural cements formed in this way are calcium carbonate and silica (quartz), which can fill the pore spaces between the individual sand grains. Thus, mainly by compaction and cementation, sediments, which can be scooped up in your hand or with a spade, are changed into sedimentary rocks which are extremely hard and can only be broken and worked with great effort, using a hammer, chisel, explosives or a diamond saw. It is from such difficult but durable materials that most of the world's great stone structures, from the pyramids to the great cathedrals (and the garden wall!), have been made.

Metamorphic. The third great class of rocks is called 'metamorphic'. Such rocks do not figure in the wall but are mentioned briefly for completeness. Such rocks, like those of the sedimentary category, are also 'secondary', for they cannot form without the existence of older rocks. Metamorphic rocks from as the result of the influences of heat and/or pressure on pre-existing rocks of any type. Fortunately these complex rocks are not represented in the wall. Metamorphic rocks make up much of the Highlands of Scotland but most of the local rocks in the Edinburgh area are either sedimentary or igneous.

Local Geology

Perhaps before considering the story of the wall we should think about the origin of the hill on whose slopes it is situated. Corstorphine Hill, like many others in the Edinburgh area, is a prominent landmark. Why is it there? Even the most subtle details of the landscape have a geological meaning. Most highs and lows of the topography reflect the underlying materials, usually rocks. The rocks underlying Corstorphine Hill are mostly hidden by a veneer of soil and vegetation but, if you keep your eyes open, you will see places where hard grey rocks come to the surface. Such occurrences are called 'outcrops' and it is from these sparse occurrences that geologists are able to piece together geological maps which depict the distribution of the different rock types on the surface of the land (see the map shown in Figure 1) and permit an interpretation of what happens to them beneath the surface (cross section shown in Figure 1). The map and cross section show that the rocks of the area have been folded into a large dome-like structure and Corstorphine Hill and surrounding areas lie on the west side of this structure so that all the rocks are tilted (dip, in geological terminology) towards the west. The rock outcrops on Corstorphine Hill are mainly igneous rock. They bear a variety of marks such as striations or scratches made by the passage of glaciers over the hill, for the area was covered by thick ice during the Pleistocene glaciation. The ice moved up the hill from the west, scraping the surface clean and leaving deep scratch marks as evidence of its former presence. Following disappearance of the ice, outcrops that we can still see today must have been present, for some have been sculpted by human hands – for example, the *ca.* 5,000 year-old cup marks present near the top of the hill above the Capital Hotel. Why has this area remained upstanding? How has it withstood the passage of great masses of ice and the ravages of storm and rain over millions of years? It is because it is an intrusion of hard igneous rock. An 'intrusion' is formed when a body of magma forces its way into existing rocks and consolidates into rock itself without ever reaching the surface, in contrast to what happens with lava flows when they come out of volcanoes. A glance at the geological map (Figure 1) shows the Corstorphine Hill area to be underlain by a N-S-trending body of igneous rock, called 'Teschenite and Olivine Dolerite'. This is the geological name for a quite large igneous intrusion that forced its way into much softer sedimentary rocks known as the Lower Oil-Shale Group. These rocks are all thought to be Lower Carboniferous in age – in the vicinity of 350 million years old. Thus the high ground making up Corstorphine Hill is the result of the presence of a ridge of hard igneous rock that has resisted the effects of erosion by water, wind and ice much more efficiently than the surrounding sedimentary rocks, which are mainly softer fine grained sedimentary rocks such as mudstones or shales (formed from muds), together with some beds of sandstone, such as the Craigleith and Ravelston Sandstones..

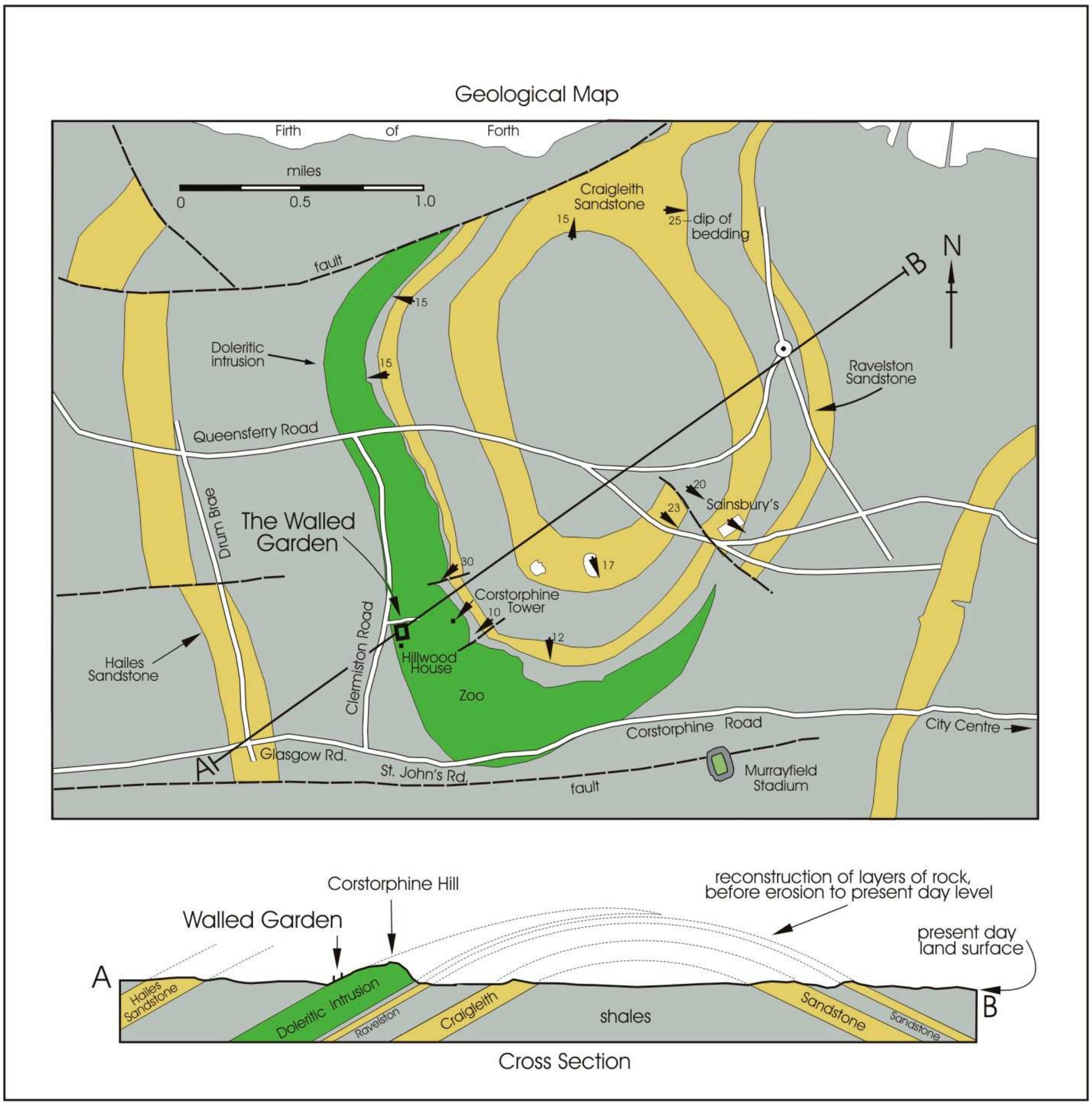

Figure 1. Geological sketch map (simplified from British Geological Survey maps) and cross section to show the geology of the area around Corstorphine Hill.

The 'Wall'

Turning now to the wall itself, it originated as part of the Hillwood House walled garden (location shown on the map and section in Figure 1) but after falling into disrepair and becoming completely overgrown, a plan was hatched to restore it as a garden representing, on a small scale, the great variety of plants found on Corstorphine Hill. As part of this ambitious plan, the walls were repaired and rebuilt in an attempt to restore them to their former state. The east wall, together with the adjacent small storage hut, was restored in 2004. The difference between the remnants of the older wall and the more recent addition are clearly shown by the contrast between the dark and light portions (Photo 1). Many of the features described below will no doubt disappear over time as the ageing process takes place and the new wall becomes darker when dirt and lichens and mosses cover the fresh rock faces. At present, the rocks on the wall face present a variety of features that tell us much about their origin and a little about the plants and animals that inhabited this part of the world about 350 million years ago.

Rock types present in the 'Wall'

<u>Sedimentary Rocks</u>

Sandstones. By far the most common rock type among the fragments used in reconstructing the wall are sandstones. Most of them are buff or light tan in colour (Photo1) but some have a reddish tint. They are probably all Early Carboniferous in age, like the Craigleith Sandstone used to build the New Town, but some of the purple or red fragments of sandstone could be slightly older and belong to the Old Red Sandstone (Photo 2).

Conglomerates. Conglomerates are like sandstones but contain somewhat coarser fragments. A sample of a conglomerate is shown in Photo 3. In this case the rock contains many sand-sized grains but also scattered pebbles, some of which have been eroded out to leave hollows. A second example of a sandy conglomerate is illustrated in Photo 4. This rock is actually a white sandstone containing scattered rounded fragments of mudstone. Mudstone is a very fine grained clastic sediment made up of very fine particles (clay- and silt-sized). The mudstone was probably deposited in an area of slack water at the same time as sands were being laid down elsewhere. The muds sometimes dry out and become semi-consolidated so that if there is a later stronger current, they can be broken into small pieces and incorporated as fragments in the sand. When such a sediment, with particles of various sizes, solidifies into a rock, it becomes a conglomerate with dark mudstone fragments derived by erosion of fine muddy sediments that were contemporaneously formed. Such features are commonly found in deposits of rivers and deltas.

Mudstone. Mudstones tend to be soft and break easily so they are not favoured by stonemasons or wall-builders. A single example of a mudstone was, however, discovered in the wall. It is a small fragment of grey, rusty-weathering mudstone (Photo 5). The rusty weathering colour probably indicates the presence of the iron-rich mineral pyrite (iron sulphide) in the mudstone.

Igneous Rocks

Gabbro There are very few examples of igneous rocks among the stones used to reconstruct the wall. They are easy to find by virtue of their dark colour, in contrast to the light sandstones. The dark greenish-coloured igneous rocks go by the general name dolerite or gabbro. Such rocks tend to be physically tougher and less susceptible to alteration by weathering than the sandstones and are commonly used to edge kerbs and as cobblestones in the older streets of Edinburgh and elsewhere. They are similar in composition to the most common kind of lava (basalt) but are coarser grained because they generally occur in intrusions (as opposed to basaltic lavas, which are erupted onto the surface). Because they cool underground the process takes longer and the individual crystals that make up the rock have more time to grow and are therefore larger (Photos 6 and 7). There are many Carboniferous intrusions of dolerite or gabbro in the Midland Valley of Scotland (including that which forms Corstorphine Hill).

Sedimentary Structures

Sedimentary structures are features of the rocks that tell us something about how they formed. There are many such structures preserved in the sedimentary rocks used in construction of the wall.

Bedding. Among sedimentary structures, layering or bedding is the most common. It forms due to changes, from time to time, in the grain size or composition of material carried into the site of accumulation (river bed, sea bottom etc.). Examples of thin or fine bedding (sometimes called lamination) are shown in Photos 8 and 9.

Cross bedding. This structure is extremely useful for it tells us something about the environment in which the sedimentary rock accumulated (commonly in shallow moving water, such as in a river channel), it can be used to determine the direction in which the current was flowing, and it can tell us which side represents the top of a succession of rocks when they have been steeply tilted by folding. The name derives from the fact that such bedding runs at a different angle from that of the enclosing rocks. i.e. it tends to cross the 'normal' bedding in the rocks. There are several examples of cross bedding in the sandstone fragments of the wall. For example Photo 10 illustrates cross bedding. This fragment of rock has probably been placed 'upside down' in the wall because of the manner in which the inclined or 'cross' beds are truncated. Smaller scale examples of cross bedding (sometimes known as ripple cross lamination) are shown in cross section in Photo 11 and on a surface that is nearly parallel to the original bedding surface in Photo 12. These structures are formed in a manner similar to that in which ripples may develop today in fine sediments deposited by a fast flowing river current.

Primary Current Lineation. When a strong current carries sediment forward it sometimes causes arrangement of tiny elongate particles into streaks or lines. These are useful to the geologist for they show the direction in which the current was moving many millions of years ago. In the case of Photo 13 the current was moving from top left to bottom right or in the opposite sense, for current lineations do not allow differentiation of the sense of movement but give the direction of the current flow.

Evidence of Ancient Life

Plant fragments. Grey and black ‘coaly’ plant fragments are present in a number of sandstone blocks in the garden wall. Most of these are of uncertain origin but are almost certainly fragmented remains of ancient plants that were carried on water currents until they became waterlogged and sank or were caught somewhere and covered and buried by sediment. Such fragments become ‘coalified’, losing most of the elements they contain (e.g. oxygen, hydrogen, nitrogen and sulphur) to leave only carbon, which is commonly compressed under the sediment load to leave a ‘carbon film’ of the plant or plant fragment (Photos 14, 15). In some cases, fragments of plant are recognisable as such and there are two such cases in the wall. In one case (Photo 16) two plant stems (about as thick as a pencil) are preserved. In a second example (Photo 17) a fragment of a similar but much larger plant stem is preserved. In both cases the stems show a ribbed ornament. These plants may have resembled modern bamboos.

Animal Activity. When pieces of an animal are actually preserved (e.g. bones or shells) they are called ‘body fossils’ but when all that is preserved is evidence of the life activities of an ancient creature (such as trails or burrows) these are called ‘trace fossils’. Sandstone blocks in the wall contain some good examples of the latter. Photos 18 and 19 show the undersides of fine sandstone or siltstone beds that are replete with evidence of the burrows once occupied by worms that existed by eating their way through the sediment and leaving behind a small tunnel or burrow filled with the material that had passed through their gut. Thus although the organisms are not preserved there is clear evidence of their presence and activity as they burrowed their way through the soft sediment in search of something tasty to eat, 350 million years ago.

Summary

Thus there is a story behind the garden wall. It is not merely a bunch of old rocks that were thrown together as a protection from the wind and predatory creatures (including humans). When you look closely at the pieces that constitute the wall, you discover rocks fragments of two kinds, sedimentary and a (very few) igneous. The sedimentary rocks are mostly sandstones but there are also coarser examples (conglomerates) and a few finer ones (mudstones). The sedimentary rocks show various structures ranging from bedding and cross bedding to primary current lineation. Some of the rock fragments contain evidence of ancient life, in the form of plant fragments, both unidentifiable flattened carbon films and ornamented cylindrical shapes representing the stems of ancient plants that were buried and preserved in the sediment when it was laid down. Animals are represented only by trace fossils but they show evidence of the existence of a thriving community of soft bodied animals (worms?) that made their living by ingesting fine sediment (and contained organic particles) and left a tell-tale trace of burrows in the sediment. Next time people get excited about an antique which may be a couple of hundred years old, take them into the garden and (in addition to showing them the modern plants) let them feast their eyes on rocks and fossils that formed over 300 million years ago! The story behind the wall is both very ancient and complex. Much can be learned by looking carefully at these ordinary blocks of stone.

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Photo Descriptions

Photo 1. The east wall to show the light-coloured Carboniferous sandstones of which it is mostly made. The darker portion is the old wall.

Photo 2. Fragment of red/purple sandstone that may possibly be Old Red Sandstone, which is older than the Carboniferous.

Photo 3. Conglomerate composed of sandstone with larger (pebble sized) fragments, many of which have been eroded away. Note that the rock also displays cross bedding – the bottom layers show normal bedding but the main part shows bedding at an angle to this (known as cross bedding).

Photo 4. Conglomerate made up of white sandstone with small pebbles (dark) of mudstone. These mudstone fragments were probably formed when strong currents picked up fragments of semi-consolidated mud that had hardened enough (by drying out?) to form cohesive lumps.

Photo 5. Fragment of grey, rusty-weathering mudstone. Such rocks are rare in the wall because mudstones tend to be too soft to stand up to the ravages of the weather but this little fragment managed to become part of the otherwise sturdy wall.

Photo 6. One of the rare igneous rock fragments in the new wall. This rock is a dolerite or gabbro, which formed when an intrusion of magma (molten material from depth) cooled slowly and solidified into visible crystals of minerals such as feldspar and pyroxene.

Photo 7. This rock is similar to that shown in Photo 6 but it is somewhat coarser textured so that individual crystals can be easily seen. The light coloured minerals are feldspar.

Photos 8, 9. Parallel bedding in fine sandstones. Such layering is formed when the current strength changes slightly or when the composition or texture (grain size etc.) of the supplied material changes over time.

Photo 10. Possible cross bedding in a sandstone. True bedding may be approximately horizontal, whereas the cross bedding is at a distinct angle. This is caused when strong currents throw the sediment into sand waves (like ripples or small scale sand dunes) within which the bedding is inclined at an angle.

Photo 11. Small scale cross bedding (lower part of the block) showing the ripple-type shape in cross section. Inclination of the small scale cross beds indicates that the current moved from left to right.

Photo 12. Small scale cross bedding (as in Photo 11) but I this case, instead of seeing a cut cross section, we see a bedding plane view with the ripples picked out by carbon-rich material preserved on some of the beds.

Photo 13. Primary current lineation, caused by alignment of small particles in a strong current. The current must have travelled from top left to bottom right (or in the opposite direction) for the lines on the bedding plane have that orientation.

Photo 14. Small carbon-rich plant fragments preserved in a massive sandstone. The biggest fragment is above the coin.

Photo 15. Bedding plane view to show a multitude of black, carbonaceous plant fragments preserved by being buried under layers of accumulating sediment.

Photo 16. Pencil-sized fragments of plant stems. These are well preserved and show ribbing ornament along the length of the stem.

Photo 17. Stem fragments of a larger example of the same sort of plant as that shown in Photo 16. The ribbed ornament along the length of the stem is once again apparent.

Photo 18. Abundant worm burrows on the base of a bed of siltstone or fine sandstone. These structures point to the existence of a thriving community of burrowing organisms (worms?) that churned up the sediment in search of food.

Photo 19. A second example illustrating the activity of animals in the sediments that now form rock fragments incorporated in the wall. Small animals dug these burrows about 350 million years ago and the evidence of their activity has been preserved in the rocks.

Plate 1

Plate 2

Plate 3

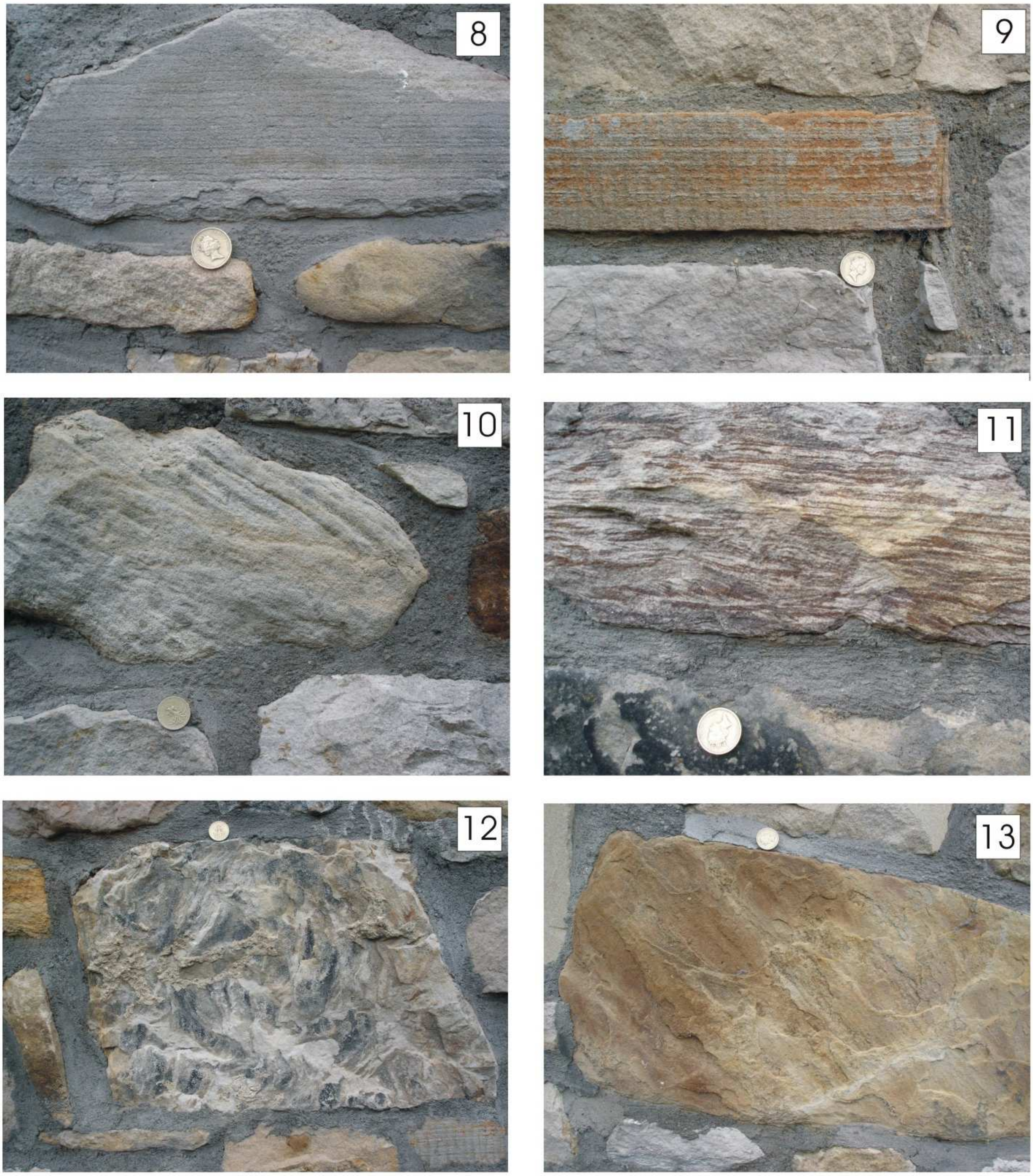

Plate 4