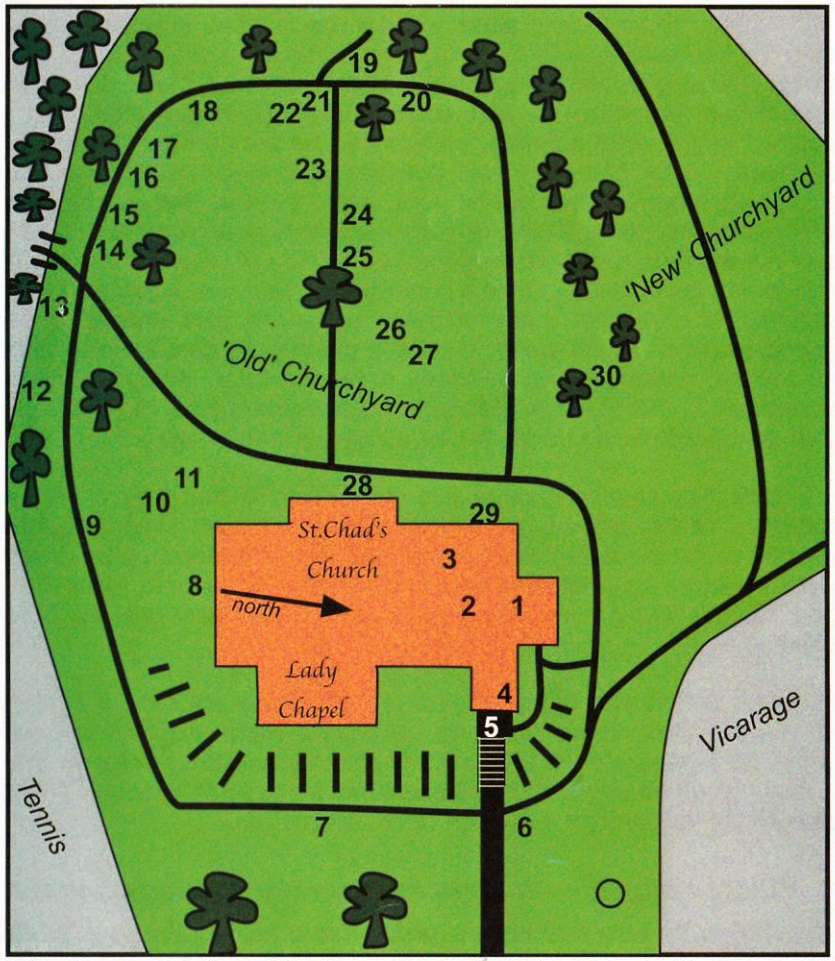
Further Reading: *The Building Stone Heritage of Leeds. Dimes & Mitchell. Leeds Phil. & Lit.Soc., 1996.*

WJVarker/Chadtour/pages/2013

ST. CHAD'S CHURCH

FAR HEADINGLEY

Geological Trail



Follow the route indicated by the guide numbers, beginning inside the Church

St. Chad's church was dedicated on 11th January 1868 and it is therefore a Victorian church, built in the then popular gothic revivalist style. It was considerably extended from 1909 to 1911. An unusual feature is its approximate north/south alignment *i.e.* parallel to Otley Road, from where it provides dramatic visual impact. The building material was a locally derived gritstone known as the "Rough Rock", which during the 19th century was being quarried in many small quarries across north Leeds. These have now all closed down and have more or less disappeared, but it is often possible to determine the precise source of the building-stone by examining the stone masons' marks, or 'tool marks' (see location 8).

Burials began in March 1868, with the majority occurring during the period 1890 - 1940. Since Britain already had a national rail network at that time, stone for headstones was available from almost anywhere in the country, the only limiting factor being cost. Locally derived rocks do of course predominate, but there are also rocks from much further afield that were imported into coastal quarries, particularly the famous granite quarries at Aberdeen. After being cut and polished at that location, these 'foreign' rocks were often sold-on under new 'trade names' that ignored correct geological convention. Many were consequently wrongly named, and were often not even derived from their implied country of origin. There are many such examples in the St. Chad's churchyard. However, in addition to being durable and attractive, many of these rocks are also unique to certain specific locations in the world, making it possible to determine where they came from, sometimes even down to a particular quarry. There are headstones in the St. Chad's churchyard fashioned from rocks from India, Brazil and South Africa, for example, as well as from many parts of Europe.

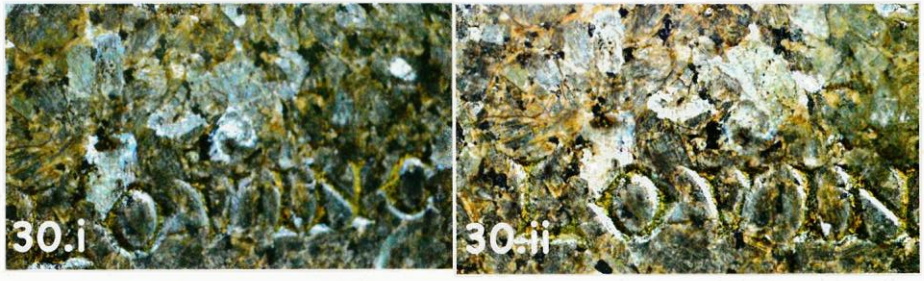
One further unusual feature of this churchyard is that only a very small proportion of the graves are aligned East/West, and even these do so because of the irregular outline of the churchyard rather than by design. It would therefore be confusing and entirely false to assume (do you watch Time Team?) that graves that do not point to the east are not Christian burials!

Do not be deterred by the geological terms. These are kept to a minimum and are explained as we go along. Numbers in the text refer to positions on the front-page plan. Italicised, bracketed surnames refer to the first surname given on any particular headstone, for ease of location. The lower scale on the yellow tape is in each case centimetres.

Please remember that gravestones are memorials to the deceased, so you are requested to treat them, the graves they represent and the church precinct in general, with respect.

so it is not possible to replace crumbling stone with new blocks of identical material. The best local match for Rough Rock is from the hilltop quarry just to the east of Bramhope, which exploits a slightly older gritstone horizon (*i.e.* it is the gritstone beneath the Rough Rock). Unfortunately this rock also contains more iron oxide, which accounts for its stronger orange colour, and it is therefore never likely to be a perfect colour match for the rest of the church, even after it has 'weathered-in'. Notice the strong directional orientation of the different layers of sediment. Some layers are coarse and contain quartz pebbles, whilst others are finer grained with more iron stain.

30. ***(Walker)*** There is one final rock type in the tour. It is in the newer part of the churchyard, but since it does not occur in the older part, and it is a very unusual type of rock, it is worth the slight excursion through the trees.

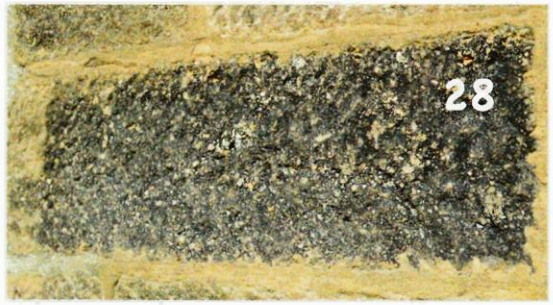


This rock is an igneous rock that consists almost entirely of very large crystals of a variety of felspar known as **Labradorite.** The complex layered structure within the crystals causes light to be reflected backwards and forwards within each crystal. This in turn causes the crystals to change colour as you move your head from side to side.

The two pictures above are of exactly the same piece of rock, the only difference being that the camera was angled more in one picture than in the other. The rock is called **Larvikite** and is named after a small town in southern Norway, which is the only source of this rock. There is a lighter coloured, bluer version of the rock at the same locality, that is extensively used as a polished facing stone for shop fronts, hence the colloquial student name for the rock - 'shopfrontite'! Since this rock is so easily identifiable, and it originates only in Norway, the rounded pebbles of it that are washed out of the boulder clay along the the Holderness coast indicate that the ice that deposited the clay must have crossed over from Norway about 20,000 years ago.

extremely durable rock as witnessed by the complete lack of any weathering/ solution effects, except the accumulation of dirt and algae. Note that the edges and corners of the cross, for example, are still as sharp as the day they were cut.

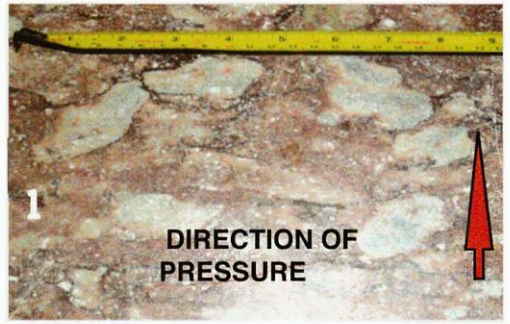
28. Remember discussing the evidence for the use of re-claimed stone in the 1911 additions to the church? There is further evidence here. At head height, in the centre of the wall immediately to the left of the steel gates, there is a rectangular, sooty block with the indistinct remains of a word(s) carved into its surface. See if you can decipher what it said. It appears that this word, which had letters perhaps 5 cms high, was already weathered and blackened before the stone was recovered from a previously demolished building to be incorporated here into the St. Chad's 1911 extension.



If you look into the porch at this location you will see that the shaped stonework around the arched doorway etc. all bears the Harehills tool mark, and was probably commissioned new for this purpose. It was the general building work of the extension that employed re-used stone with the Meanwood tool mark.

29. Notice that the stone blocks used for repairs have a brighter colour than the rest of the stonework. This is not just because these blocks are new. The local **Rough Rock** quarries have been filled in and lost,

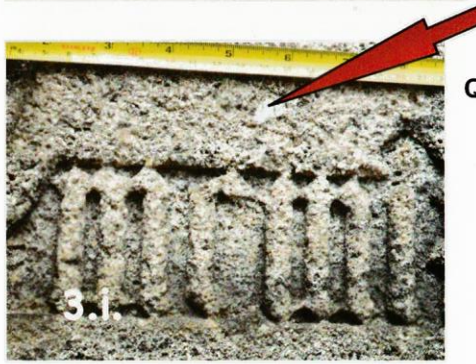
This geological trail is purposely confined almost entirely to the church and to the older parts of the churchyard, even though some of the more exotic, 'long distance rocks' are in the newer part. Begin inside the church and then follow the route outlined by the numbers on the front-page plan, stopping at each numbered location.



1. This strip of brightly-coloured stone just inside the crèche screen is a metamorphic rock (*i.e.* it has been changed by intense heat and/or pressure) called a **breccia** (pronounced "bretchia"). It consists of limestone fragments, (including some fossils) that have been squeezed by enormous pressure in the roots a mountain chain; in this case probably the Alps. The red colour is due to the presence of iron oxide.

2. The font was carved from a fine-grained **sandstone** (sand grains fastened together), called the **Thornhill Rock or Sandstone** (c.305 million yrs. old – ages of sedimentary rocks are determined from the fossils they contain), from Morley. Intricate, high quality sandstone carving such as this (see insert) is only possible if the rock is fine-grained and uniform in character. (Compare with No.3 below).

3. Like most of the church, the columns (3.ii-iv) are constructed of locally quarried, coarse-grained **gritstone** (sandstone with very large grains) called the **Rough Rock** (*c.*315 million yrs. old). This excellent building stone was much used in West Yorkshire *e.g.* Leeds Town Hall. However, its large grains and the presence of quartz pebbles (3.i) render it



unsuitable for detailed carving. To obviate this problem a piece of the much finer-grained **Thornhill Sandstone** (*n.b.* the font?) was inserted at the top of each column, for the carved capitals. Photographs ii - iv show details of the 'stiff-leaf' design (a Gothic design much re-used in Victorian times) of the capitals inside the church. Note that whilst these capitals are all of the same basic design, the work of each stone mason was unique. These blocks would have been carved at the quarry, near Huddersfield, and brought here ready to be inserted.

Look upwards and confirm that in fact all of the carved features are pieces of Thornhill Sandstone that have been inserted into the structure.

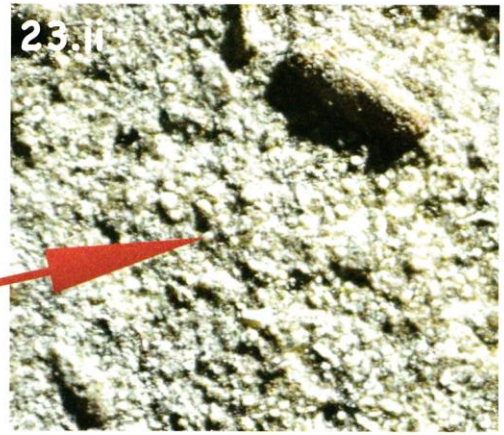
For comparison, photograph (v) depicts similar carvings in **Rough Rock** from the church porch. The difference in quality of carving is obvious and is entirely the result of the differing physical properties of these two rocks.

4. In addition to being coarser than the Thornhill Sandstone, the Rough Rock also contains **felspar**, a mineral that slowly decomposes (weathers) into clay, and may cause the rock to become soft and crumbly. One particularly large felspar crystal (2 cms) can be seen at waist-height on the column that projects furthest into the doorway of the porch, on the left as you are leaving. Felspar can be many colours; here it is reddish, and this is a variety that will be seen later in a famous igneous rock.

solution has taken place, combine to make deciphering this inscription (see arrow above) rather difficult, but if you persevere you will see that this is the grave of the Revd. Stables, vicar of St. Chad's from 1896 until 1906.

26. (***Haste***) A **shiny black curb** without a headstone. This curb is made of glazed, fired clay and is therefore not a natural rock at all but rather a type of brick material, with which it compares in durability. It is an example of **Burmantofts Faience,** a product for which Leeds became justifiably famous in Victorian times. Many city centre buildings of that period are faced with this material in bright colours. Black was the preferred colour for grave curb-stones. It produces a more intense blackness than that seen in polished black rocks but although its surface is extremely shiny, it is not as flat as a polished rock surface, giving rise to rippling shadowy effects as you move your eye across its surface. Examine the chipped edges - the colour is only a surface glaze - if this had been a natural rock the colour would have penetrated throughout.

27. (***Renton***) A large, ornate **sandstone** cross. This cross is cut from the best local material for headstones. It is a hard, fine-grained sandstone, (much finer grained than Rough Rock, and harder than Thornhill Sandstone) in which the sand grains (quartz) are firmly cemented together by silica (which is what the quartz is made of). This is therefore an

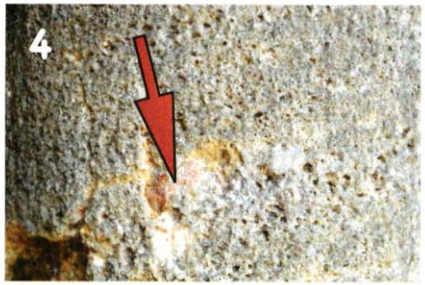


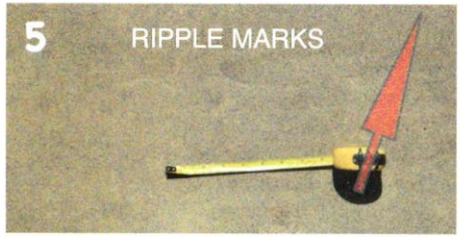
Portland in Dorset, having been formed in a shallow sub-tropical sea at a time, 150 million years ago, when Britain was at about the same latitude as the present-day Mediterranean. It accumulated as lime deposited in an evaporating lagoon, protected by a reef, but with waves breaking over the reef causing the water in the lagoon to oscillate. This in turn caused the lime mud on the floor of the lagoon to roll into tiny limy spheres (**ooliths** - 23.ii). These are what look at first sight to be the 'grains' of the rock, but with a hand lens each 'grain" is seen to be a tiny 'snow-ball' of lime. Such rocks are described as **oolites,** from the Greek meaning "egg stone" *i.e.* they look to have the texture of fish roe. See if you can see the spheres, which are about 0.5mm in diameter.

24. (***Whitehead***) Large flat slab of **slate.** Slate is a metamorphic rock. This example accumulated as mud on the seabed in what is now North Wales, 450 million years ago. When the Welsh mountains were formed, the mud was compressed and heated, and so was converted into the much harder slate. This blue-grey colour is a typical Welsh slate colour (there are also blue and purple ones, with green slates being more typical of the Lake District). Being slate it cleaves into flat slabs or 'slates', depending upon how thick they are. This is an extremely durable rock, well suited to roofs and gravestones.

Notice that the inscriptions on this slab indicate some deaths that pre-date the building of St. Chad's church in 1868. The explanation for this apparent anomaly is also in the inscription.

25. (***Stables***) A large, flat slab of **crystalline limestone**. Rock similar to this has already been seen, but it is interesting to read the inscription that goes all around this slab. The style of the script and the fact that some



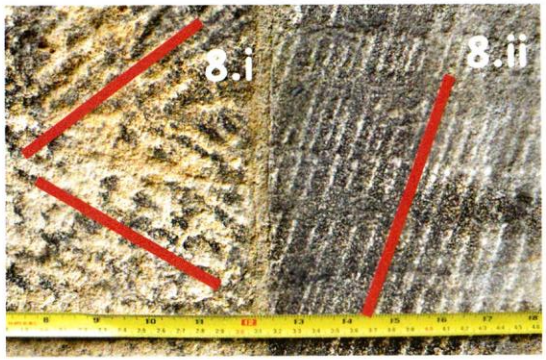


5. Notice also the huge slab of fine-grained sandstone at the top of the steps. This is an example of **Elland Flags,** which contains layers of mica that cause it to split into flat slabs suitable for headstones and paving flags (the so-called '**Yorkshire Stone**'). This slab is exceptionally large and it is worth pondering how it was brought here from near Huddersfield. Also see if you can spot the parallel alignment of 310 million yrs. old ripple marks on this surface. Unlike ripples on a modern beach these are not raised because the slab of rock has been ground to a flat surface.

6. Look up towards the clock-tower, where the building stones are uniformly blackened and shaped. The blackness is due to soot, mainly from domestic fires, and its uniformity here indicates that these blocks have all been exposed to weathering for the same amount of time *i.e.* they form part of the original structure of the church. (Compare with 7. below.)

7. Here at the Lady Chapel, the stone blocks vary in size, shape, blackness and even composition. This all indicates that re-used stone from previously demolished buildings was used to construct the newer parts of the church, *i.e.* those parts dating from 1911. This was/is normal practice; every stone block bears the evidence for having been dressed by hand – they were/are too valuable to discard. For information regarding repairs to the church fabric, as seen here on the south wall of the Lady Chapel, see No. 29.

8. Each mason left his company/quarry mark on the stone blocks he dressed (carved). These are known as 'tool marks'. On the "East" wall of the church (actually the south wall because of the church's unusual orientation), you will see that most of the stone blocks have a herring-bone (chevron) pattern chiselled into their surface (8.i).

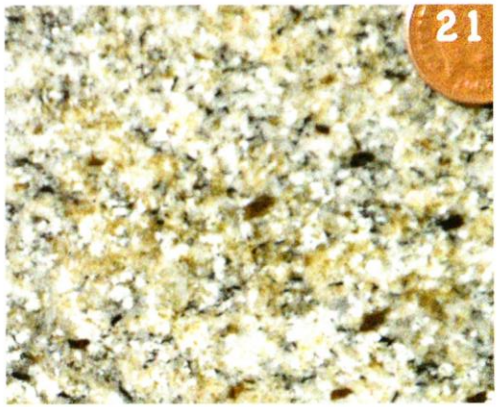


These should all point the same way but 20th century builders were not that particular! In north Leeds these chevron tool marks represent a long-disappeared 19th century quarry in Meanwood. Can you see any different tool marks? Look at the stones surrounding the two small windows – they have oblique, parallel tool marks (8.ii) from another filled-in quarry, in Harehills (Leeds).

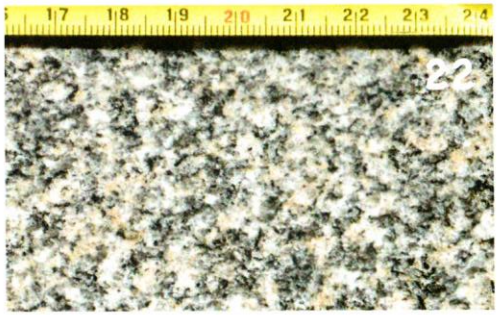
9 (***Cullingworth***) Polished white **Aberdeen granite** headstone. Unlike the **sedimentary** rocks seen so far, that accumulated as sand grains on the sea-bed, granite is an **igneous** rock *i.e.* made of crystals that formed when hot molten rock (**magma**) cooled below 1000^{0}C and started to freeze. This is the same process that converts liquid water into solid water – ice, but much hotter! Igneous rocks like granite are hence frozen liquids, consisting of interlocking crystals, making them hard and durable. They can therefore be polished to a mirror finish (this cannot be done to sandstone), which in addition to making them attractive, reveals their component minerals more clearly. Since the crystals in granite are by definition large (up to 2 cms in this example), cooling must have taken place very slowly, perhaps over millions of years, 5-10 kilometres below the Earth's surface. Whenever granite is visible at the surface, *e.g.* on Dartmoor, this is the thickness of rock that must have been removed by erosion. ***All*** granites contain **quartz** (colourless crystals), **felspar** (white here but can be many colours) and **mica** (here black), and

20. (***Marshall***) Small cross of unpolished **"Cornish Giant White" granite**. The name given to this granite is a clue to its most obvious characteristics – it is very coarse grained and it contains an unusually high proportion of white felspar. Examine the cleaner rear side of the cross, where there are several very large (up to 5 cms) white felspar crystals. Note that they are parallel sided (*i.e.* show crystal form) and the largest even shows the inclined faces forming the pointed end to the crystal. This rock is from Bodmin in Cornwall, part of the Dartmoor complex, which has been shown by the measurement of its radioactivity to be about 290 million years old.

21. (**Granite** cross lying face down. (***Name obscured***) This attractive coarse granite has some felspars that are yellowish and a pale orangey colour, making it distinctly different from the Aberdeen granite seen elsewhere. It also contains rectangular dark crystals of a mineral called **hornblende** and silvery flakes of white mica (**muscovite**). Probably from Scotland.

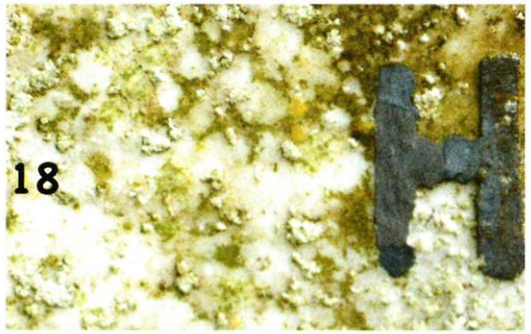


22. (***Crosland***) Ornate **granite cross,** upright, off its base. This is a darker coloured granite from Sweden, with large pinky/orange felspars.



23. (***Emsley***) **Portland Stone obelisk** (the tallest). This monument is constructed of Portland Limestone; the same white limestone used for the Leeds Civic Hall and University clock tower. It was a popular building stone in cities because, unlike sandstone for example, the solution effect meant that it remained fairly clean. The depth to which this monument has dissolved since its erection, is indicated by the fact that the numerous, sharp, curved, fossil **oyster** shells (23.i.) that it contains are protruding from the surface by about 2-3 mms. This rock comes from the Isle of

17. (***Glaisby)*** – Celtic cross of very coarse, rough-cut **gabbro**. This monument is of roughly chiselled gabbro in which the felspar crystals are almost white. This rock looks very different, and very beautiful, when polished. From Scotland or Norway.



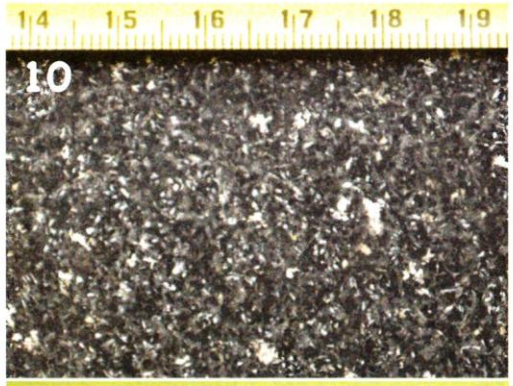
18. (***Grant***) Grey-veined **Carrara marble** headstone. The main output of marble from the famous Carrara quarry in Italy is of the pure white variety for sculpture. There are however other colours in the same quarry complex, one of which is this grey-streaked variety. The grey streaks are the result of slight impurities in the original limestone when it was being metamorphosed. One of the benefits of "limy" rocks in urban environments is that by slowly dissolving in rainwater, they remain relatively clean. Compare the white limestone lions outside of the Leeds Town Hall, with the building itself. The lions are dissolving and stay white, whereas the Rough Rock of the building does not dissolve and so accumulates dirt on its surface.

19. (***Slater***) Tall cross of unpolished **Carrara marble**. We have already seen that limy rocks slowly dissolve in rainwater. At No.19 we see the further damaging effect of moss that had grown on this marble obelisk. The lower part of each level of the base was until recently covered by moss. This held water, and consequently the marble was wet for a greater time than it otherwise would have been. The result is increased solution (dissolving) damage. Notice how the solution effect has picked out imperfections in the rock; the damage is not to a uniform depth over its surface.

these can be easily identified in this rock. **If these 3 minerals are not present, the rock is not granite.** Mica is slightly radioactive, enabling its age to be determined – important since igneous rocks cannot contain fossils. Aberdeen granite is about 420 million years old.

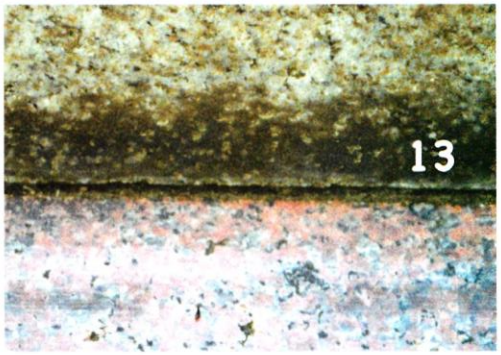
10. (***Peel***) Polished black **gabbro** headstone. Gabbro is also an igneous rock but it does not contain the 3 minerals listed at No.9. It actually contains large crystals of 2 types of felspar (in this case one is grey, the other nearly white), and an almost black mineral called **pyroxene,** that appears dark green under the microscope. Like granite, gabbro also forms deep below mountain ranges. This one comes from Norway and is one of the rocks sold under the trade name of "**Bon Accord**" (see No.14).

11. (***Dyson***) Polished red **granite** headstone. This rock contains the same 3 minerals as No.9, so it is a granite, but in this case the felspar is red (just like the felspar crystal you saw in the Rough Rock at the porch doorway). This beautiful and popular rock only occurs in Finland; it was imported into Aberdeen, cut and dressed, and then misleadingly sold as "**Balmoral Red**", presumably to give the impression that it was British and even had Royal connections - very good for sales but not for geological correctness!



12. (*Cooke*) Unpolished **Carrara marble** monument. Like the name "granite", the name "marble" is often grossly misused in monumental masonry, often being applied to any polished rock, irrespective of its origin or composition. Marble is always a metamorphic rock (remember No.1?) - originally a limestone that was heated, perhaps by volcanic activity, until the lime formed crystals. ***All*** marbles consist of uniform, interlocking crystals of lime (calcite), irrespective of their colour. If the original limestone was pure, the marble is white. Usually however impurities create different colour varieties of marble. Carrara marble (from one quarry in northern Italy), is distinctively white, hence its worldwide use for sculpture; being made of a relatively soft mineral, it is very much easier to carve than igneous rocks. The surface is not usually polished if the rock is to be used for external monuments, such as this one, because rainwater destroys the polish by slowly dissolving the surface, particularly in an urban/industrial environment. Run your fingers over its surface where it is clean and feel its distinctive sugary crystalline texture.

13. (***Oxley***) Pink **Peterhead granite** base overlain by grey **Aberdeen granite**. There are two granites at Peterhead (Scotland), a white one that is different from the Aberdeen granite already seen, and this pink one. As usual, the colour of the granite is controlled mainly by the colour of its constituent felspars.



14. (***Dean***) Black **gabbro** headstone. Unlike the gabbro seen at No.10, all of the felspars in this rock are dark grey, so it is a darker, more sombre rock much prized for grave-stones, particularly during Victorian times. This one was imported into Aberdeen from South Africa, but in view of the Boer War it was marketed under the name **"Bon Accord"**. In spite of the language this name has strong Scottish connections since it appears as the motto on the Aberdeen Coat of Arms. Most black gabbros soon traded under this name, partly to hide their origins and partly to imply that they were the same as this South African example. Like "Balmoral Red', it is a meaningless name geologically.

15. (***Whitehead***) Massive unpolished **Aberdeen granite** headstone. This is the same rock as that seen at No. 9 but in this case it is unpolished, clearly demonstrating that polishing a rock exposes details of colour, texture and composition that may not be obvious in the unpolished rock. Polished rocks also stay cleaner longer.

16. (***Marshall***) Celtic cross of weathered, **crinoidal limestone**, from North Yorkshire, or Derbyshire. This limestone consists of fossil fragments, mainly **crinoids** (related to sea-urchins) in a background of lime precipitated by the evaporation of seawater. Since the lime (calcite) of the crinoids dissolves in rainwater more slowly than the background lime, the fossils now stand proud of the surface by more than a millimetre, rendering the rock rough to touch – it would not have been like this when the monument was erected. It also indicates that this rock is dissolving away at the rate of about 2mms per century. Most of the fossils are fragments of the calcite (lime) stalk by which crinoids were fastened to the seabed. Look at the back of the cross – at about half height there is an oblique cross-section (16.i.) through a large crinoid stalk showing the latter to have been a hollow tube. The white circular structures near the base of the column (16.ii) are fossil **corals**. These indicate that this rock formed 320 million years ago in shallow, warm (min. 20^{0}C), salty (3.5% salinity) seawater that was clear and had strong currents. This information has long provided evidence that Britain was situated on the equator during Carboniferous times when this rock formed.