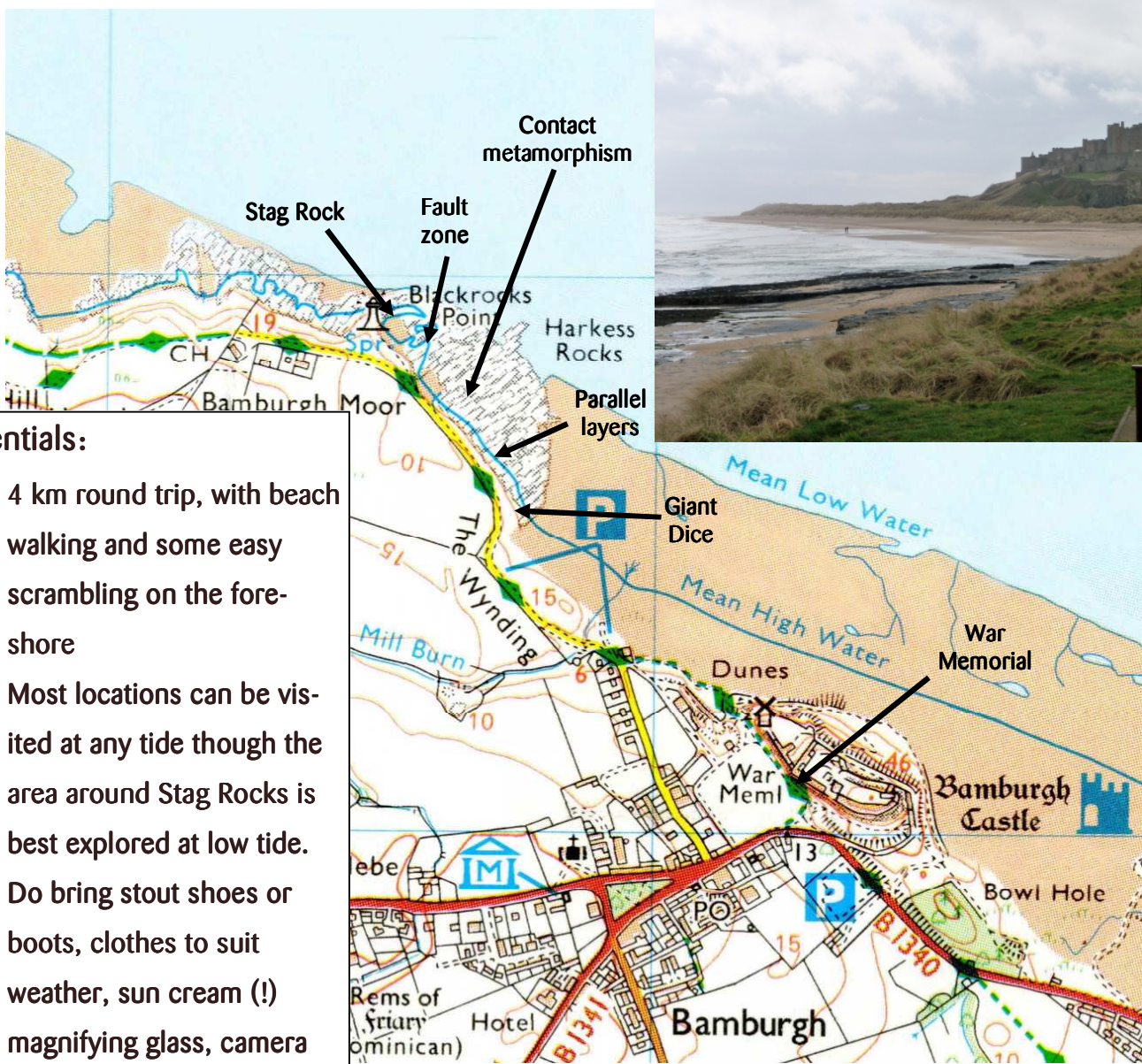


Northumberland Coast Rock-Walks

Exploring the landscape
and its geo-diversity

The Igneous Underground – the Whin Sill at Bamburgh

Bamburgh Castle is an imposing landmark from our military history; but what were the events in pre-history that formed the crag on which it sits? Explore the geology of the Whin Sill on this short walk from Bamburgh to the lighthouse at Stag Rock.



Essentials:

- 4 km round trip, with beach walking and some easy scrambling on the fore-shore
- Most locations can be visited at any tide though the area around Stag Rocks is best explored at low tide.
- Do bring stout shoes or boots, clothes to suit weather, sun cream (!) magnifying glass, camera and binoculars

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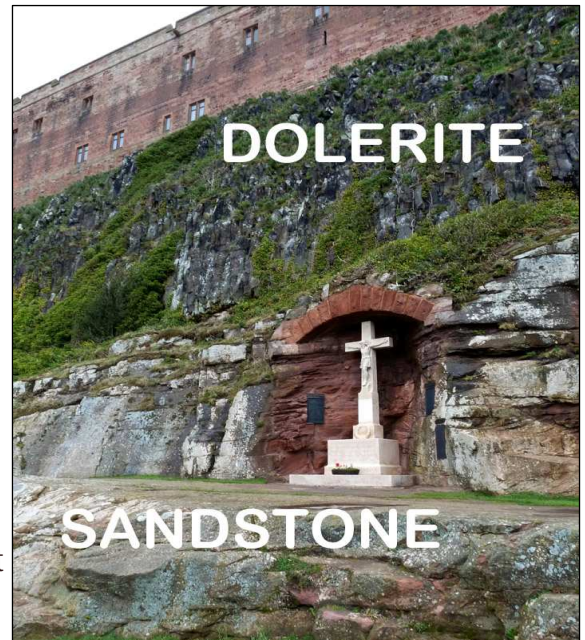


Start

Start the walk at the war memorial at the bottom of the castle crags at the edge of the cricket pitch.

Take a look at the pinkish coloured rocks immediately behind, and surrounding the war memorial. Notice how the rocks are laid down in extensive horizontal layers (picture 1) and that between these layers there are fine striations cross-cutting at different angles (picture 2). These are sandstones laid down by ancient rivers, with the fine striations – called cross-bedding - a feature of sediments laid down as ripples (see box 1, below on boundaries).

Now look up above the arch of the war memorial and right up to the castle walls, and compare the massive dark grey blocky rock here, with large vertical joints, with the pink layered sandstones next to you. This distinctive dark rock started out as molten rock at temperatures of over a 1000°C, which was intruded between the layers of sandstone and other sedimentary rocks. Now cooled and crystallised, the joints formed as the rock chilled and shrank to form this hard rock called dolerite. This igneous intrusion is



Picture 1: War memorial at Bamburgh



Picture 2: Cross-bedding in sandstone

part of the Whin Sill (see box 2), which form rocky crags across Northumberland and County Durham.

Now walk along the path under the Castle Crag heading north. Follow the path as it bends around the castle onto the beach. At this point look back, and make a mental note of the height of the crag face which is all part of the Whin Sill here. Having done this, walk north across the beach admiring views of the Farne Islands, which are also part of the Whin Sill, and now a superb habitat for a wide range of nesting seabirds.

Box1: Different Boundaries

Boundaries are fascinating because they tell us useful things about what happened to form them. At the war memorial there are three different sorts of boundaries. First there are the extensive flat layers which are parallel to the ancient land surface on which these sandy sediments were progressively laid. Secondly there is the fine cross-bedding between the layers. Ripples invariably form when sediments are deposited from flowing water, and the way the sediment is deposited depends on how the water is flowing - how fast, which direction, how deep, with how much sediment. In rivers - which flow in only one direction unless tidal - sediment is deposited on the downstream edge of asymmetric ripples leaving behind cross-bedded sediments. If the direction of flow in the river changes, or a new channel is formed, then the cross-beds may be cut by a new regime of cross-beds. This is what we see here. The boundaries between the sets of cross-beds tell us where erosion has taken place, and, within a given set, the angle of the cross beds tells us the direction of flow which laid them down.

The third boundary is between the Whin Sill and the sediments. Exploring this boundary you can find evidence that sediments next to the sill have been baked. Elsewhere you can see that the very margin of the sill is much more finely grained than the main body. This is as a result of the edge of the magma flow being chilled by the sediments so that it cooled and crystallised more quickly. This boundary yields evidence that tells us that the Whin Sill is younger than the sedimentary rocks through which it has been intruded.



Harkess Rocks

Keep going north along the beach towards the rocks and “giant dice”, which are tank traps, a small remnant of the World War II sea defences. To the north and west of the dice is a hummocky rock surface, much of which is the top surface of the Whin Sill. Note how this is sometimes smooth and sometimes



Picture 3: Amygdale

quite slaggy looking. Look here for holes and cracks (see pictures 3 and 4) filled with white minerals.

Molten rock sometimes contained dissolved gases, which emerged, like champagne bubbles. These gas bubbles rose through molten rock leaving the holes, or vesicles, in the rock.

This shows where the top was



Picture 4: Calcite vein

when the rock was liquid. Residual heat from the magma also caused ground-water to heat up and circulate through the porous sedimentary rock. This then dissolves some minerals in the sedimentary rocks which are later re-deposited, as the water cools, in the cracks and vesicles to form the white crystals of calcite and quartz that we see here. These filled in vesicles are called amygdales. Look around and you can also find some small patches of rock that look like stretched sticky toffee (see picture 5).



Picture 5: Flow texture in amygdale

This dark, somewhat shiny and wrinkled rock may well be the inner surface of cavities that formed as the cooling but still sticky and molten dolerite flowed horizontally. Captured in the frozen curve of these wrinkles is the suggestion that the molten rock was flowing from east to west.

Box2: So what is the Whin Sill?

Around 295 million years ago, late in the Carboniferous period when the land that is now England was much nearer the Equator, there was a period of enormous earth movements and crustal stretching affecting this area. This allowed huge quantities of molten rock (magma) at temperatures of around 1100°C to rise up and spread out rapidly as intruding horizontal sheets, called sills, between the Carboniferous rocks that had been deposited in the previous tens of millions of years. Here the rising magma formed a sill because the liquid rock naturally flows along the easiest path. At this depth of lateral intrusion through the horizontal layers of rock was easier than upwards intrusion. As the magma cooled it crystallized to form a hard rock, dolerite, which is locally known as “whinstone” and this is the rock of the Whin Sill. Rocks formed from magma are called igneous rocks. Cooling also resulted in cracks and joints and some of these formed columns, all of which you can see locally. At Bamburgh we are on the northern edge of the Whin Sill but it extends south to Teesdale and west to Cumbria. Most of it is still underground but here, as on parts of Hadrian’s wall, it is well exposed and up to 10m thick although elsewhere it can be at least twice as thick. Dolerite erodes more slowly than some of the surrounding rocks into which it was intruded. As a result it often forms rocky headlands, islands such as the Farnes, foreshores and, further inland, crags.



Parallel Layers:

Walk further north across Harkess Rocks a few tens of metres along the top surface of the sill. Here you will find that the Sill appears to be in layers or sheets (diagram 1) suggesting that there was a second flow or pulse of molten rock over the earlier, slightly cooled layer.

Walk on now towards Blackrock Point passing a nice example of contact metamorphism, to a small bay just south of Stag Rock. Here, there are some good examples of faulting in the rocks, most easily examined towards low tide. These faults occurred after the Whin Sill was intruded and hardened. In a number of places you can see a section of sandstone adjacent to the Whin Sill, but between the two is an area of crushed material caused when the faulting and movement occurred

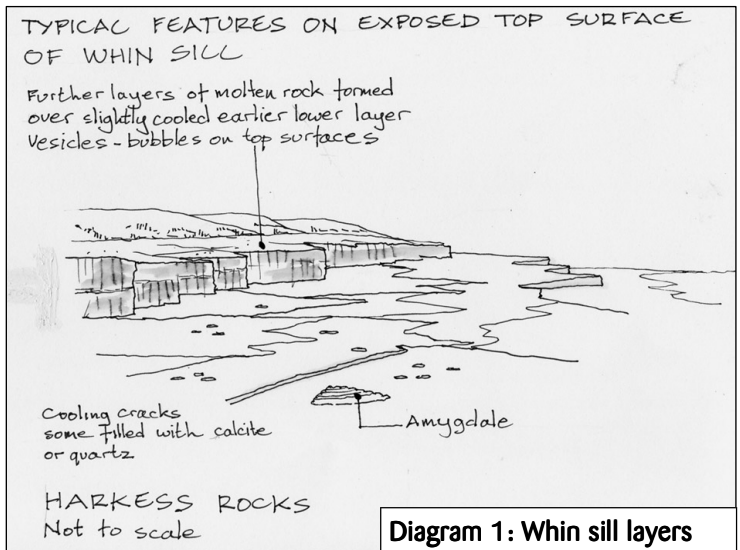


Diagram 1: Whin sill layers



Picture 6: fault zone

(picture 8). The sandstone and dolerite are hard to tell apart when weathered and can only be definitively distinguished with a hand lens. Under magnification the sandstone can be seen to be made of rounded grains of sand whereas the dolerite is composed of interlocking crystals

Box 3: The Restless Earth

The faults which we see next to Stag Rocks are evidence that this part of the world has not always been as stable as it is now. Earthquakes of any size are rare here. Earthquakes are caused by the release of tension when bits of the earth are moving against each other along fault lines. So the fault line we see here is a distant echo of an earthquake that happened many millions of years ago.

There are different types of fault depending on whether the earths crust is being stretched or squeezed - geologists call these normal (squeezing) or reverse (stretching) faults. Faults usually cut the rocks at a steep angle so that the rock on one side of the fault, the "hanging wall", hangs over the rock on the other side. If the rock on the hanging wall side has moved upwards relative to the other side of the fault, then we are dealing with a normal fault, and vice versa. Diagram 2 explains this some more.

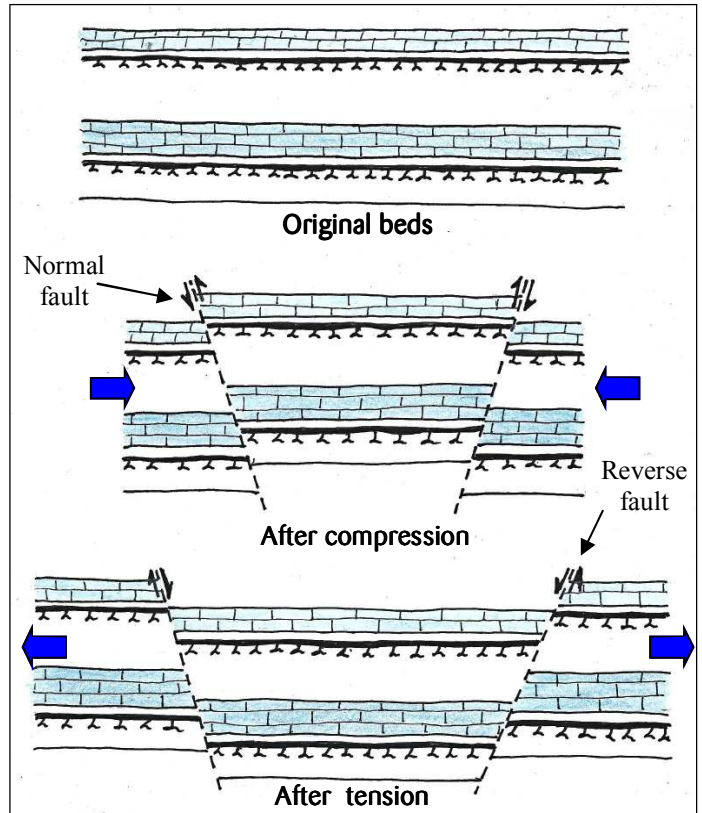


Diagram 2: Normal and reverse faults



Stag Rock

The Whin Sill here is only some 3 to 4m thick (compare this to the Castle rock). You can easily see the bottom of the sill as it has been greatly undercut resting on a softer shale which has been more rapidly eroded by the sea (shale is a fine grained rock formed from compacted clay or silt and is a type of sedimentary rock).

To the left of the Stag the Whin Sill rises over limestone. This occurred when the molten rock was being intruded, exploiting joints in the hard limestone to find the easiest path through (picture 7). In this area you will also see large circular holes in the limestone which are due to weathering of the rock.

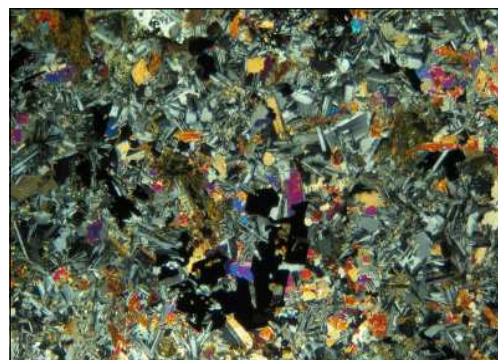
This is not to be confused with vesicles which are a unique feature of igneous rock such as the Whin Sill dolerite.

To the right of the Stag the sill overlays a layer of limestone in which you can find small fossils (picture 8) such as corals and crinoids.



Picture 8: Limestone fossil

Crinoids, also called sea lilies, look a bit like a plant or the stems of plants but is in fact an animal related to sea urchins. Limestone is another sedimentary rock often laid down in shallow warm seas and suggests that the whole area was then much nearer the equator.



Picture 9: Dolerite in thin section



Picture 7: Whin Sill at Stag Rocks

Box 4: Back to the Lab

The dolerite of much of the Whin Sill looks rather dull and grey to the naked eye. However, back at the lab with a microscope and geo-chemical analytical tools, more exciting and sometimes beautiful stories are revealed.

Rocks can be cut into slices which are so thin you can see through the rock like a stained glass window and study the different minerals in detail (picture 9). One of the minerals, which you can't see through even with the rock in thin section is an iron oxide. Amazingly, when these tiny crystals solidify, they freeze in the magnetic field. This gives us an ancient compass telling us where North was when the magma was intruded. Not only this, by looking at the tilt of the magnetic pointer you can find out how far the crystals were from the North Pole when they froze. What this tells us is that when these rocks were cooled, Bamburgh was somewhere close to the Equator.

If you would like to find out more about how the movement of continents is explained, then you will need to explore the exciting history and science of plate tectonics. There is good information online as on the BBC website, Wikipedia, and through the United States Geological Survey. You can also use the Open University "Learning Space" or even register on one of their courses.

The other thing is that frozen into the magma is a radioactive clock using the elements Rubidium and its decay product Strontium. This tells us quite accurately that the Whin Sill was intruded some 295 million years ago.