Inventory of the Building Stones of Devon

and adjacent parts of Dorset and Somerset

Volume II

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100, Fine-grained Ham Hill Stone

This building-stone type is composed of flat shell fragments set in a matrix of calcareous sand. The shelly clasts are thin and perhaps no more that 3mm in average long dimension and lie in and define the bedding (Figures 1 and 2). The stone is biscuit-coloured and closely resembles Ham Hill Stone except that it is much finer grained. Rarely, unoxidized stone is used in which case it is grey in colour. In some examples, larger pale grains made of crinoid ossicles are prominent. The building blocks tend to be small and irregular in shape but somewhat elongated in the plane of the bedding which is usually laid horizontally. The stone is of poor quality and is mainly used for rubble walling, in which case, the quoins and dressings may also be made of it or better quality stone is used - Ham Hill Stone and limestone from the Inferior Oolite for example.

This building stone is differentiated from Ham Hill Stone by smaller size of the component shell fragments which are also noticeably thin (Figure 1). It shows affinities with limestone from the Inferior Oolite, for example in containing prominent crinoid ossicles and some composite blocks containing both types of limestone have been seen (Figure 3). Some blocks are vuggy or contain inclusions of ochre mudstone, a feature also of the Forest Marble building stone used in the Hardingtons nearby. Considering its indifferent quality and the nearby source of good quality stone on Ham Hill, the stone is quite intensively used. (Figure 5). It is however, restricted in its distribution to the villages of Chiselborough, Merriot, the Chinnocks, Haselborough Plucknett and North Perrot. These villages all lie to the south of Ham Hill, suggesting a source also to the south of the Hill, perhaps in quarries developed in Ham Hill Stone known to extend to the south with diminishing quality as far as West Chinnock Hill and Chiselborough Hill.

Figure 1. South side of Gas Lane, Hinton St George.

Figure 2. Manor Farm, Middle Chinnock.

Figure 3. House in Church Close, West Chinnock. The block on which the coin is resting is a mixture of bedded limestone (Code 100) and nodular limestone resembling stone from the Inferior Oolite (Code 15).

Figure 4. A block of fine-grained biscuit-coloured bedded Ham Hill Stone, lower left, in a wall otherwise mainly made of nodular shelly pale sandy limestone from the Forest Marble (Code 166, qv). Old Stable Cottage, East Coker.

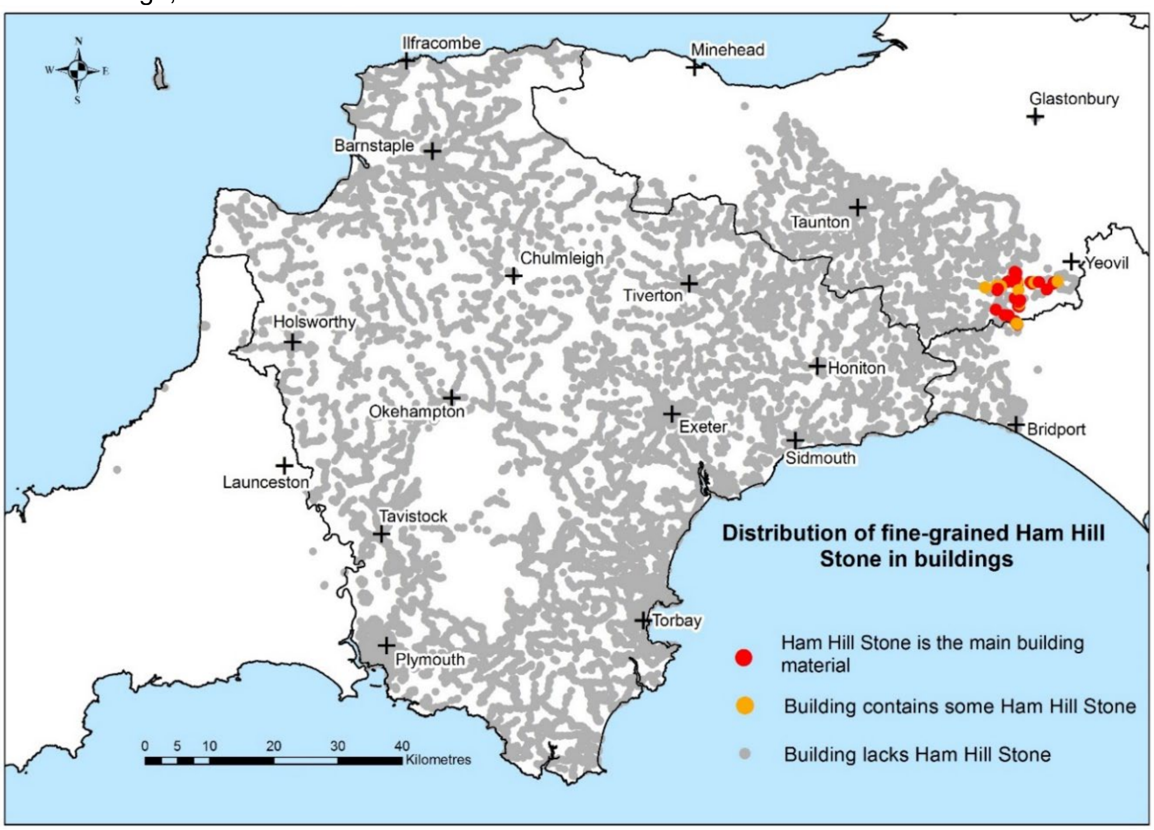

Figure 5. Distribution of fine-grained Ham Hill Stone in buildings.

102, Gastropod Limestone (Purbeck Marble)

Limestone made predominantly of gastropod shells with almost circular sections perpendicular to the bedding planes and up to 15mm across is a rare but widespread constituent of buildings, mainly but not exclusively, medieval churches (Figures 1-4). The rock is bedded, in some cases with a strong oriented fabric (Figure 3) and consists of the shells embedded in a rubbly sparite matrix in many cases quite dark grey or with a greenish hue. Initially it was thought that the limestone was associated with Pocombe Stone but later examples show this not to be the case. An alternative more likely identification is Purbeck Marble, an early Cretaceous fresh-water limestone widely used in English medieval churches – the few small external blocks seen being material left over from stone imported for internal ornament (Figure 5).

Figure 1. South porch of St Mary's church, Totnes.

Figure 2. Detail of Figure 1 showing the outlines of gastropod shells.

Figure 3. Strongly bedded greenish limestone with enclosed gastropod shells, wall of derelict cottage, east side of lane behind the museum, Topsham.

Figure 4. Gastropod limestone, Tower of St Peter's church, Uplowman

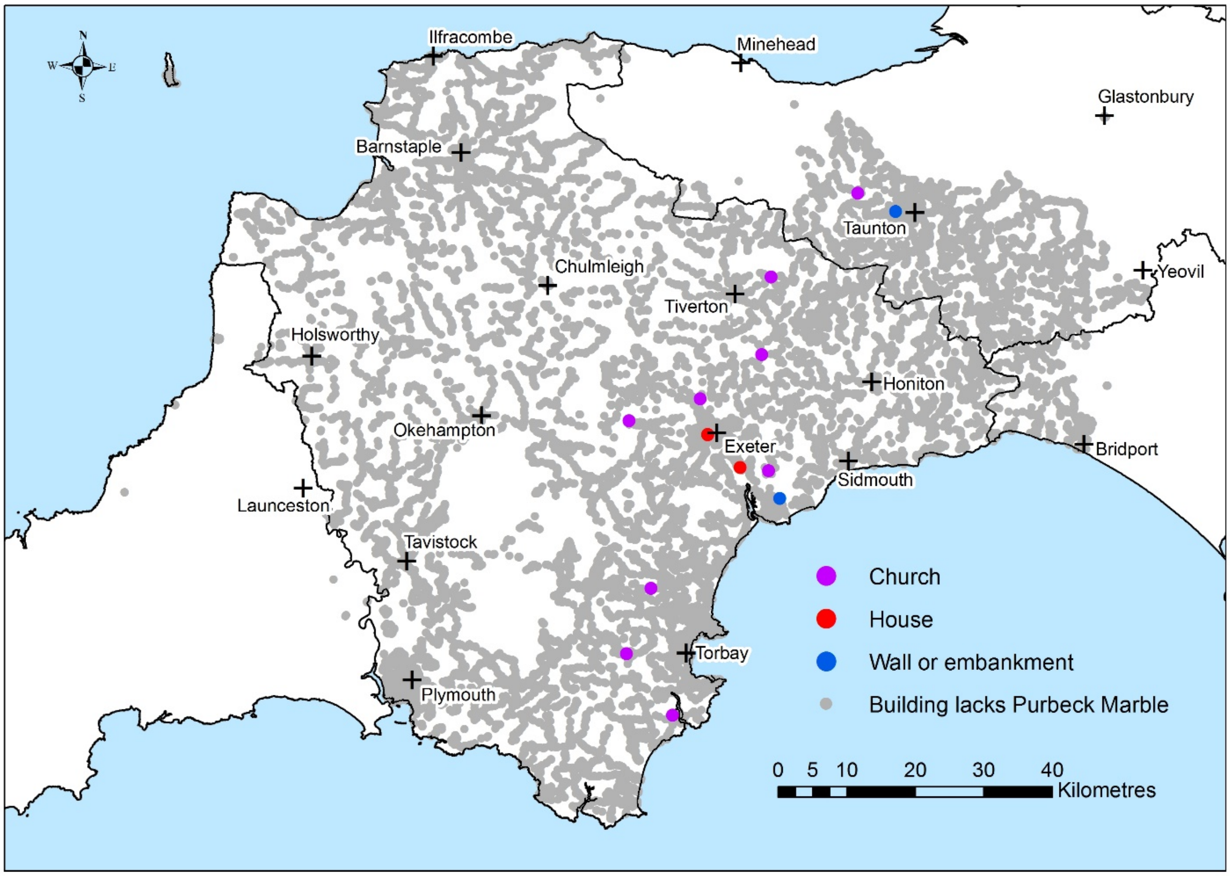

Figure 5. Distribution of Purbeck Marble by building type.

104, Speckled Limestone (Bampton Limestone Formation)

The rock has a compact texture but with a characteristic speckled “salt-and-pepper”, appearance caused by a mixture of darker and lighter grains (Figure 1). Some parts of the rock are coarse grained, of darker grey parts enclosed by lighter. The light parts are cream-coloured and include coarsely crystalline zones that may be shell fragments but many examples of this rock appear dark grey and typically lack obvious banding. The rock weathers to a rich ochre in some cases, reflecting its plentiful iron content, perhaps as siderite. It is associated with other rock-types of the Bampton Limestone Formation and occurs mainly close to that town (Figure 3). It is distinguished from the Bampton Limestone (Code 123) by a general lack of banding and chert and by its dark grey colour and ochre weathering, and from limestone of Code 137 of Huntsham by “salt-and-pepper” texture.

Figure 1. Speckled calcarenite. Wall at 107 St John’s Road, Exmouth.

Figure 2. Dark grey homogeneous medium-grained limestone with figured finish and with some blocks weathered ochre. The dressings round the door are of more normal banded Bampton Limestone. Tower of St Peter's church, Oakford.

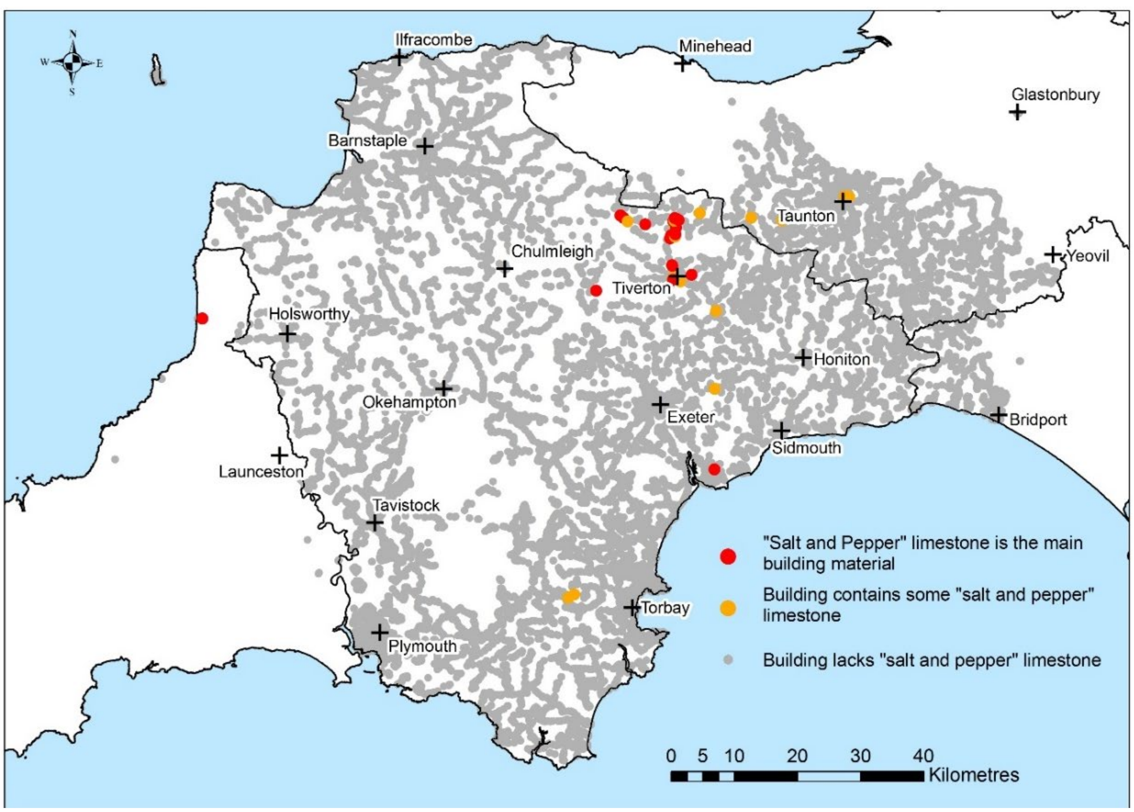

Figure 3. Distribution of "salt-and-pepper" limestone in buildings.

105, Cemented River Gravel

Four examples of this building stone have been documented, 3 of them in Whimple and the other in the Gun Terrace Gardens in Exmouth. The rock is a conglomerate composed of subangular to well-rounded pebbles to small cobbles, mainly of vein quartz, set in a gritty friable red sandstone matrix (Figure 1). During the fieldwork, it was thought to be a variant of the Budleigh Salterton Pebble Beds but it lacks the brown Silurian quartzite cobbles that are the main clast type in the south crop of that formation. It cannot be matched with any other conglomerate or breccia of the area. The suggestion is, perhaps it is a Quaternary deposit, a well cemented river gravel just about usable for building lowly structures like roadside walls.

Figure 1. Roadside wall, Church Road south of Whimple village centre.

106, Red Sandstone (Exeter Group)

Lithology code 106 covers sandstones referred to the Exeter Group, mainly drawn from the Dawlish Sandstone but probably also covering sandstones occurring as bands and lenses within the breccias of the Group. The sandstones show a wide range of characteristics no doubt reflecting a similarly wide range of depositional environments. They are fine- to coarse-grained – a substantial minority of examples were described in the field as gritty - and are well to poorly sorted. Well sorted varieties are described in the notes as clean washed, with sparse carbonate cement. Poorly sorted varieties, which are in the majority, may have pebbly lenses and contain lenses of breccia or conglomerate (Figures 1 and 2), or, very commonly, have a muddy matrix in which the sand grains are set. With few exceptions, the sandstone is rather soft; building blocks tend to have rounded outlines and exposed surfaces are smoothed by erosion. The sandstone is mainly brick red to deep red or maroon in colour (Figure 3). Varieties mottled in red and fawn occur around Dawlish and Stoke Cannon (Figure 4).

The clasts are mainly of subangular to subrounded quartz with many examples containing a coarser-grained fraction of well-rounded grains with a frosty surface finish believed to have been transported by the wind. Quartz is joined by chalky yellowish feldspar and lithic fragments in some cases. The pebbles of pebbly sandstone, breccia and conglomerate are mainly of exotic rock-types similar to those of the Heavitree Breccia but vein quartz is more prominent and the pebbles tend to be better rounded than in the breccia. In a few cases, intraformational sandstone also occurs as small pebbles. Bedding defined by grain size variations and weathering is present in many examples but cross-bedding is seldom observed at the scale of the building block. Thin blocks of this sandstone are used to even up the courses of walls built of breccia in the Sowton and Clyst Honiton area (Figure 5).

The building blocks are of moderate size and typically have rectangular outlines in the plane of the wall (Figure 3). The sandstone is associated with one or other, or both, of Exeter volcanics and breccia from the Exeter Group in many buildings (Figures 1 and 6).

Exeter Group sandstone is used in a few buildings in Exeter and along the Exe estuary, mainly subordinate to other building stones, and figures more prominently in Poltimore and Broadclyst (Figure 7). Considering the striking coastal exposures of red sandstone at Dawlish, it is used surprisingly little for building in the town, perhaps because of its poorly cemented nature. It is distinguished from Otter Sandstone in Devon (Code 81, qv) by the almost complete absence of intraformational conglomerate. However, because this conglomerate is not everywhere present in Otter Sandstone building stone, the distinction is not everywhere very well founded and more dependence than ideal has had to be made on the location of the building in which the stone occurs, those to the west deemed to be drawn from the Exeter Group, and those to the east, from the Otter Sandstone. The difficulty is acute around Vexford and Stogumber. It is distinguished from tough red sandstone (Code 144) by its much softer nature. It was confused during the original mapping with maroon sandstone from the Bude Formation (code 119) but it is believed that this has been successfully resolved. It closely resembles sandstone from the Aylesbeare Group (Code 121). It was originally distinguished from it by the much commoner presence of mottling in red and fawn present in the latter, which contrasts with the deep red pigmentation of Dawlish Sandstone around Exeter, but mottling is also present in the Dawlish Sandstone around Dawlish, making the distinction on these grounds problematic.

The Exeter Group contains rather numerous named sandstone formations, for example in the Crediton Trough, of which the Dawlish Sandstone is perhaps the best known. The distribution of red sandstone of the kind described is more widespread than the mapped extent of the Dawlish Sandstone and it is likely that the term covers sandstone from other horizons in the Exeter Group interbedded with breccia or associated with outcrops of Exeter volcanics.

Figure 1. Red breccia, red pebbly sandstone and medium-grained red sandstone without pebbles. St Michael's church, Clyst Honiton.

Figure 2. Poorly sorted partly nodular red sandstone and breccia, Outbuilding, Lower Vexford.

Figure 3. Bampfylde Cottage, Poltimore.

Figure 4. Roadside wall 700m south of the bridge at Cockwood. Soft medium-grained sandstone, mainly fawn but partly mottled in fawn and red, probably from the Dawlish Sandstone. The top 2-3 courses are mainly of pale grey limestone from Torbay.

Figure 5. Red sandstone fillers used in the gaps between rounded blocks of breccia. Tower of St Michael's church, Clyst Honiton.

Figure 6. Wall at the gate into St Peter’s churchyard, Brampford Speke, made of a mixture of red sandstone and Exeter volcanics.

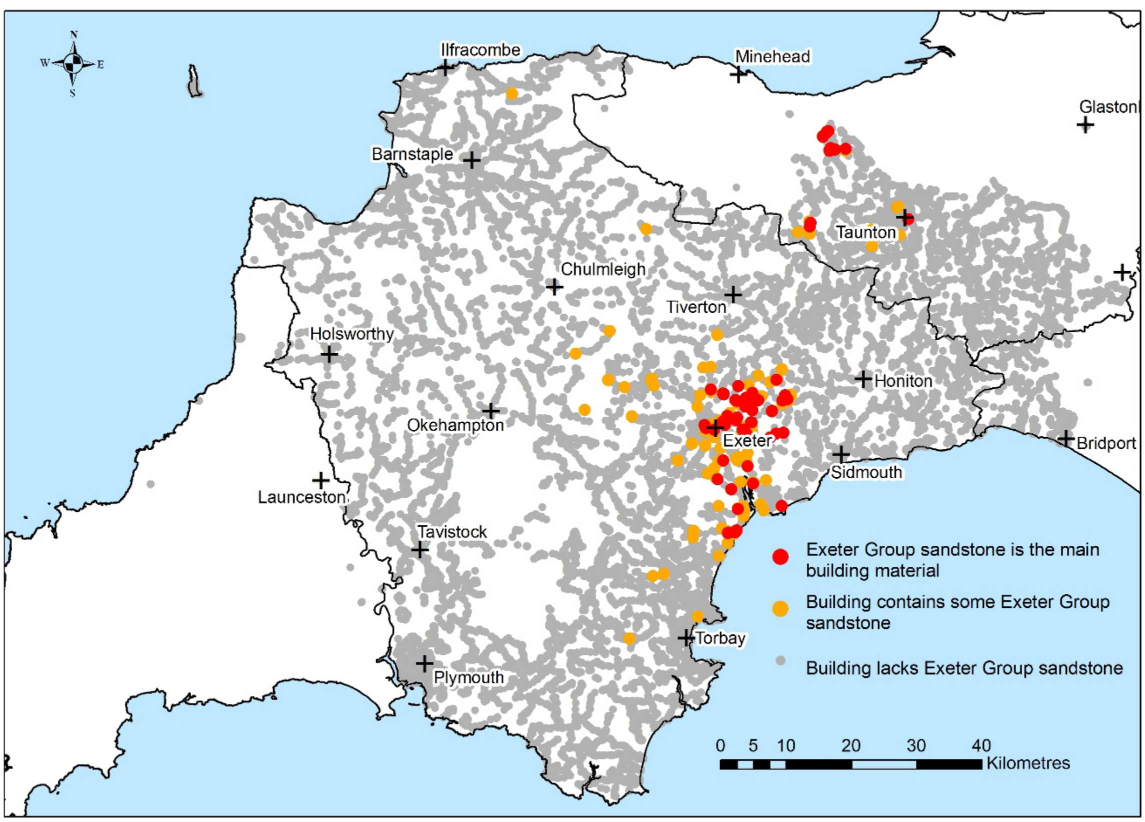

Figure 7. Distribution in buildings of red sandstone from the Exeter Group.

107, Fawn Calcarenite

The rock-type is medium- to fine-grained, rather homogeneous or partly bedded and soft, poorly cemented. It is fawn or grey in colour and some blocks may be blue-hearted (Figure 1). Some examples contain shell fragments. The sand grains are mainly of calcite but may also include quartz. It is associated with Inferior Oolite limestone and Ham Hill Stone in buildings between Crewkerne and Middle Chinnock. The rock is best seen in the walls of Lower Severalls outbuilding adjacent to the public road.

The relative proportions of quartz and calcite grains in these sandstones is open to question. The stone probably comes from the Bridport Sand but also resembles sandstone from the Forest Marble (Code 166).

Figure 1. Embankment below new houses, east side of North Street, Crewkerne.

110, Black Sandstone (Dawlish Sandstone)

Black or very dark red sandstone occurs in a few buildings mainly east of Exeter associated with maroon sandstone of the Dawlish Sandstone Formation. The rock is medium grained, well sorted without mud or noticeable silt fraction, and laminated, although coarser grained parts appear unbedded. Some parts are pebbly. It forms characteristic small flat pebbles and cobbles often used to even up the courses of blocks of breccia that are difficult to shape accurately (Figure 1). Alcock (1962) notes the use of this material in Sowton and concludes that it is sourced from narrow doggers in the Dawlish Sandstone visible in nearby quarries.

The main occurrences are at Sowton and Clyst St Mary but the distribution of the stone extends from Monkerton and Clyst Honiton (Figure 3) south to Starcross and east to Farringdon. The parapet of the medieval bridge at Clyst St Mary dating originally from 1238 is made of this stone.

Reference

Alcock, B.A., 1962. Houses in an East Devon parish. *Transactions of the Devonshire Association,* **94**, 185-232.

Figure 1. Roadside wall, Sowton Lane, Sowton. Small thin blocks of black sandstone are used to fill the gaps between poorly dressed blocks of Heavitree Breccia.

Figure 2. Flat blocks of very dark red sandstone and maroon sandstone, south aisle of St Michael's church, Clyst Honiton.

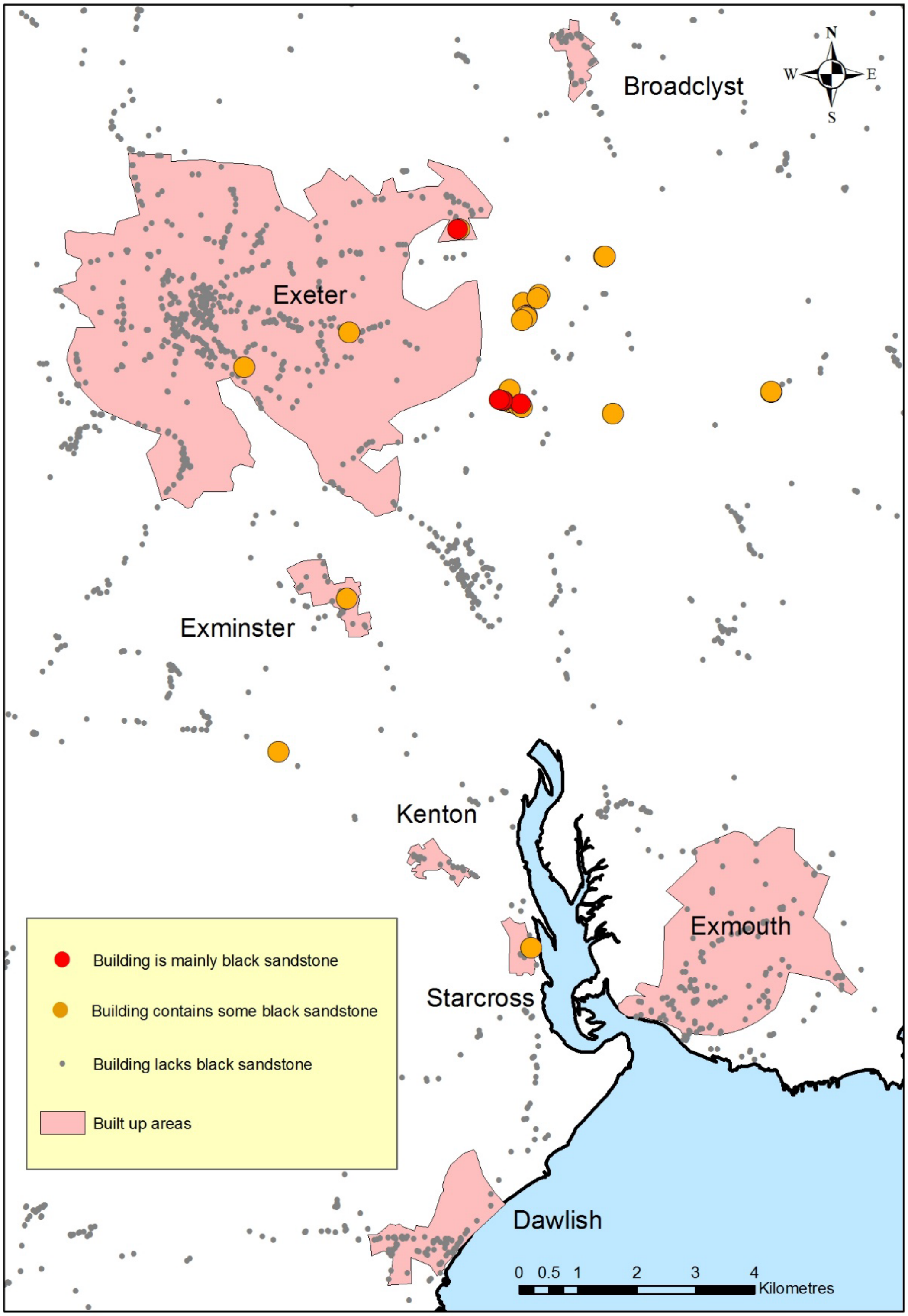

Figure 3. Distribution of black sandstone in buildings.

111, Tufa

Pale grey and pale brown calcareous rock occurs sparingly in buildings in the vicinity of Exeter. The typical material consists of an open framework of platey calcite with the main plates lying in and defining the bedding and the interstices filled with powdery calcite or calcite concretions. The colour is predominantly pale grey but some varieties are pale brown. One example is described as oolitic and one as pisolithic. Because of the framework structure, the rock is quite strong. There is an association with Pocombe Stone (Code 115, qv) and most examples from Exeter are probably from tufa associated with the Exeter lavas but some examples may be from recent tufa formed around calcareous springs.

See also Travertine, Code 143.

Figure 1. Pale grey tufa composed of flat plates of carbonate enclosing more powdery micrite, embankment east of Colleton Hill, close to the river, Exeter. The wall is mainly composed of Pocombe Stone.

115, Pocombe Stone (Exeter Volcanic Series)

The lava from the quarry on Pocombe Hill, Exeter, is mainly distinguished from other rocks of the Exeter Volcanic Series (Code 79) by the presence of many sub-parallel veins of a carbonate mineral, reported (Edmunds and Scrivener, 1999, p145) to be dolomite (Figure 1). The rock is maroon or red in colour, and medium grained (Figures 1-4). The groundmass minerals can be resolved with the hand lens which distinguishes this rock from porphyry (Code 155) and include feldspar, chlorite, carbonate and iron minerals. The rock typically lacks obvious amygdales, but close inspection may show the presence of very small vesicles not easily identified by a casual inspection. However, some examples of the rock have amygdales larger and less regular than those typical of other lavas from the Exeter Volcanic Series but in these cases, it is hard to be sure that the rock is from Pocombe Quarry (Figure 3). In other cases, the lava may occur as blocks up to 20cm across enclosed in red sandstone; these occurrences are believed to represent intrusion of lava into contemporaneous soft sediments (Figure 2). In still other cases, the lava is associated with pale grey or white tufa, presumably deposited from associated hydrothermal springs.

From a distance, Pocombe Stone may be confused with red sandstone where it lacks carbonate veins or amygdales. However, its igneous texture is obvious on close inspection and serves to distinguish the lava from sandstone of both the Permo-Triassic succession and the Devonian and Carboniferous. The anastomosing and intersecting white carbonate veins are diagnostic and distinguish Pocombe Stone from other Exeter Volcanic rocks.

Figure 1. Wall, Barrack Road, Exeter. Subparallel veins of carbonate mineral cutting purple lava generally lacking amygdales.

Figure 2. Wall, Magdalene Road, Exeter. The central stone consists of red sandstone enclosing blocks of purple amygdaloidal lava. The surrounding stones have the carbonate veins typical of Pocombe Stone.

Figure 3. Pocombe Stone with large irregular amygdales. End of riverside embankment wall at the foot of Colleton Hill, Exeter. The central stone at the bottom of the picture is of Heavitree Breccia.

Figure 4. The Bike Shop, The Quay, Exeter. Quoins, dressings and footing are of Pocombe Stone, repaired with red sandstone. The rest of the wall is of limestone from Torbay.

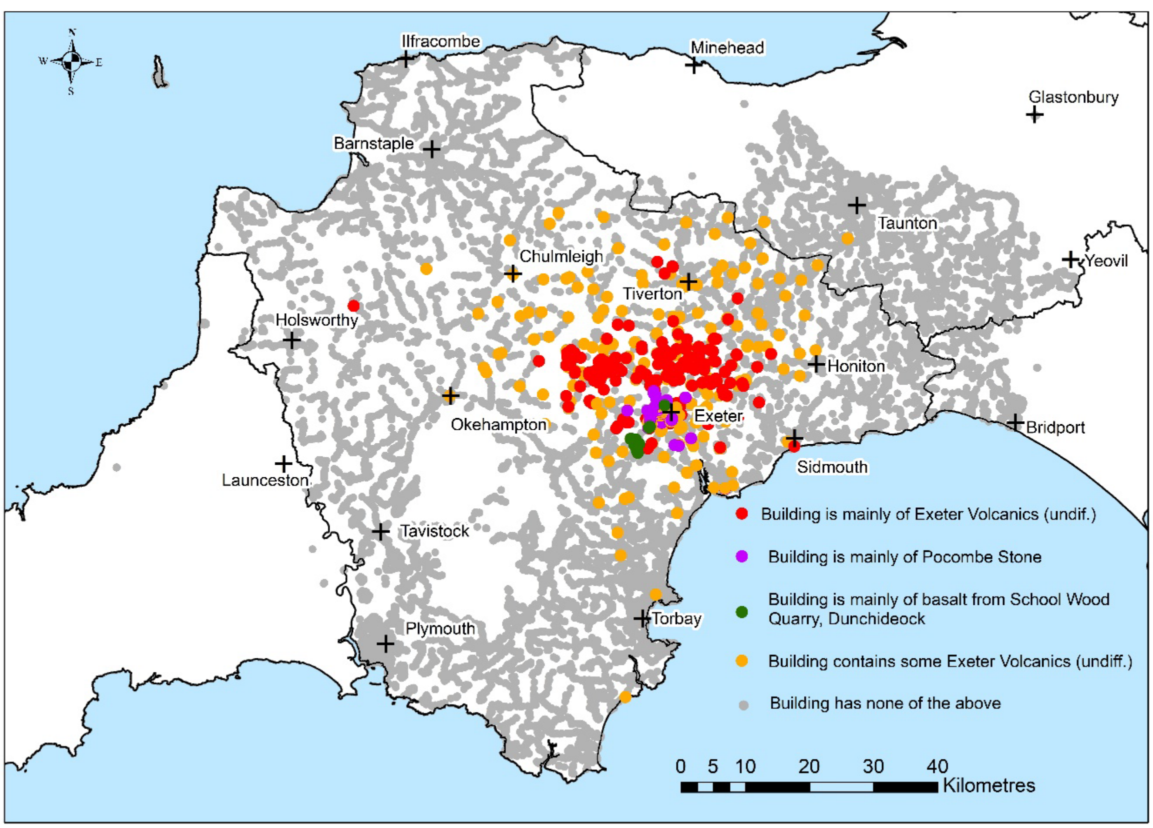

Figure 5. Distribution of rocks from the Exeter Volcanic Series in buildings.

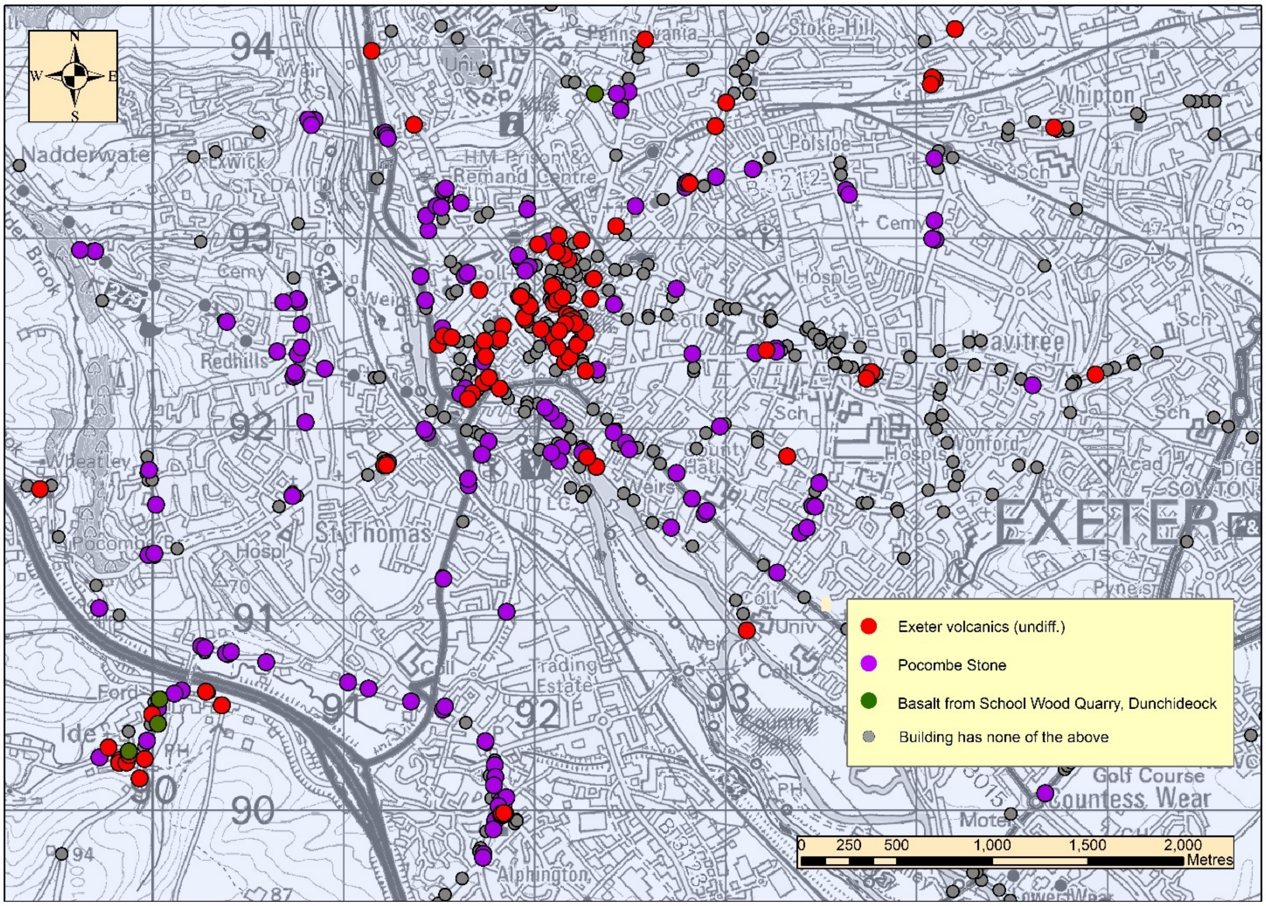

Figure 6. Distribution of rocks from the Exeter Volcanic Series in buildings in Exeter. Base map © Crown copyright and database rights 2018 OS 93830343

Figure 5 shows the distribution of buildings mainly composed of or finished with Exeter Group volcanic rocks, shown in red where further differentiation has not been attempted (Code 79), in purple where they are believed to have been won in Pocombe Quarry (Code 115) and in green where they were extracted from School Wood Quarry, Dunchideock (Code 164). Buildings where these volcanic rocks are subordinate to some other building material are shown in yellow regardless of the source quarry.

Figure 6 shows the distribution of different kinds of Exeter volcanics in Exeter. Pocombe Stone (Code 115) predominates in the outskirts of the city, mainly built in the Nineteenth Century. Volcanic rocks generally lacking the distinctive features of Pocombe Stone predominate in the city centre and in the older buildings and in the case of medieval and early modern buildings, were probably won from Rougemont on which Exeter Castle now stands.

119, Maroon Sandstone (Bude Formation)

Sandstone with a dark brownish-red (maroon) body colour is widely used for building near the contact of the folded Carboniferous rocks with the Permo-Triassic cover sequence mainly between Crediton and Tiverton. It is also an important building stone of the medieval churches of East Devon as far south and east as Rockbeare and Talaton (Figures 1-4).

The rock is medium-grained, even grained and generally well sorted, with subangular grains composed mainly of quartz with in some cases small admixtures of feldspars and lithic fragments. Mica flakes have been reported at a few localities. Typically, the spaces between the grains are void and the outlines of individual grains can be easily seen with a hand lens. Some blocks however, have a more compact texture with matrix material that fills the voids between the grains.

The rock is remarkably homogeneous; blocks seldom display bedding or other sedimentary structures although rarely, some have finer-grained more muddy selvages top and bottom, as if they are the more sandy beds in a succession that includes shaley bands. Many examples are crossed by joints in the walls of which the maroon pigment has been reduced to ferrous iron minerals (Figures 3 and 6), giving the rock a distinctive blue-green or grass green colour, quite distinct from similar reduced zones in Permian and Triassic sandstones which tend to be olive green or fawn. Green zones and blotches of this kind are very characteristic. Spherical green reduction spots around organic fragments have been noted in a few places. Many blocks have fractured along the reduced zones. Where the fractures form the face of the building stone, they display the green altered material (Figure 6). Green-stained joints are never filled with quartz or other vein material. The absence of quartz veins in this rock-type is also characteristic, especially considering that veining is widespread in the grey sandstones of the Bude and Crackington Formations. However, in a few places, a set of veins distinct from those associated with the green discolouration are filled with a coarse carbonate mineral, probably calcite.

Building blocks range in size from small to large. Many of them exhibit onion skin weathering (Figure 3) where the rock scales off along incipient fracture surfaces that follow the outlines of the block but are more rounded at the corners. The surfaces of blocks where this is prevalent tend to be smooth. Where the surface follows a joint, it is flat and nearly planar. Otherwise, blocks have planar surfaces showing the tool marks of the mason or show a natural hackly fracture (Figure 4).

The origin of this rock-type has been the subject of several revisions during the course of the survey, reflecting the difficulty in distinguishing it from other red sandstones used for building in Devon. It was singled out by Hoskins (1954) for its remarkable colour contrast with Beer Stone where used in the tower of Kentisbeare church (Figure 2). He assumed it was part of the cover sequence, of Permo-Triassic age. However, Chalk (1934) identifies the source quarry as the one on Upton Farm just east of Cullompton. Although he does not name the source formation, float at the quarry is of Carboniferous sandstone matching that in the church and this is confirmed by reference to the geological map. Chalk (1910) also identifies the source of the cinnamon coloured stone of the south aisle of Collumpton church as Hockworthy. This makes its source very likely to be in the Carboniferous sequence and certainly not in the Permo-Triassic.

Maroon sandstone is widely used in the Crediton Trough; many buildings in the village of Sandford are composed of it. Initially, it was thought that this stone was won from the Knowle Sandstone, a Permian formation interlayered with Exeter volcanics in its type area but very poorly exposed. This conclusion was inferred by tracing the outcrop of the Knowle Sandstone on the geological map south along the basal unconformity of the Permian as far as Ideford where it was correlated with the tough red sandstone exposed and used for building there (Code 144). However, this correlation has now been abandoned because of the lithological similarity of the maroon sandstone of the Crediton Trough with that used in the churches of East Devon. Further confirmation comes from the identification of the maroon sandstone used for Knightshayes (Figure 5) as coming from Hensley (Cherry and Pevsner 1989). This locality is near West Worlington on the outcrop of the Bude Formation according to the geological map.

Figure 1. Tower of St John's church, Plymtree. Rubble wall of maroon sandstone as rather small flat blocks, dressings of Beer Stone and relieving arch of Exeter volcanics.

Figure 2. Tower of St Mary's church Kentisbeare. Quoins of the tower and staircase are of alternating blocks of maroon sandstone and Beer Stone.

Figure 3. St Swithun's, Sandford, south aisle.

Figure 4. St Thomas', Chevithorne. The colour of the stone here is a good match for the cinnamon mentioned by Chalk (1910).

Figure 5. Knightshayes Court. Maroon sandstone with Ham Hill Stone dressings.

Figure 6. St Swithun's, Sandford. These blocks have partly split along the hairline fractures where the maroon sandstone is reduced to green sandstone.

The accepted explanation of the maroon pigmentation of these rocks is that it is a consequence of oxidation and weathering of the rock within the zone of meteoric water when it was near the surface in Permian times (de la Bêche, 1839, p124 and Edmonds *et al*., 1968). A more elaborate or even completely different explanation is required to account for all aspects of these rocks.

The maroon sandstone records several separate events after it acquired its maroon pigment. Most striking is the passage of reducing formation waters to produce leached green sandstone but there are also carbonate-bearing veins, though very few. If the maroon pigment is of superficial origin, then these later events must have taken place during reburial. This of course is possible; Permian hydrothermal mineralisation is known east of Dartmoor (see for example Dines,1956, p719 *et seq.).* However, the simplest and most natural explanation of them is that they record a period of reducing formation water circulation during the deformation of the rocks by mountain building.

The maroon sandstone doesn't look at all like a rock that was weathered. A case can be made that the rock always contained oxidised iron. This is the case elsewhere in the late Carboniferous, for example in the Warwickshire Group of Waters and Davies, (2006). It could be argued that the maroon Bude Formation represents the start of the onset of arid conditions in the late Carboniferous and exhibited its characteristic pigmentation from the time it was deposited. Of building stone sandstone with a maroon component described in the study area, 82 per cent of occurrences are on the Bude Formation and only 18 per cent on the Crackington. This is consistent with a depositional cause of most of the pigmentation and only a minor contribution from surface weathering at the present day.

Maroon sandstone in buildings, coded 119, is almost entirely restricted to the outcrop of the Bude Formation, or younger rocks of the cover sequence in the Tiverton and Crediton Troughs and to the east. It is very noticeably absent from buildings on the Crackington Formation south of the Crediton Trough and north of the Tiverton Trough. Of course, the distribution of stone is buildings is a poor guide to their distribution in the bedrock. But it is noted that the only quarry where the stone has been seen *in situ*, is in the Bude Formation at GR 295193,107927. The maroon sandstone used for Knightshayes Court is reputed to come from Hensleigh (Hensleigh Quarry - Images of England, 2018). There is a candidate site here marked by a pond in the present landscape (GR 293409,112714) although so far unsubstantiated by any supporting written evidence other than the name of the former quarry.

The maroon sandstone differs from the rest of the Carboniferous succession in appearing to be little deformed (although in outcrop it has steep dips) and apart from the reduced zones mentioned above, lacks the veins so typical of the Bude/Crackington succession. Could the maroon sandstone be separated from the rest of the Bude by an unconformity representing the main period of folding of the older rocks?

The maroon pigmentation is a defining characteristic of the stone. Its origin may include any of the following.

1. Mainly present-day oxidation, but then it would not be restricted to the Bude Formation. Even part oxidation to a maroon pigment is largely restricted to the Bude Formation.
2. Oxidation beneath the Permian unconformity. Once more, it would be surprising if it were restricted to the Bude Formation and not affect those parts of the Crackington Formation exposed at the surface when the Permian started to be deposited.
3. It was maroon when it was deposited.

However, note that the Meadfoot Group rocks exposed at Cockington are red throughout and this kind of pigmentation is not seen anywhere in the formation remote from the Permian unconformity.

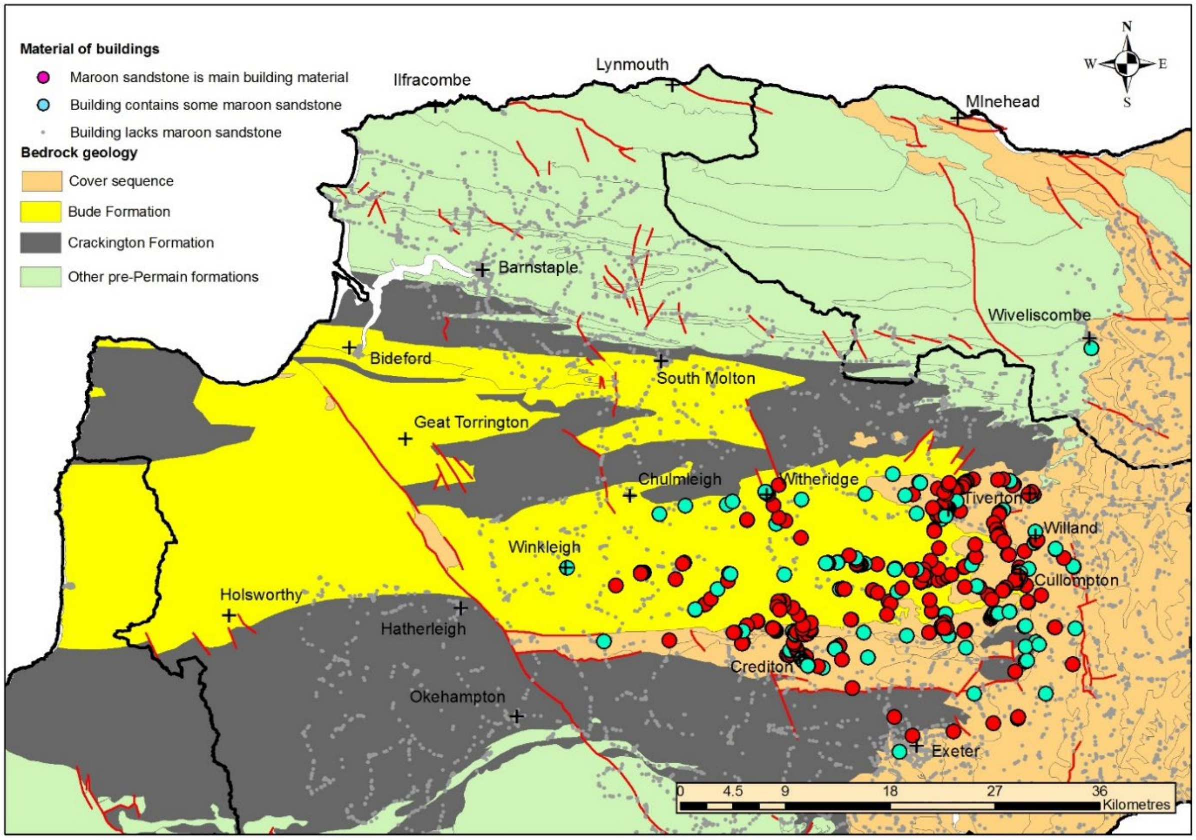

Figure 7. Distribution of maroon Carboniferous sandstone.

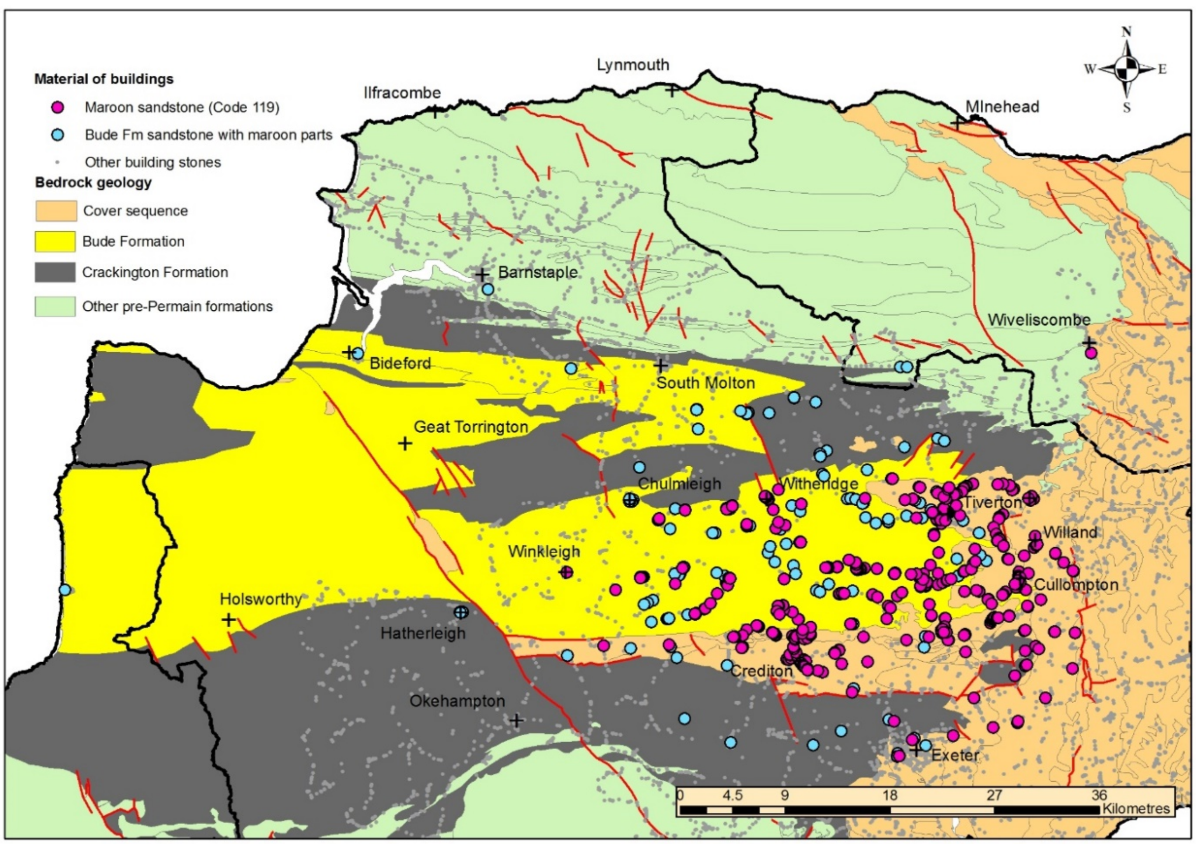

Figure 8. Distribution of maroon and partly maroon Carboniferous sandstone.

Figure 7 shows the distribution of maroon sandstone coded 119 and other examples of Bude and some Crackington Formation sandstone in buildings, parts of which have a maroon pigmentation. The map was prepared to see if the distribution of these differently pigmented sandstones throws further light on the origin and timing of the maroon colours.

Figure 8 extends the distribution of sandstone with maroon pigmentation over a larger part of the outcrop of the Bude and Crackington Formations but if anything, weakens the pattern of buildings containing this kind of stone to a zone between the Crediton and Tiverton Troughs and adjacent areas to the east. For example, quite a few occurrences are located on the Crackington Formation and it is hard to argue that these rocks acquired their distinctive colour at the time they were deposited.

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120, Halberton Breccia Formation

The red breccia widely used for building in Sampford Peverell and won from nearby quarries is distinct from those found elsewhere in the area of study. The clasts are angular to rounded, of granule and pebble grade or in some cases cobble-sized, set in a coarse-grained sandstone matrix. Many of the pebbles are oblate, with their long axes tending to lie in and define the bedding; in some cases they are imbricated. The rock-types of the clasts include maroon, grey and black sandstone and greywacké, white vein quartz and light-grey limestone. Limestone clasts tend to be better rounded than those of other lithologies. Vein quartz is especially plentiful and fragments of igneous origin appear to be entirely absent, in contrast to the Heavitree and Newton St Cyres Breccias used further south. The matrix is rather muddy; compaction of the mud fraction across the bedding has contributed to the clear expression of a bedding fabric.

These breccias may be distinguished from other breccias and conglomerates used for building nearby as follows.

1) The matrix is muddy in Rock-type 120 but tends to be clean-washed sand in the Budleigh Salterton Pebble Beds and the other breccias of the Exeter Group. Under the hand lens, the individual grains of the matrix cannot be resolved in Rock-type 120; coarser grains appear to be set in an irresolvable matrix. Where pebbles are not abundant, the rock tends to be rather soft and easily eroded because of the mud content of the matrix. Conversely in the Budleigh Salterton Pebble Beds, the sandy matrix is clean washed and all the grains can be clearly resolved under the hand lens.
2) Flat pebbles tend to lie in the bedding and they are imbricated in some blocks. Conversely, in other Permian and Triassic breccias and conglomerates used for building, clasts are usually set at any angle to the bedding and where there is no variation in the distribution of clasts sizes to define it, the bedding may be hard to discern.
3) Clast rock-types do not include those of igneous origin; vein quartz is exceptionally common.
4) The muddy matrix permits the development of bedding splitting planes through the alignment of mineral grains during compression resulting from burial. Splitting planes of this kind do not help to define the bedding in other breccias and conglomerates of the area.
5) There are fewer extreme changes in grain size within blocks compared to other conglomerates and breccias of the area. Isolated large pebbles and cobbles are rarer. The rock more closely resembles a conventional conglomerate than the Budleigh Salterton Pebble Beds, which have extreme variations in pebble size and concentration, making pebbly sandstone a suitable general term for the whole group of rock-types represented by Code 127. The same remark can be usefully applied to Exeter Group breccias used for building further south.
6) Because of the muddy matrix, not only are parts of the rock with few pebbles quite soft, the rock, taken as a whole, tends to weather with the production of nutritious soil in which mosses and plants can find a foothold. Consequently, structures made of this breccia tend to be more covered in these growths than those made of other kinds.
7) The breccia is finer grained than is typical of other breccias and conglomerates of the area.

This description is based on the properties of breccias used for building in the Uplowman-Halberton-Sampford Peverell-Burlescombe-Ayshford-Bathealton area, with the main concentration in and around the first three villages. The breccia is also much used for the bridges and banks of the Grand Western Canal. These all fall within or near the outcrop of the “Breccia and Conglomerate” unit mapped below the Lower Sandstone of the old BGS Tiverton sheet and is shown as Halberton Breccia on the new Tiverton sheet.

The code has also been extended to other breccias used in the Tiverton Trough including the Sampford Peverell Breccia. However, these are not so distinct lithologically and could have come from other parts of the Exeter Group. The code has also been extended northwards to cover building stone believed to have been won from the Vexford Breccia. Here again, the rock is not well differentiated, in this case from the Budleigh Salterton Pebbles Beds. It was correlated with the Sampford Peverell breccias on the basis that it is the lowest breccia horizon in the Permo-Triassic cover sequence. However, it is noted that the BGS lexicon assigns the formation to the Aylesbeare Mudstone Group and gives it a Triassic age.

The new Blundell’s School campus on the outskirts of Tiverton is made of red breccia. Only the chapel which is next to the public right of way has been examined. The breccia has been assigned code 120. According to https://en.wikipedia.org/wiki/Blundell%27s_School, the buildings were designed by Hayward & Son and built in red Halberton Stone.


Figure 1. Breccia forming the tower of St Peter's church, Uplowman.

Figure 2. Red conglomerate probably from the Vexford Breccia and associated sandstone, outbuilding, Vexford. The conglomerate clasts are of sandstone, greywacké. black vuggy quartzite or volcanic rock and vein quartz set in a soft gritty sandstone matrix. The clasts are subrounded rather than angular.

Figure 3. Buttress of the swing bridge on the Grand Western Canal, Halberton.

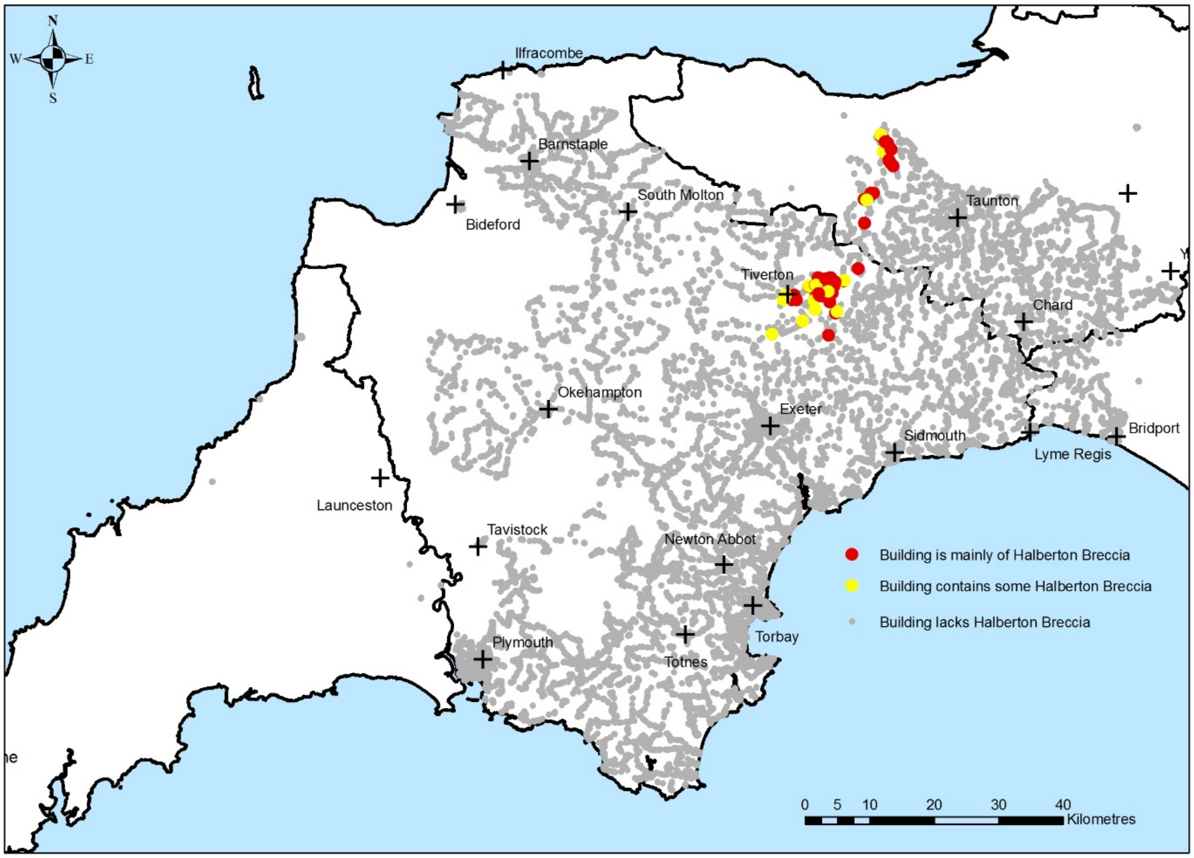

Figure 4. Distribution of Halberton Breccia in buildings.

121, Sandstone from the Exmouth Mudstone and Sandstone Formation

Sandstone used for building mainly on the east side of the Exe estuary is referred to the Exmouth Mudstone and Sandstone Formation of the Aylesbeare Mudstone Group. The sandstone is typically mottled in shades of fawn, red and pale pink. The fawn variety includes cream or very light brown sandstone, mainly medium-grained, even grained and well sorted although there are some less well sorted gritty layers. It consists of sub-rounded to subangular grains of quartz in sparse cement, whence its porous and permeable nature. A crude bedding fabric is usually present defined by variations in grain size, resistance to weathering and colour, and cross bedding is visible in some large blocks. The quartz grains are mostly translucent but a proportion are stained yellow or brown giving the rock its pigmentation. Some of these might include feldspar. There are a few greenish grains too.

The red variety is essentially the same except that the intense red pigmentation obscures any variation in the nature of the clastic grains.

It is evident from this description that there is very little difference between the fawn variety and rock-type 89 (qv) on the one hand, and the red variety and similar sandstone from the Dawlish Sandstone (Code 106) on the other. An analysis of the distribution of these rock-types carried out at the end of 2006 shows that, with few exceptions, all buildings that contain both rock types or have a reference to mottled red and fawn sandstone occur on the east side of the Exe estuary and mainly in the Woodbury-Exmouth area. It was concluded that in these cases, both rock-types are from the same quarry (although perhaps not the same quarry for all occurrences) and that they should be combined and referred to sandstones within the Exmouth Mudstone and Sandstone Formation. Since that time, mottled sandstone has been observed in buildings in the Kenton and Dawlish areas. These occurrences are also referred to the Exmouth Mudstone and Sandstone Formation although it is conceded that they may originate from west of the estuary in the Dawlish Sandstone. it seems quite likely that sandstone would have been carried across the estuary given that, in former times, carriage by boat was greatly preferred to transport by land where pack horses or at best, horse-drawn carts were the only means available.

Figure 1. Vestry, St Swithin's, Woodbury.

Figure 2. Outbuilding, Maer Farm, Exmouth.

Figure 3. Montpellier Rd. at junction with Boarden Barn, Exmouth. Cream and pink sandstone with some grey Torbay limestone.

Figure 4. West door of St Margaret's and St Andrew's church, Littleham.

Figure 5. Tower of the church of St John in the Wilderness, Withycombe.

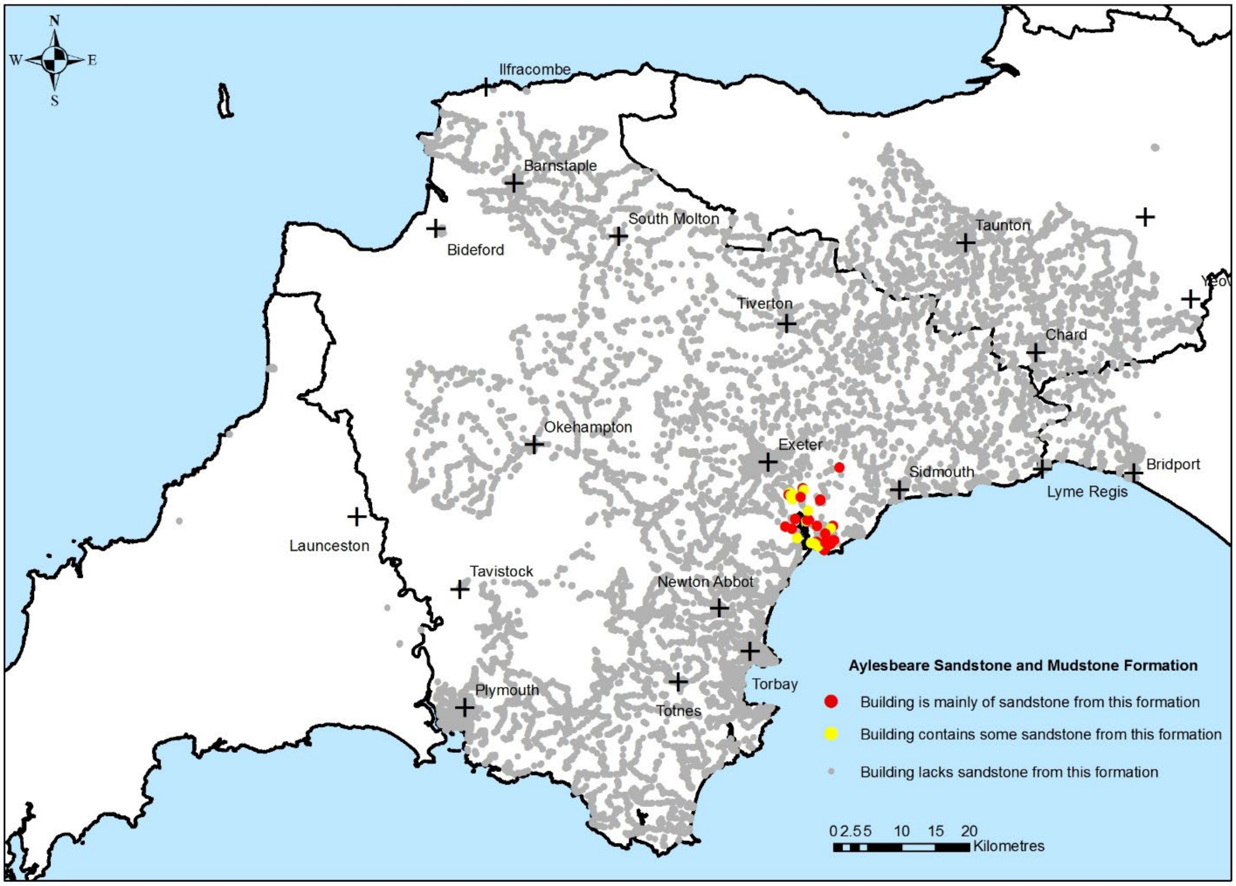

Figure 6. Distribution of buildings containing sandstone from the Aylesbeare Sandstone and Mudstone Formation.

123, Bampton Limestone

The typical limestone from the Bampton Limestone Formation used for building is banded and laminated and strongly pigmented in shades of grey, light grey, purple, buff, ochre, orange, yellow, red and pink (Figures 1-4). The general effect from a distance is of variegated pigmentation and an overall brown colour (Figure 2). The banding is typically very regular and varies from thin laminae no more than a millimetre or so thick (Figures 4, 5), to homogeneous bands of limestone 50cm thick (Figure 7). The limestone is typically fine grained to porcellanous but the thicker bands may be medium grained. Where thinly laminated, the limestone appears to be foliated but this probably is not reflected in any parallel orientation of the long axes of mineral grains. In a significant minority of cases, the stone is laid with bedding parallel to the plane of the wall and in these cases is more difficult to identify although the variegated colours are often well displayed. Otherwise blocks laid on bedding planes are rather thin compared to their breadth and length, especially if strongly banded.

A suite of other rock types are interbanded with the limestone of which the most characteristic is chert. Chert bands may be black as in the Westleigh Limestone even where the enclosing limestone is variegated, but in a large minority of examples of building stone, it shows the same range of colours as the limestone or most characteristically, is toffee-coloured. Chert bands are typically less than 5cm thick and vary in thickness along their length or are discontinuous, represented by alignments of chert nodules or lozenges (Figure 5). As well as chert, the sequence includes layers of sandstone or quartzite and shale. Weathering along the contacts of the different rock types making up the sequence has given rise to the variegated colours of the building blocks.

All beds may have closely spaced cross joints and in some cases these are filled with silica even where crossing limestone bands (Figure 6). Strong red weathering colours characteristic of some limestone beds may extend along the cross fractures into adjacent beds. Fracturing in some places is so widespread that the rock resembles a breccia.

Northwest of Holcombe Rogus, stone particularly rich in toffee-coloured chert bands and less obviously banded was originally given the code 130. It is also clearly part of the Bampton Limestone Formation and the distinction through the material code is no longer applied.

The banded cherty limestone is associated in many buildings with two other limestone lithologies, salt and pepper limestone coded 104 and dark grey limestone weathered to rich ochreous colours mainly found around Huntsham, coded 137.

Variants of the typical colourful banded and laminated limestone include more homogeneous limestone used for the street-side walling at the junction of Blundell's and Station Roads in Tiverton, at the entrance to Morebath House and elsewhere (Figure 8). It is uniformly grey in colour and lacks chert although retaining texture and grain-size lamination. It has strong similarities with similar laminated limestone used, for example, for the street walls around the Royal Devon and Exeter hospital in Exeter but there assigned to the Westleigh Limestone. Pale grey limestone without lamination seen around North Molton as also assigned this code although it looks rather different.

Limestone coded 123 is used for building in a zone extending from Greenham in the northeast, and along the northern limit of the mapped area to Morebath in the north and dies out west of Oakford and south of Tiverton (Figure 9). To the east and south its place is taken by the Westleigh Limestone, distinguished by predominantly grey colours, less obvious banding and smaller proportions of chert. To the west, chert and mudstone become more plentiful and any limestone present becomes hard to identify in the building stone. These mudrocks have a blocky appearance and are poorly cleaved. They are coded 177 and are believed to represent in part the westwards continuation of the Bampton Limestone as the Codden Hill Chert. Stone dug from the Bampton quarries is used in widely but thinly scattered buildings elsewhere in the area of study (Figure 9).

Figure 1. Colour-banded Bampton limestone, Arden House, Brook Street, Bampton.

Figure 2. Luke Street, Bampton.   Victorian terrace houses built of Bampton Limestone with brick quoins and dressings and slate roofs.

Figure 3. South side of St George's church Morebath. The nave and tower are both made of Bampton Limestone but the colours in the tower walling, which is much older, are subdued compared to those in the nave.

Figure 4. Detail of the nave wall of St George's, Morebath, south side. Note the colour banding, range of colours and shape of the blocks. The windows dressings are of Bath Stone.

Figure 5. Detail of chert-bearing limestone blocks showing both pale grey and black chert bands. The latter, at the base of the top right-hand block, is broken up into lozenges. St Michael's church, Bampton, south side of nave.

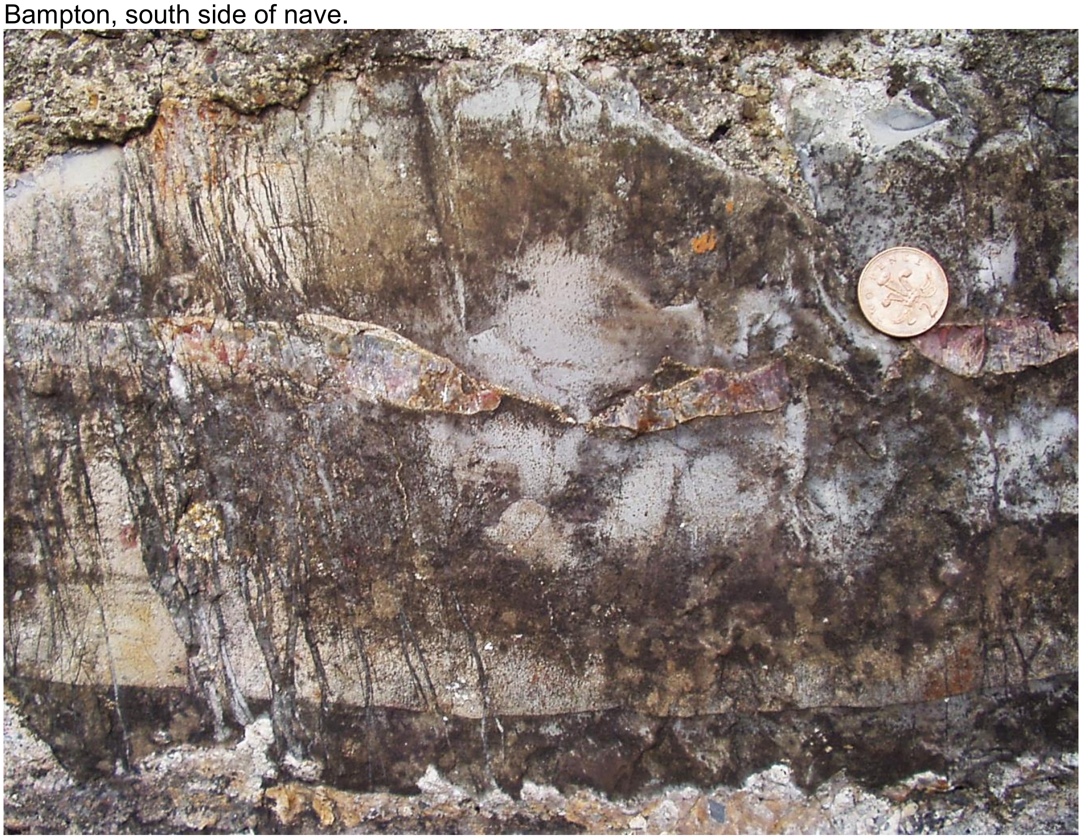

Figure 6. Limestone block with a band of toffee-coloured chert of variable width crossed by a set of oblique fractures. St Michael's church, Bampton, south side of nave.

Figure 7. Church of St John the Baptist, Ashbrittle. Less strongly banded pink limestone with some blocks entirely of purple chert e.g. large block lower right hand side. The pointing makes the wall look as if it was laid snecked.

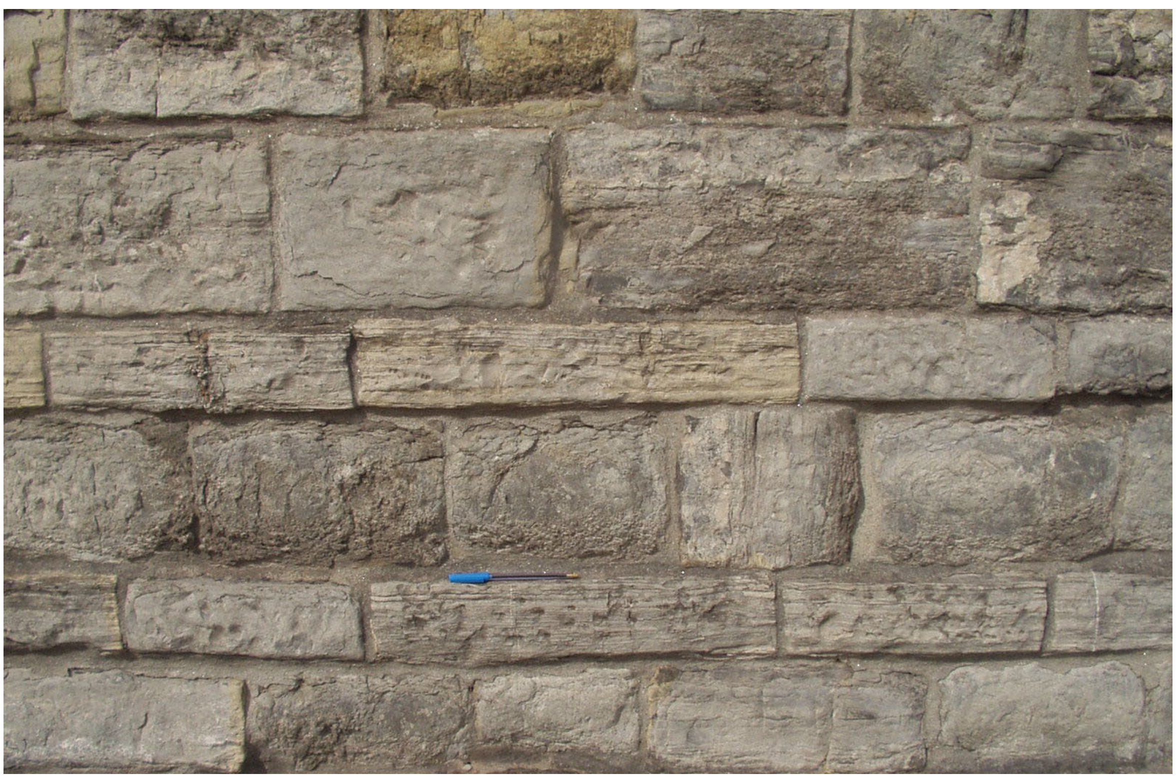

Figure 8. Wall at junction of Blundell's and Station Roads, Tiverton. The limestone is uniformly grey with alternating layers of laminated and unlaminated limestone, the latter showing onion-skin weathering. The stone was originally mistaken for Blue Lias limestone.

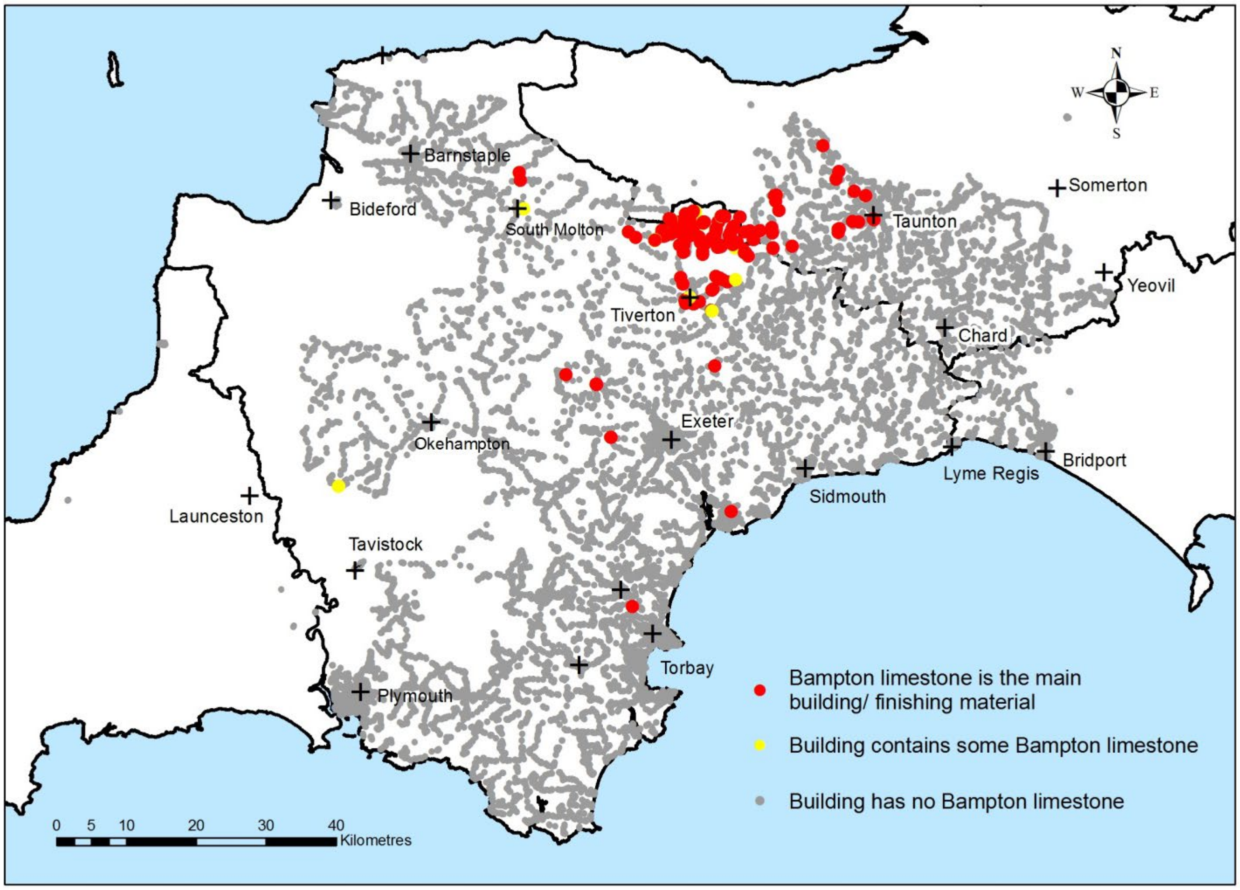

Figure 9. Distribution of buildings containing Bampton limestone.

Figure 10. Pale grey fine-grained limestone without banding. Parapet of Fitton Bridge, 2km northwest of North Molton.

125, Fine-grained Red Breccia (Permian)

The rock is closely similar to the Heavitree Breccia, consisting of angular fragments of sandstone, greywacké, hornfels, sanidine and other materials in a coarse-grained sandstone matrix. It lacks limestone clasts. It is distinguished from Heavitree Breccia by finer grain size. However, it is not clear that the distinction has been applied in the same way at every occurrence.

Its distribution is restricted to the area bounded by Kenn, Dunchideock, Ide, Alphington, Topsham and Exminster and it overlaps with normal Heavitree Breccia, Code 85.

Figure 1. Outbuilding, south side of Brenton Road between Clapham and Kennford. Cob on a footing of Fine-grained red Permian breccia.

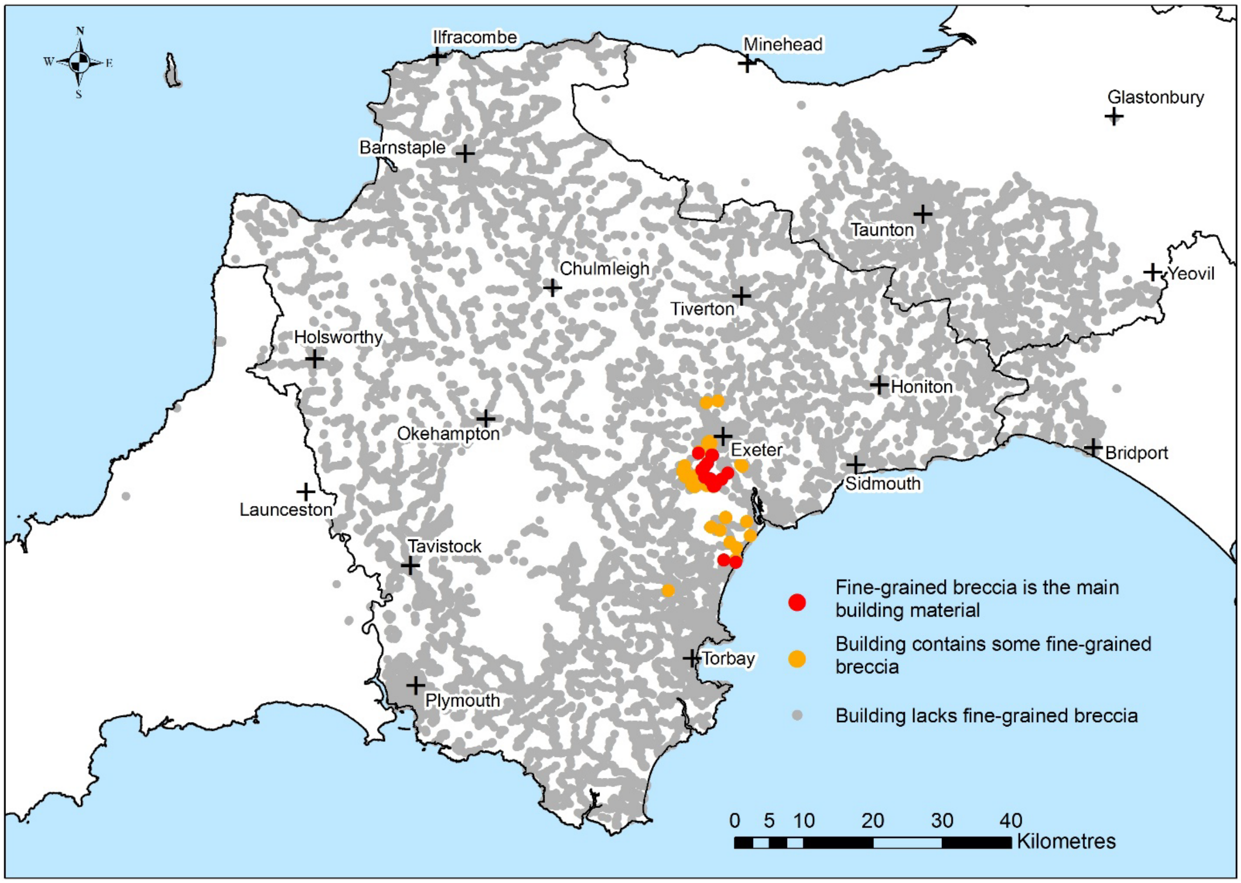

Figure 2. Distribution of fine-grained breccia in buildings.

126, Slag

Materials interpreted as slag from a range of smelting and pottery-making activities are a rare but widespread constituent of buildings in the region. They consist of fine-grained black or brown shiny materials, in many cases with inclusions of rock or brick, or of brick with included spherules of slag or of brick encrusted with slag. The largest occurrence is in Brimley and Wellfields Roads in Bovey Tracey where slag is used for the coping of the roadside walls, no doubt a waste material from the nearby potteries and glassworks. Minor occurrences are also reported from West Bay, Tiverton, the walls of Kirkham House in Paignton, Kingston St Mary, Bradninch and Knowle, close to Budleigh Salterton. The origin of the slag is unknown in most cases. In some it may have been derived from Iron Age bloomeries widespread on the Blackdown Hills.

Figure 1. Slag used as the coping of a roadside wall, Wallfield Road, Brimley.


Figure 2. Former foundry building, north side of Foundry Mews, Tavistock. Made of a range of different kinds of stone, many rounded, from the river bed but including fragments of slag and slag-encrusted brick towards the top.

127, Pebbly Sandstone (Budleigh Salterton Pebble Beds Formation or Chester Formation)

Red pebbly sandstone, conglomerate and breccia are widely used for building in the Vale of Taunton Deane (Figures 1 and 2). The clasts vary from small pebbles to medium cobbles in size and are composed of rock-types drawn from the underlying folded Devonian and Carboniferous sequence. Vein quartz, pale and dark grey limestone some parts of which may be fossiliferous or oolitic, red and maroon sandstone or quartzite, black sandstone and hornfels, dark purple volcanic rocks with zeolite-filled amygdales and black glassy quartzite have all been recognised (Figures 3-5). Both rounded and angular clasts are present, in some cases in the same block; limestone clasts are usually well rounded (Figures 3 and 5). In some places they are abundant enough to have been collected for burning for lime.

The coarse clasts are set in a matrix of poorly sorted medium- to coarse-grained sandstone with carbonate cement. Their distribution is irregular. In some cases they are present throughout the building block in which case the rock is properly called a conglomerate or breccia. In some cases they form distinct layers and lenses in blocks composed mainly of sandstone without pebbles. In some cases a few isolated pebbles occur in an otherwise pebble-free sandstone and in still others, the pebbles are very small so that the rock could be called a very coarse-grained sandstone (Figure 5).

It has proved very difficult to decide where the distinction should be drawn between rock-types that should be referred to the Budleigh Salterton Pebble Beds and those that should be referred to the overlying Otter Sandstone. The BGS memoir for this area (Edmonds and Williams, 1985), notes that the sequence consists of interlayered breccia and sandstone and that the boundary is drawn where sandstone becomes predominant over breccia going upwards in the succession. This criterion is useful for the purpose of geological mapping but is not very helpful in deciding if a particular building block belongs to one formation or the other. Comparison of the distribution of pebbly sandstone in buildings and the geological map shows that many examples fall within the outcrop of the Otter Sandstone and Mercia Mudstone especially south of Bishops Lydeard. It may be, therefore, that some pebbly sandstone used for building was won from breccia bands in the Otter Sandstone. An alternative explanation, not currently favoured, is that the Otter Sandstone is unsuitable for building in this southern part of the Vale and all the pebbly sandstone here was won in quarries within the Budleigh Salterton Pebble Beds; this is certainly where most of the evidence of past quarrying seems to be with few old quarries sited on the outcrop of the Otter Sandstone.

There is also difficulty in differentiating between the rock-types of the Budleigh Salterton Pebble Beds and those of the Vexford Breccia. There is no doubt that some stone was extracted from the latter but useful lithological criteria for making a distinction where there is doubt have not been worked out so far. There is also difficulty in deciding what is the minimum proportion of pebbles that merits the rock being called a pebbly sandstone assigned code 127 and similarly, what is the minimum size of coarse-grained clasts that merits this assignment. It has to be admitted that the choices made are somewhat arbitrary but they are believed to correspond with what most workers would be prepared to accept.

The criteria for assigning a building block this lithology code may therefore be summarised as follows:

- Where at least 20% of the red sandstone blocks in a building contain clasts however few of at least medium pebble grade and there is no evidence that the blocks were extracted from different quarries, then all the sandstone blocks are assigned Code 127.
- Where the maximum size of the coarse fraction does not exceed small pebble grade, then the blocks should be assigned to the Otter Sandstone regardless of the proportion of the blocks that contain this coarse fraction.
- If some of the blocks contain intraformational (mud flake) conglomerate those blocks and any sandstone blocks without exotic pebbles should be referred to the Otter Sandstone.

Reference

Edmonds, E.A. and Williams, B.J., 1985. *Geology of the country around Taunton and the Quantox Hills.* Memoir for 1:50,000 geological sheet 295, New Series. HMSO, London.

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Figure 1. Lloyds TSB Bank, Wellington. Red pebbly sandstone with Ham Hill Stone used for the facing of the ground floor and for the quoins and dressings.

Figure 2. Lower Grants Farmhouse, Ford.

Figure 3. All Saints church, Rockwell Green. Breccia with very prominent well-rounded clasts of pale grey limestone.

Figure 4. Breccia block in wall in front of Nynhead Court, Nynhead.

Figure 5. Pebbly sandstone block in wall in front of Nynhead Court, Nynhead. Note isolated fractured pale-grey limestone pebble.

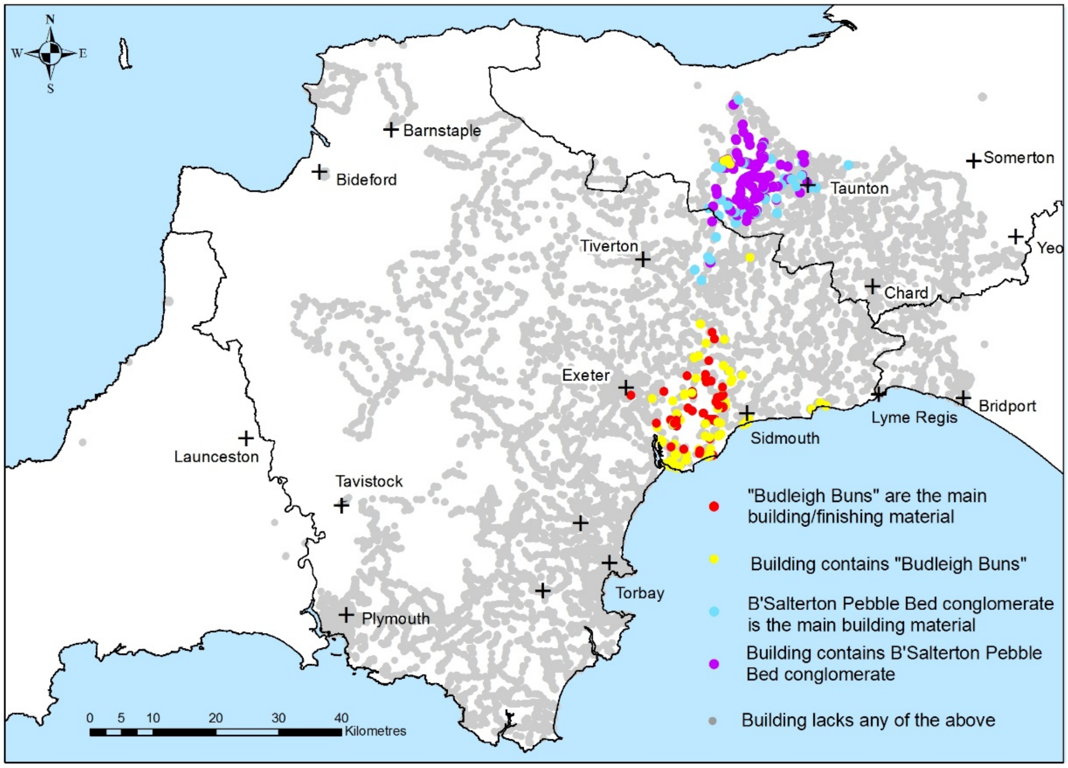

Figure 6. Buildings shown by the purple and blue symbols are those that contain Budleigh Salterton Pebble Bed conglomerate, well enough cemented to be used as building blocks. Stone from the same formation used in the south (red and yellow symbols) consists of individual well-rounded cobbles mainly of brown quartzite which have fallen out of the conglomerate (see Code 36).

128, Black and Grey Slate from the Stratigraphic Interval Doddiscombe Formation to Ashton Shale member of the Crackington Formation

Code 128 was first assigned to the distinctive black slate (Doddiscombe Formation) quarried at Tracebridge and widely used there and at Ashbrittle and Brushford for walling as well as more widely for roofing until better quality slate became available from more distant sources. After March 2011 as the work progressed westwards from these localities, it became increasingly difficult to differentiate these slates from those of adjacent formations. Consequently, the definition was extended to include slates with a wider range of characteristics, but predominantly dark grey or black in colour. Based on its distribution, building stone coded 128 may include slates drawn from any of the formations between and including the Doddiscombe Formation and the Ashton Shale member of the Crackington Formation, especially the Bampton Limestone and the Codden Hill and Teign Chert. Building stone from this stratigraphic interval also includes black mudstone coded 177. It is evident from a comparison of the distribution of these building stone types that they are more or less coincident and are likely to have been won from about the same stratigraphic interval. Those coded 128 are obviously cleaved; those coded 177 are not. A case can be made for amalgamating the two since this distinction does not seem fundamental. Nevertheless, both codes are retained.

The slate from Tracebridge and nearby quarries is pelitic, very well and regularly cleaved but is rather soft. Consequently its use is restricted for walling although it is understood that it was formerly more widely used for roofing. The cleavage is penetrative and cleavage surfaces may be stained by ochreous iron minerals.
Elsewhere, the code covers similar slate lacking associated sandstone and black or dark grey in colour depending partly on the state of weathering (Figures 1-4). Colour lamination is visible on the cleavage surfaces where the bedding is oblique to the cleavage in some blocks. The composition is pelitic (Figure 2) or rarely semi-pelitic. The cleavage is usually well developed but in fresh stone may not be obvious (Figure 4) in which case, it may be described as mudstone or “blocky”, providing a link with stone coded 177. This no doubt has contributed to the names of the formations involved which are described as mudstones rather than slates. However, whether or not the cleavage is obvious, most building blocks are strongly elongated in the cleavage direction (Figures 5 and 6).

These slates are distinguished from other grey slates by their dark grey or black pigmentation and tendency towards ochreous weathering. They are frequently associated with Teign or Codden Hill Chert in the walls of buildings or, in the northeast, with Bampton Limestone. An overlap with slate from the Crackington Formation, especially the Ashton Shale is suspected.

Black slate used around South Brent and Ivybridge extends also well to the east into the outcrop of the Nordon Formation (Figure 7). Black slate is also seen in outcrop in this extension and it may be that the geological mapping here needs minor revision. Black slate is also widely used around Lifton and Chillaton. The coding of building stone in this complex area is discussed in the appendix.

Appendix: North-west Dartmoor Fringes

The stratigraphy of this part of Devon is complex, caused by the conflation of complex thrusting and facies change from the Tavy Basin across the Laneast High to the Culm Basin (Isaacs *et al.* 1982, Issacs, 1983, Leveridge *et al.* 2006). The disposition of the various formations on the current BGS geological map is based to a significant extent on the work of Isaacs described in the above papers with a further important input concerning the age of the various formations based on the conodont stratigraphy (Stewart, 1981).

Figure 1 sets out lithological characteristics of the formations described in Isaacs, 1983 that might have been useful in identifying the unit from which a particular building stone was won. However, there are very few characteristics of value in this respect; black or dark grey slates and mudstones are common to nearly all the stratigraphic units as are intervals containing chert or cherty mudstone. Volcanic rocks are present in at least three units and carbonate rocks in four. The available descriptions in Isaacs (1983) and the BGS lexicon lack enough detail to allow confident assignment of a stone to a particular formation. The references in the lexicon are unhelpful in many cases and just refer to the BGS map sheet on which the formation was mapped, usually No. 338, Tavistock. In contrast to rock-types observed in outcrop, building stones lack the field relationships that assist the geologist in arriving at a consistent set of stratigraphic units, and so it has not been possible to identify with any certainty the source formations from which building stone was drawn in this region.

	Slate	Sandstone	Chert	Volcanics	Carbonate	Age from BGS Lexicon
Liddaton Formation	Dark grey, phyllitic, banded grey; greenish grey slate with siltstone and sandstone laminae	<10cm. With some thicker beds, graded, load casts, ripple drift cross bedding	Black slate , siliceous nodules			Famennian
Whitelady Formation	Pale, greenish, calcareous	Thin quartzite			Dolomitic, siliceous, well bedded, nodular; anastomosing clay lamellae	Famennian
South Brentor Formation	Black, micaceous, pale greenish	Siltstone <30cm			Nodular	Famennian-Tournaisian. Passes up into the Lydford Fm.
Lydford Formation	Black	Thin siltstone and fine-grained sandstone beds	Bedded chert as lenses intercalated with volcanics	Thin tuff; pillow lavas		Tournaisian- Visean
Greystone Formation (=Brendon Fm.)	Black siliceoius slates with chert; sooty black shale	Conglomerate	Black siliceous slates with chert. No chert in BGS description	Tuff, pillow lava; manganiferous; plentiful		Tournainsian
Fire Beacon Chert Formation (= Codden Hill Chert Formation)	Thin; black slate and mudstone		Chert		Limestone beds	Brigantian (Visean)
Meldon Shale and Quartzite Formation	Black slates and mudstones	Thin, clean-washed	Chert lenses		Limestone lenses	Tournaisian-Visean. Immediately underlies Codden Hill Cherts
Lowerton Limestone Formation	Grey, calcareous. Black				Limestone turbidites	Not in BGS lexicon
Brendon Formation	Black, dark grey	Thin. Includes greywacke	Mudstone locally siliceous			Visean
Cotehele Formation (St. Mellion Fm.)	Subordinate shale	Preponderant sandstone				Not in BGS lexicon (Tournaisean-Arnsbergian
Crackington Formation	Black and bluish-grey, sandy micaceous shales	<4m but typically much thinner; sedimentary structures				Arnsbergian- Langsettian (lowermost Westphalian)
Milton Abbot Formation				Agglomerate, tuff, pillow lavas (basic)		Visean
Bealsmill Formation (age equivalent of the Ashton Shale member of the Crackington Fm.)	Dark grey mudstone	Preponderant; coarse-grained, feldspathic; some conglomerate				Namurian

Figure 1. Lithology of stratigraphic units, from Isaac, 1983

For these reasons, the threefold division of building-stone types that have served reasonably well further east is mainly retained here rather than attempting a more detailed correlation with likely source formations. The scheme largely ignores the thrust systematics in the naming of formations and plays down the influence of depositional environment, concentrating instead on lithology as follows:
Youngest – flyssh. Crackington, Bealsmill, St Mellion Formations and Meldon Shale and Quartzite (part). Building stones thought to come from these formations are coded 152 (sandstone) or 171 (slate);
Middling – black slate interval. Newton and Teign Chert, Meldon Chert, Brendon Formation, Crackington, Lyford, Liddaton and Whitelady Formations, Burraton and Yealmbridge Formations. These are coded as 171 if likely to be part of the Crackington Formation, 146 if cherty or strongly laminated, 177 if poorly cleaved and called mudstone rather than slate in the database descriptions and 128 if black slate not cherty or laminated. Brown and pale grey lustrous slates seen in Lewtrenchard on the outcrop of the Teign Chert are tentatively assigned to the Yealmbridge Formation and do not fit in this scheme; they are coded 193. This merely reflects lithological similarity with pale brown lustrous slate with this code used for building close to Start Point in the South Hams and in no way implies any stratigraphic correspondence.
Oldest. Tavy Formation and those slates mapped as Middle and Upper Devonian slates. Coded as 59.

The difference between slate coded 59 and the overlying units here as further east, is the coming in of significant intervals of black slate. It is accepted that the difference is not all stratigraphic and there is some interdigitation of green/grey and dark grey/black slate and anyway, it is not always easy to tell the colour of stone when it is in a building. Note also that code 171 falls in both middling and upper subdivisions. If a building in this region also contains sandstone, then the sandstone will be mapped as Code 152 unless there is overwhelming other evidence that it should not be.
In reality of course, further confusion is caused by stone imported from far away.

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Figure 1. Brook Villa, Landkey. Black slate with orange-weathered surfaces; brick quoins and dressings.


Figure 2. Roadside wall near Shillingford. Well cleaved pelitic black slate.


Figure 3. Dark grey pelitic slate. The Castle, Castle Hill Gardens, Filleigh.


Figure 4. Black slate weathered ochre. Many blocks are equidimensional. Chancel of St Nicholas' church, Brushford, Somerset.

Figure 5. Well cleaved black slate blocks elongated in the cleavage direction. Roadside wall, Lifton. The coping is of Pentewan-type elvan (Code 208).

Figure 6. South aisle of St Mary's church, Lifton. The wall is of mixed black slate and Pentewan-type elvan. The window dressings are of Polyphant Stone and Hurdwick Stone.

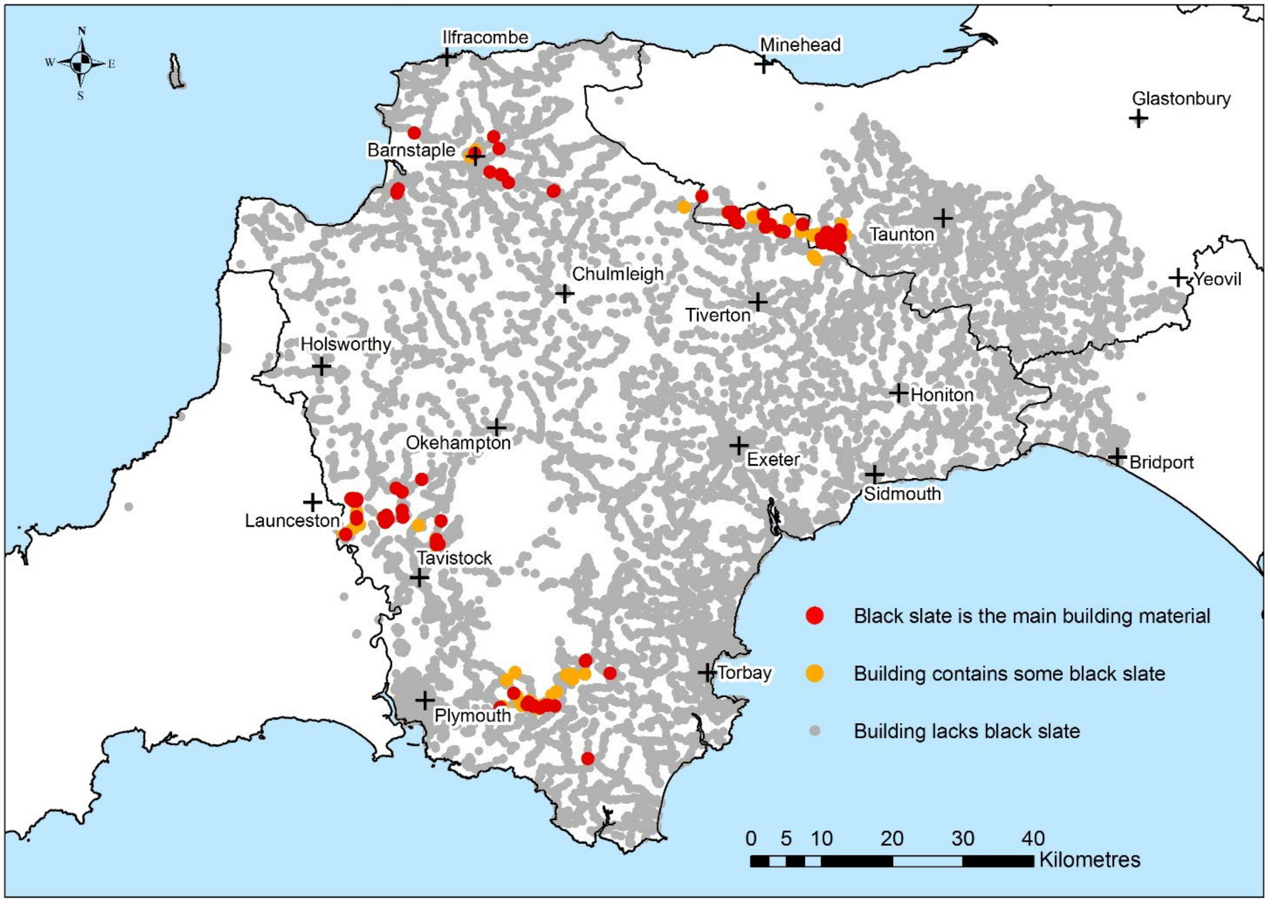

Figure 7. Distribution of black slate (Code 128) in buildings.

131, Vein Calcite

The examples seen are of coarse-grained reddish or white calcite, either carefully selected for decorative effect, for example as the coping of garden walls (Figure 1), or else incorporated as a minor component because plentiful in the source quarry. The material is perhaps more common in areas where Devonian limestone is used for building but its distribution shows no strong preference (Figure 2).

Figure 1. Block of coarsely crystallised calcite forming part of the coping of a roadside wall, Tavistock Road, Plymouth, just south of junction with Powisland Drive.

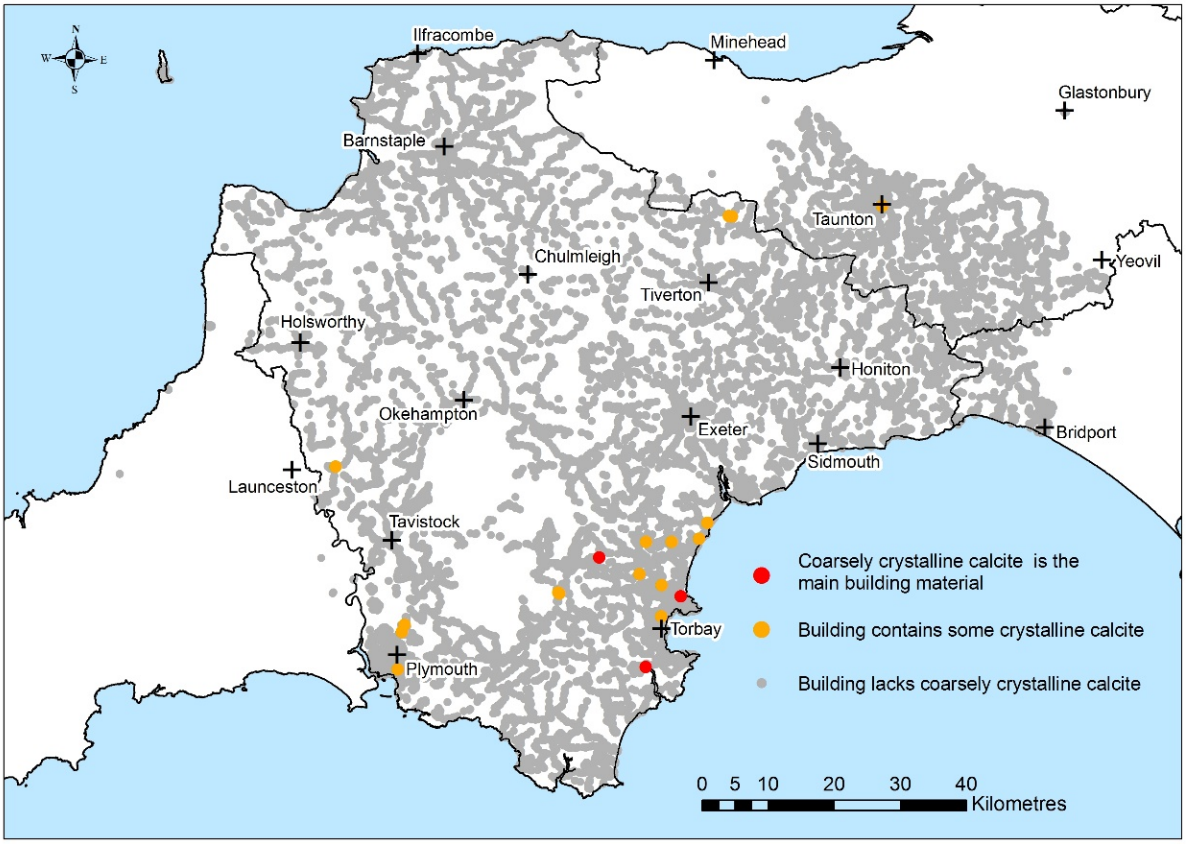

Figure 2. Distribution of vein calcite in buildings.

132, Ilfracombe Slates Formation

Slate from the Ilfracombe Slates Formation is typically pelitic, rather soft and dusty or with a silvery finish on the cleavage planes; many examples are described in the database notes as phyllite (Figure 1). The predominant colour of fresh rock is pale green or where partly weathered, pale buff (Figures 2 - 4) but as is usual with slate building stone, a range of weathered colours also occur with grey-, buff,- brown- and black-weathered slate all encountered (Figure 5). Building blocks tend to be thin and small, with the cleavage set to lie horizontally but in most buildings the poor quality of the stone is obvious (Figure 6) with just one or two exceptions (Figure 7). In a few cases, it is possible to recognise colour and compositional banding of sedimentary origin lying oblique to the cleavage (Figure 1).

The slate may be accompanied in walls by impure limestone or calcareous slate coded 211, by sandstone coded 96 or by the Combe Martin Sandstone coded 213. These building stones are believed also to have been won from the Ilfracombe Slates.

The distribution of the stone in buildings is more or less restricted to the outcrop of the parent formation (Figure 8). One would hardly expect stone of such poor quality to have been carried far from the source quarries. However, it is widely used in Ilfracombe and is an important constituent of the stonework of Cothelstone Manor and the associated buildings, along with Otter Sandstone. It has not proved possible to distinguish reliably between the different members of the formation on the basis of lithology.

The main characteristics which identify the slate are pelitic composition, pale green and buff colours, silvery finish to the cleavage surfaces, small, thin building blocks and soft nature. Because most of the formations that surround the Ilfracombe Slates are of contrasting lithology, it is identified in buildings with some confidence. Confusion is possible with Morte Slate but the latter is more quartz-rich (semi-pelitic in composition), is less well cleaved and is nearly always grey, lacking the green and buff pigmentation of slate from the Ilfracombe Slate Formation.

Figure 1. Interlayered slate and sandstone with cleavage oblique to bedding, Hele Bay, Ilfracombe. The slate fragments on the beach give a good idea of the silvery finish of cleavage surfaces.


Figure 2. Buff-weathered blocks of slate, lytch gate of St Peter's church, Berrynarbor.

Figure 3. Buff slate associated with red sandstone (Combe Martin Stone), south side of Holy Trinity church, Ilfracombe.

Figure 4. Moules Cottage, Berrynarbour. Walling is of buff-weathered slate as small thin blocks.

Figure 5. South side of Malborough Road, Ilfracombe showing the range of colours in Ilfracombe Slate. Note decorative band of vein quartz above the ground floor and brick dressings.

Figure 6. South transept, Church of St Peter ad Vincula, Combe Martin.

Figure 7. Chancel of St Thomas' church Kentisbury. Regularly cleaved pelitic slate. Width of view 70cm.

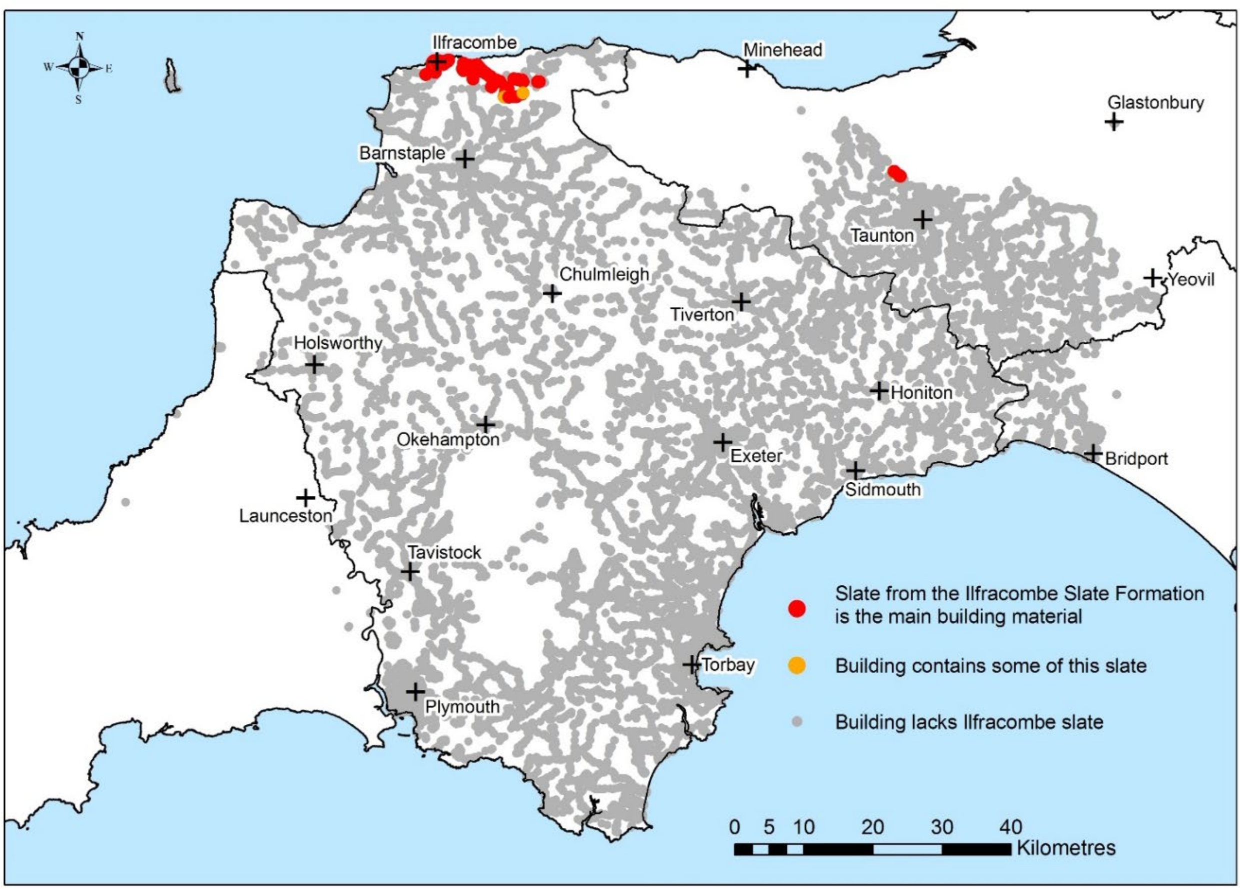

Figure 8. Distribution of buildings containing slate from the Ilfracombe Slates Formation.

133, Hangman Sandstone Formation (Hangman Grits)

Building blocks of this kind of stone are up to 40cm across with irregular outlines. The rock is typically homogeneous, and massive, lacking planar fabric of any kind (Figures 1 and 2). The fractures that outline the blocks are planar (joints?), conchoidal with concentric shallow ridges centred around the point of contact of hammer or chisel, or hackly and irregular (Figure 3). The colour is medium grey or green-grey with some surfaces stained red (Figures 2 and 5) but the stone weathers dark grey. The texture is medium grained and the clasts, typically of quartz with subordinate feldspar, appear well sorted. However, in many examples the grains are sutured together and are hard to resolve with the hand lens. This gives the rock its typical compact appearance.

Sandstone of the kind described above is associated in some buildings with subordinate psammitic slate and foliated sandstone (Figure 6) and in outcrop the beds of sandstone which may be metres thick are separated by narrow zones less than 10cms thick of psammitic slate (Figure 4). Slate of this kind was originally given its own code but following a review, is now subsumed within the stone given code 133. Crudely foliated sandstone of the Material Code is widely used in northwest Devon as monolith gateposts.

The distinguishing characteristics of building stone from the Hangman Grits include:

- Tough, compact – clastic grains can seldom be differentiated – medium grained;
- many blocks are unbedded though they may be elongated in the plane of the bedding;
- conchoidal fracture; hackly fracture; concentric undulation around the site of impact where a block is split by a hammer blow;
- grey but in many cases has red-stained surfaces. These are so widespread that from a distance the stone looks red. It is not clear whether the red staining is an original feature of the rock or results from weathering. Some sandstone has a brown-weathered crust;
- not usually associated with slate in buildings although sandstone blocks may have slatey parts. In contrast, sandstone from the Morte Slate is associated with slate in many buildings.

There are buildings with stone where these identification criteria conflict, for example red stained or brown-weathered sandstone also occurs in the Morte Slate. It is clear that the distinguishing criteria do not always work and it is probably the case that there is an overlap in the characteristics of these two kinds of sandstone. In and adjacent to the Quantock Hills and in Taunton, confusion is likely only with sandstone from the Morte Slate but in northwest Devon there are additional candidates for confusion, including sandstone from the Ilfracombe Slates. Grey compact sandstone is widely used for building in Taunton (Figure 7). Although a source in the Hangman Grits must be more than 9km away, this is thought to be the origin of the sandstone in those cases where it is not associated with plentiful slate, in which case it is thought to be won from the Morte Slate. In some cases, the sandstone has joints stained red which also encourages the view that it is from the Hangman Grits.


Figure 1. Outbuilding opposite The Hunters Inn, Martinhoe, north Devon. Dark grey compact sandstone lacking planar fabric.


Figure 2. St John the Evangelist's church, Countisbury; buttress at west end of nave. Angular unfoliated sandstone blocks with red-stained surfaces.

Figure 3. Tower of St Mary's church, Oare. Wall, relieving arch and quoins of dark grey compact sandstone with hackly fracture; dressings of Ham Hill Stone round the west door and on top of the plinth.

Figure 4. Roadside outcrop 800m west of Countisbury.

Figure 5. Green-grey medium-grained sandstone with red-stained patches. There is one on the underside of the block immediately above the penknife. Roadside wall, 470m west of Countisbury.

Figure 6. Tower of St John the Evangelist's church, Countisbury. Grey sandstone is accompanied by blocks of crudely cleaved slate.

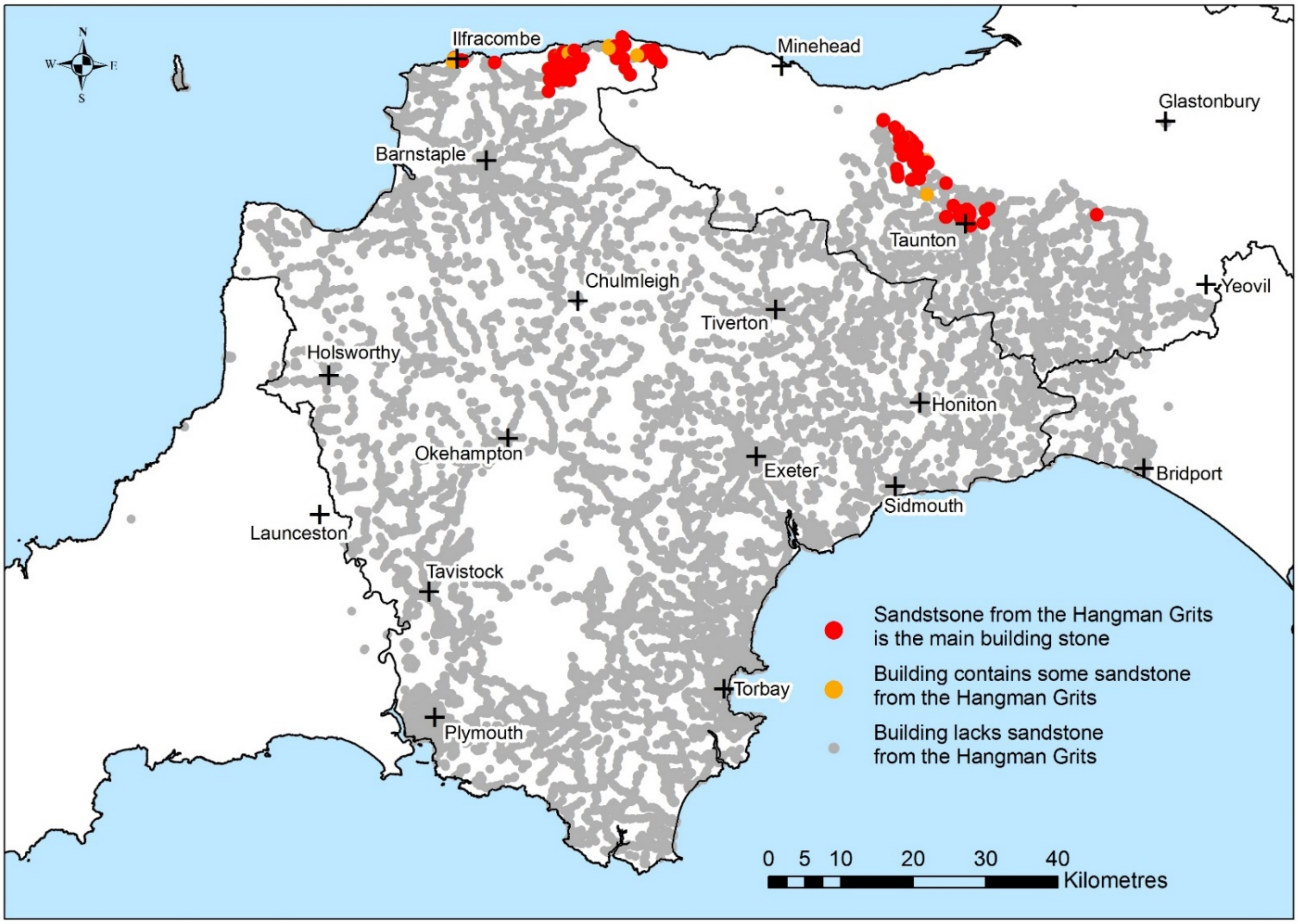

Figure 7. Distribution in buildings of sandstone from the Hangman Grits.

134, Hestercombe Diorite

The rock is composed of interlocking laths of orange feldspar and interstitial aggregates of fine-grained micaceous material, probably chlorite. No quartz is seen. This and the abundance of feldspar perhaps led to the initial identification of this rock as a syenite although it is now generally agreed to be of dioritic composition. The blocks tend to be large and are notably homogeneous, without obvious partings or planar fabrics. Surfaces have a specked appearance in orange and darker colour caused by the feldspar which generally stands a little proud of the surface, and the interstitial chlorite.

The stone has a limited distribution around the source quarry in the garden of Hestercombe House, most notably for the construction of the house itself but also as a minor constituent of buildings in Taunton, Nailsbourne, Kingstone St Mary, Cheddon Fitzpaine and Gotton (Figure 3).

Reference

Prudden, H., 2007. The Raw Materials. *In* Dunning, R., (Ed). *Somerset Churches and Chapels: Building, Repair and Restoration.* 21-28. Halsgrove, Wellington.

Figure 1. Base of the tower of the church of St Mary Magdalene, Taunton. The blocks above the string course are of red pebbly sandstone, from the Budleigh Salterton Pebble Bed Formation or Otter Sandstone (see Prudden, 2007) and homogeneous diorite from Hestercombe, distinguished by lack of bedding and pebbles and slightly browner pigmentation. It is possible that the diorite which can be identified in the tower walls at least as high as the lowest set of statues was used to supplement the red sandstone at the time of rebuilding of the tower by Sir Gilbert Scott in 1862. The string course and footing are of Ham Hill Stone.

Figure 2. South porch of St Mary's church, Cheddon Fitzpaine. The central building block above the coin is of Hestercombe Diorite. Other stone includes Morte Slate, Otter Sandstone and Ham Hill Stone.

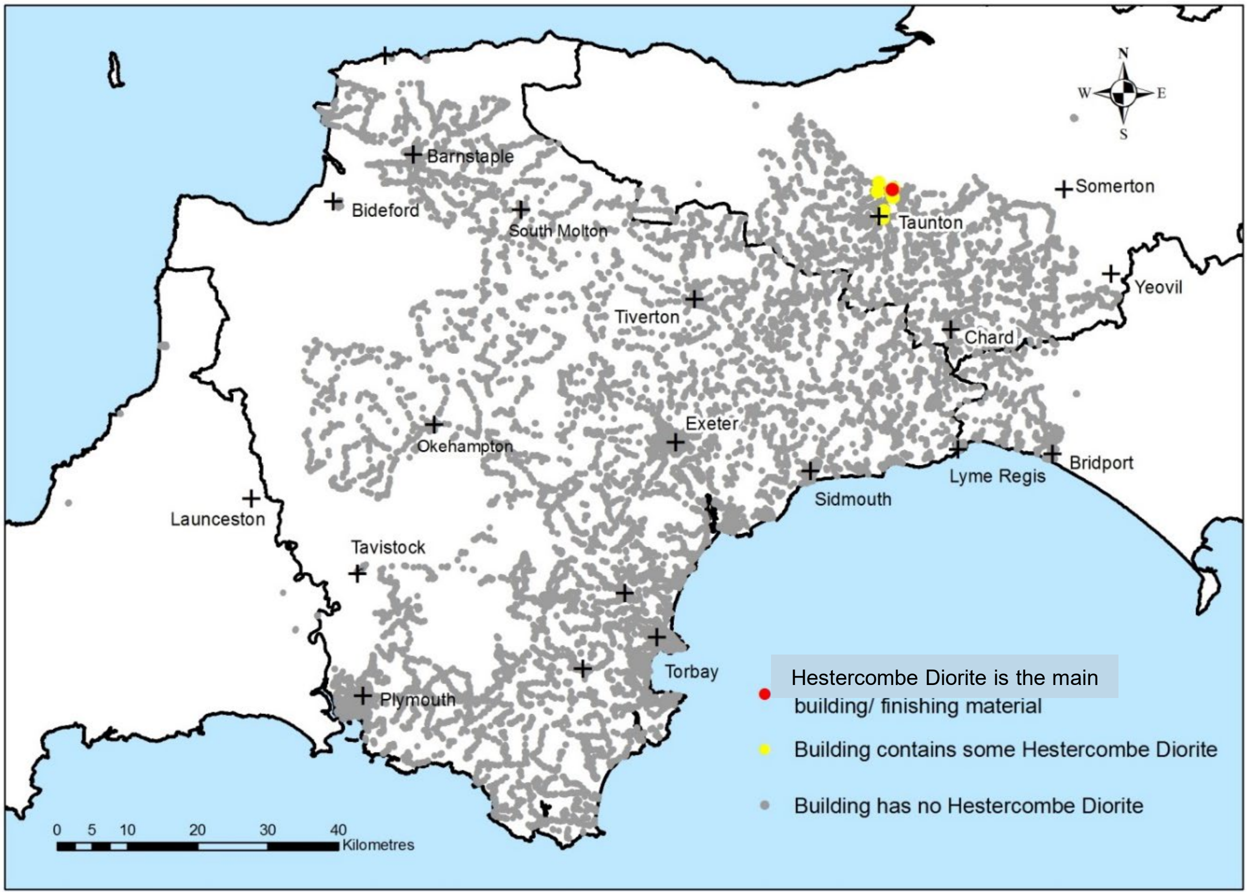

Figure 3. Distribution of Hestercombe Diorite in buildings. Hestercombe House is the only building encountered during the survey made largely of the diorite.

135, Delabole Slate

Slates used for building in Devon have proved to be the most difficult group of rock-types to identify successfully. Initially, nearly all slate was coded 59, corresponding to Devonian slate of various formations, or 171 corresponding to slate from the Crackington and Bude Formations. It was known that slate from the huge pit at Delabole in Cornwall was used not only for roofing slate, but also as building stone. The village and quarry were visited in December 2010 in an attempt to gain an insight into how to identify slate from this quarry. Following the visit, earlier observations of slate in buildings were reviewed in the light of insights gained and some were changed to Delabole slate. The slate used for building in the village of Delabole is pelitic, well cleaved and dark grey in colour. However, the slate in the quarry showroom shows a much wider range of characteristics, from fresh grey slate from the deeper levels of the quarry to slate showing a range of weathered colours including red, orange, yellow and black from shallower levels.

The observations of slate building stone up to this time were reviewed and some were changed to Code 135, corresponding to slate from Delabole Quarry but in nearly all cases with a query expressing uncertainty about the identification. Subsequently, the code was used less and less and Code 191, slate of unknown origin, used in its place. Conversely, Delabole slate used for roofing proved to be relatively easy to identify because of the mottling of cleavage surfaces with parts with a matt finish and parts with a shiny finish. Although not given a unique code, the notes identify Delabole slate used for roofing where the identification was made.

The typical slate on display at Delabole is dark grey, with regular penetrative slatey cleavage and generally lacks interesting decorative details. Cleavage slabs or slabs cut parallel to the cleavage show more interesting figuring on those surfaces including swirls and breccia like structures. More interest is added by including on exposed surfaces of slate blocks cross-cutting veins of quartz generally showing brownish colours and some texture. In other cases, partly weathered slate is selected for paving slabs with cleavage surfaces showing a range of weathered colours in shades of brown and ochre (Figure 1). There are some slabs that look greenish grey but these are not typical; the typical colour is dark grey. It is hard to be sure of the identifications as outlined above and confusion has no doubt taken place between this slate and that from other sources, especially slate offered for sale in garden centres. Nearly all identified occurrences are in modern buildings.
In the event, only 3 occurrences of Delabole Slate used for the walls of buildings were accepted. One of these is in St John's church, Delabole, one is in a new wall in Kingstone St Mary where the builder identified some of the stone as Delabole Slate and one is the example illustrated in Figure 1.

Figure 1. Slate used for the coping of the wall is believed to be from Delabole. The rest of the wall is of Bude Formation sandstone. Entrance to The Ash Stud, Monkokehampton.

137, Dark Grey Medium-grained Limestone (undiff.)

Lithology code 137 covers dark grey limestone probably mainly the stratigraphical equivalent of the Bampton Limestone Formation. The examples seen are medium- to coarse-grained, rather pure grainstones composed of equant calcite clasts; crinoid ossicles have been identified in at least one example. The high iron content leads to the development of characteristic ochre-stained fracture surfaces. The examples at Huntsham, on Bampton Down and in Exeter are from the Bampton or Westleigh Limestone. These dark limestones in the Bampton area correspond with the upper part of the Bampton Limestone Formation (Bailey's sequence) of Swarbrick, (1962). There are further grey limestones lacking laminations – not so dark, which may also belong to this division, eg in the tower of St Peter's church, Oakford.

The examples from Sidmouth and around Ugbrooke House are of unknown origin.

Reference

Swarbrick, E. E., 1962. Facies changes in the Chert formation of the Lower Culm Series of the Brampton area, North Devon. *Proceedings of the Ussher Society*, **1**, No 28.

Figure 1. Wall, Barrack Road, Exeter. Dark grey medium-grained limestone with ochre- stained fracture surfaces. Most blocks are laid with bedding parallel to the plane of the wall. Some blocks have flute casts.

Figure 2. Wall at 412 Pinhoe Road, Exeter. Rubble wall of pale-grey laminated limestone and dark-grey limestone with ochre-stained surfaces possibly from the Bampton area.

Figure 3. Bridge over the River Batherm between Shillingford and Waterrow. Bampton Limestone including some dark grey, iron-rich blocks, with concrete string course.

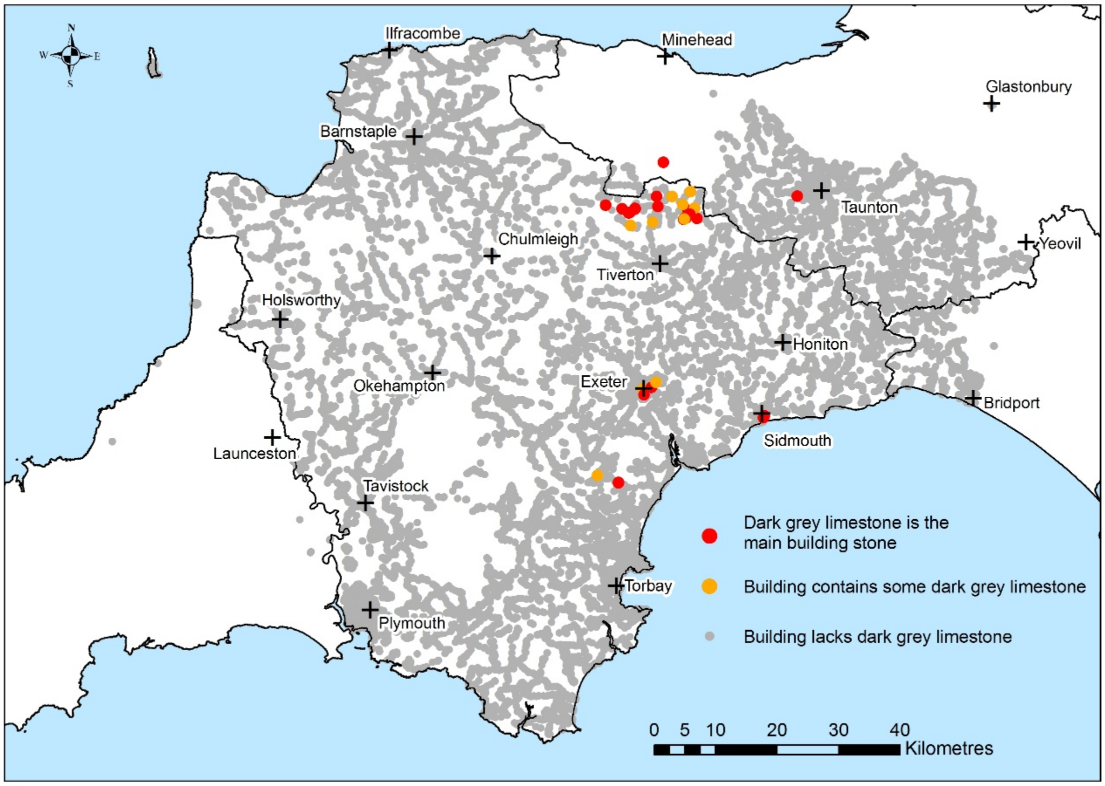

Figure 4. Distribution of dark grey limestone given Code 137 in buildings.

139, Thin-bedded Westleigh Limestone

This code refers to banded and laminated very fine- to medium-grained limestone, typically pale grey in colour but including varieties with strong variegated colours and with sparse, mainly black, chert bands. Code 139 was assigned initially to pale-grey banded and laminated limestone used for roadside walls in Exeter (Figures 1 and 6). At the time the code was created, no examples with chert bands had been seen and the origin of the limestone was unclear. Subsequently, exactly similar limestone with black chert bands was observed and it became clear that the limestone was affiliated to the grey variety with black chert from Westleigh Quarry (Figure 4). Flute casts have been observed on bedding planes as have a few goniatites. Some bands are composed of oolitic limestone (Figure 5).

A search was made of records made before a decision to create this new category of limestone was reached, to see if any limestone occurrences recorded with Code 31 corresponding to a limestone of unknown origin, should be recoded 139. Many examples in East Devon where the work started, qualified for recoding, especially those that included also black chert. Subsequently, somewhat similar limestone also showing variegated colours and strong banding was described from Bampton and adjacent areas and given Code 123. However, the code 139 is retained for the time being on the basis that the rocks are rather distant from Bampton and the nature of the bedding is different. It is admitted that a good case can be made for merging either Code 123 and 139 (Bampton Limestone) or 139 and 58 (Westleigh Limestone) on lithological grounds and this may be done in the future.

Figure 1. Classic banded Westleigh Limestone; pale grey on exposed surfaces although darker grey where the surface has been chipped off, with hairline-thick colour lamination. In this example as in many, chert is not seen. Wall outside Force Cancer Support Service, Dryden Road, Exeter.

Figure 2. Pale, medium and dark grey banded limestone with black chert bands, wall, Topsham Road outside County Hall, Exeter, indistinguishable from limestone Coded 123 and referred to the Bampton Limestone.

Figure 3. Variegated banded limestone laid with bedding parallel to the plane of the wall. Flute marks are quite commonly observed on the bedding planes. It is hard to identify the rock as a limestone when laid bedding parallel and where chert is lacking; the colour variation is the main clue as to origin. Roadside wall, Harrington Lane, Exeter. Width of view, 3 metres.


Figure 4. Emmanuel Parish Church, Okehampton Road, Exeter. The top building block shows limestone with black chert bands that appears to have been cut into by the paler grey limestone forming the lower part of the block and showing cross bedding, implying that the blocks has been laid upside-down.

Figure 5. Further detail of the block lower right in previous illustration showing salt and pepper texture. In this case, the pale carbonate grains are perfectly spherical (oolites?)

Figure 6. Emmanuel Parish Church, Okehampton Road, Exeter. Building block showing the delicate colour lamination characteristic of this limestone.

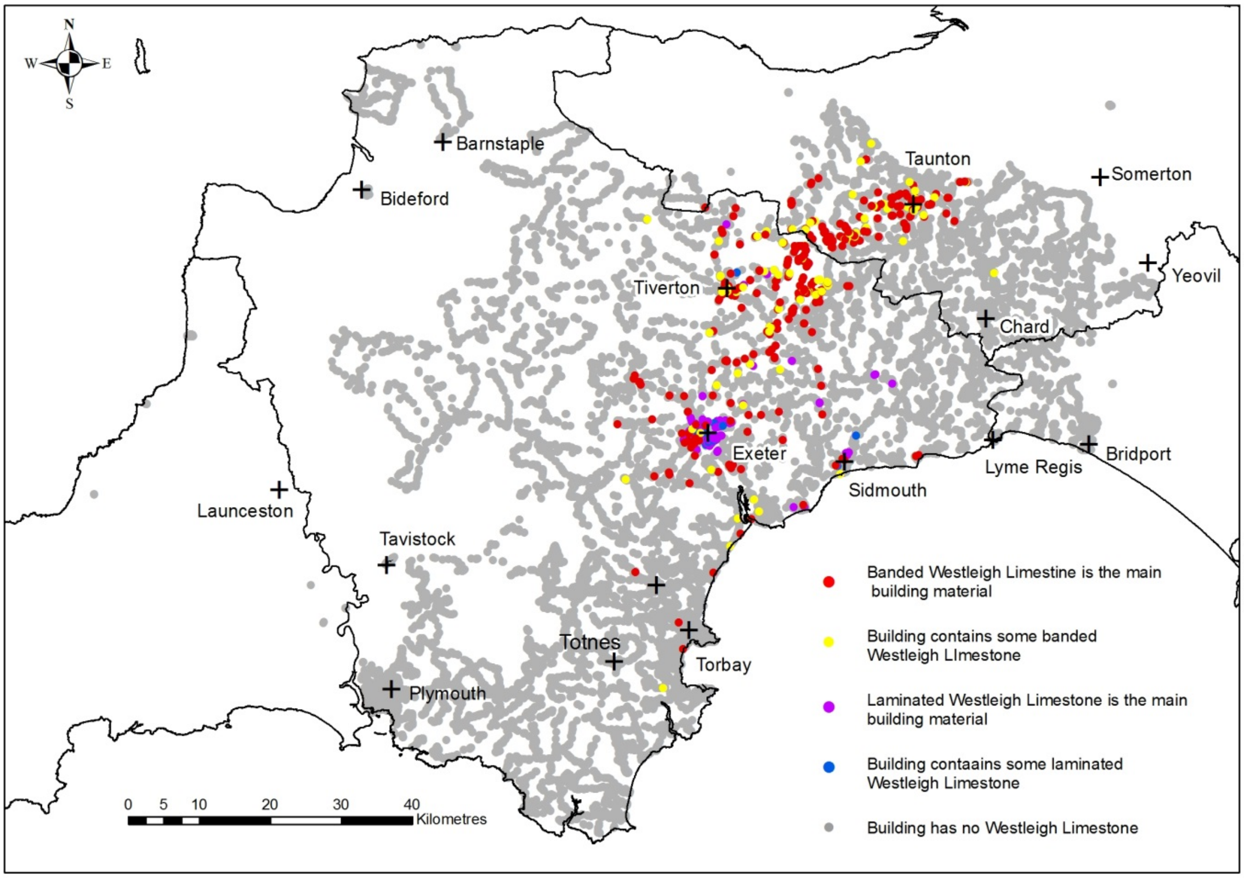

Figure 7. Distribution of Westleigh Limestone in buildings; red and yellow symbols, limestone coded 58; purple and blue symbols, limestone coded 139.

Figure 7 compares the distribution of laminated Westleigh Limestone with the more common variety where banding is less pronounced (Code 58). While there is some overlap, the former is concentrated in the Exeter area. The reason is unknown. It is suspected that it is an artifact of the survey but it might also reflect the effect of one or two large public works contracts that led to the use of stone from a particular quarry, or even location within one quarry, for the buildings in Exeter, which are mainly roadside walls.

140, Medium-grey limestone (mid-Devonian)

This code is used for limestone from Torbay, Plymouth and surrounding areas with medium-grey pigmentation. It is closely similar to the pale grey variety (Code 72, qv) except that it is darker in tone. The limestone is fine- to very coarse-grained and may be homogeneous and massive (Figures 3 and 4) or crudely foliated or bedded (Figures 6 and 8). High quality building stone made of pure limestone is very widely used in buildings but so is lower quality material with varying proportions of silicate impurities (Figure 5); some limestone has streaks and lenses of brown-weathered dolomite. Because of the stronger pigmentation, medium-grey limestone displays clastic textures, defined by fragments of pale grey limestone, in many cases representing parts of corals, stromatoporoids and other fossil fragments, enclosed in a darker groundmass, more clearly than the pale grey variety. Blebs of pale grey material flattened or sheared out in the foliation enclosed in darker grey carbonate are observed at many localities and represent deformed tabulate corals (Figure 1). Like the pale grey variety, patchy staining in shades of red, orange and ochre is common (Figure 7); some limestone blocks incorporate red-stained dripstone and some have inclusions of red sandstone, especially in the Brixham area. However, widespread pink staining appears to be less common than in the pale grey limestone.

The distribution of medium-grey limestone closely mirrors the pale grey variety (Figure 10), except that the concentration of the latter in the coastal areas of Torbay and in export destinations (Exe estuary and east Devon) is absent. Along with the paler grey variety it is the main building stone of Devon south of the Dartmoor Granite and also the main stone of Plymouth and Torbay as well as figuring prominently in Exeter.

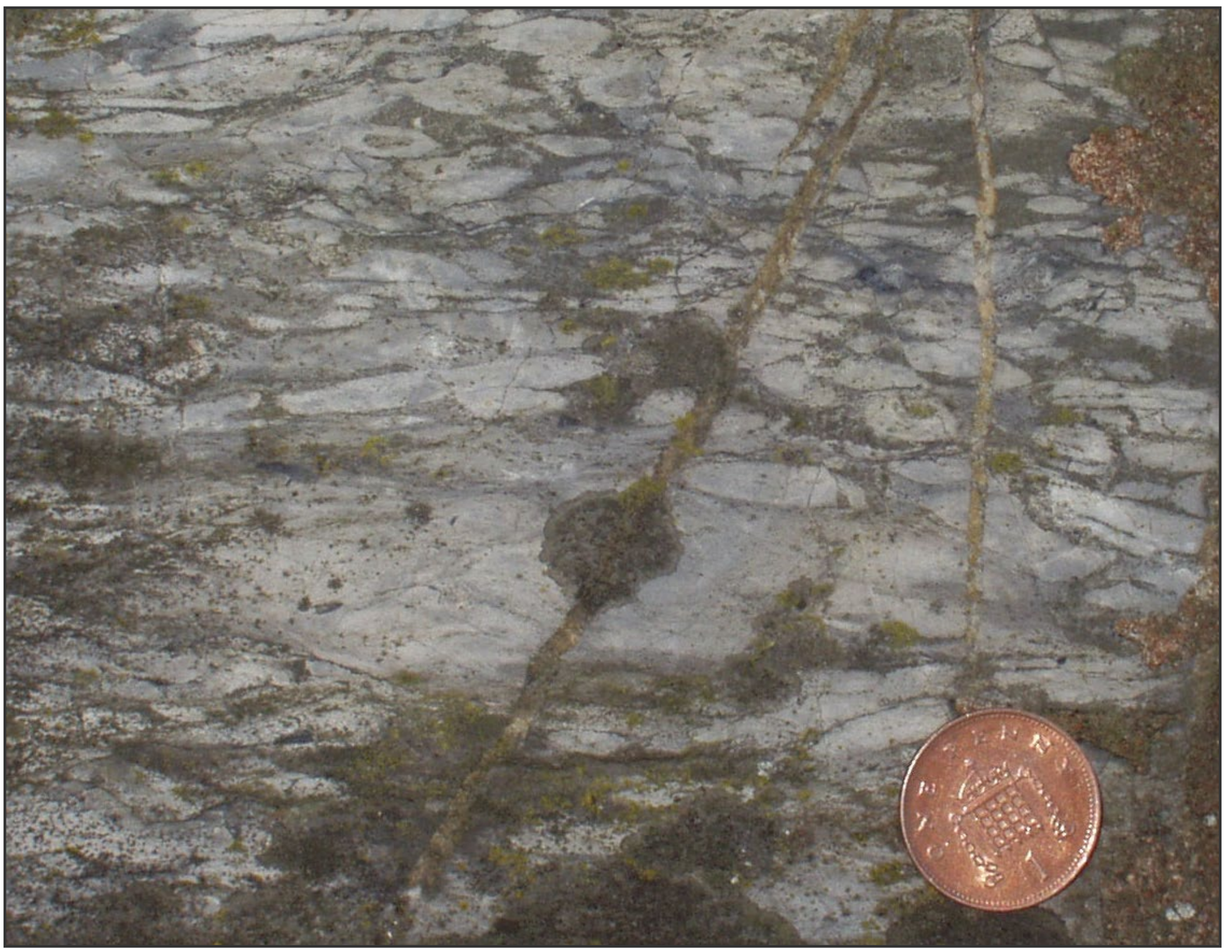

Figure 1. Roadside wall, Butts Road, Exeter. Deformed tabulate corals in medium-grey limestone.

Figure 2. 16 Church Hill, Pinhoe, Exeter. Typical appearance of medium-grey limestone.

Figure 3. Newton Abbot Library. Medium-grey limestone with yellow brick quoins, dressings and string courses.

Figure 4. 7-11 Vicarage Hill (odd), Kingsteignton. Good quality medium-grey limestone with brick quoins and dressings.

Figure 5. Compton Castle. Mainly impure medium-grey limestone of poor quality but the dressings are of red sandstone and the corbels supporting the machicolations are of Dartmoor Granite.

Figure 6. Garden wall, Copythorne Road, Brixham. Medium-grey foliated limestone.

Figure 7. Palace Hotel, Babbacombe Road, Torquay. Medium-grey limestone with reddish staining. The older wall on the right has a predominantly grey cast. The wall on the left, rebuilt using recycled stone and much less strongly weathered, displays stronger red staining. The white surfaces are caused by adhering plaster.

Figure 8. Garden wall, Dainton. Typical expression of crude bedding in medium-grey Dainton Limestone.

Figure 9. Livery Dole almshouses, Exeter. The contrast between pale and medium-grey limestone gives a decorative effect.

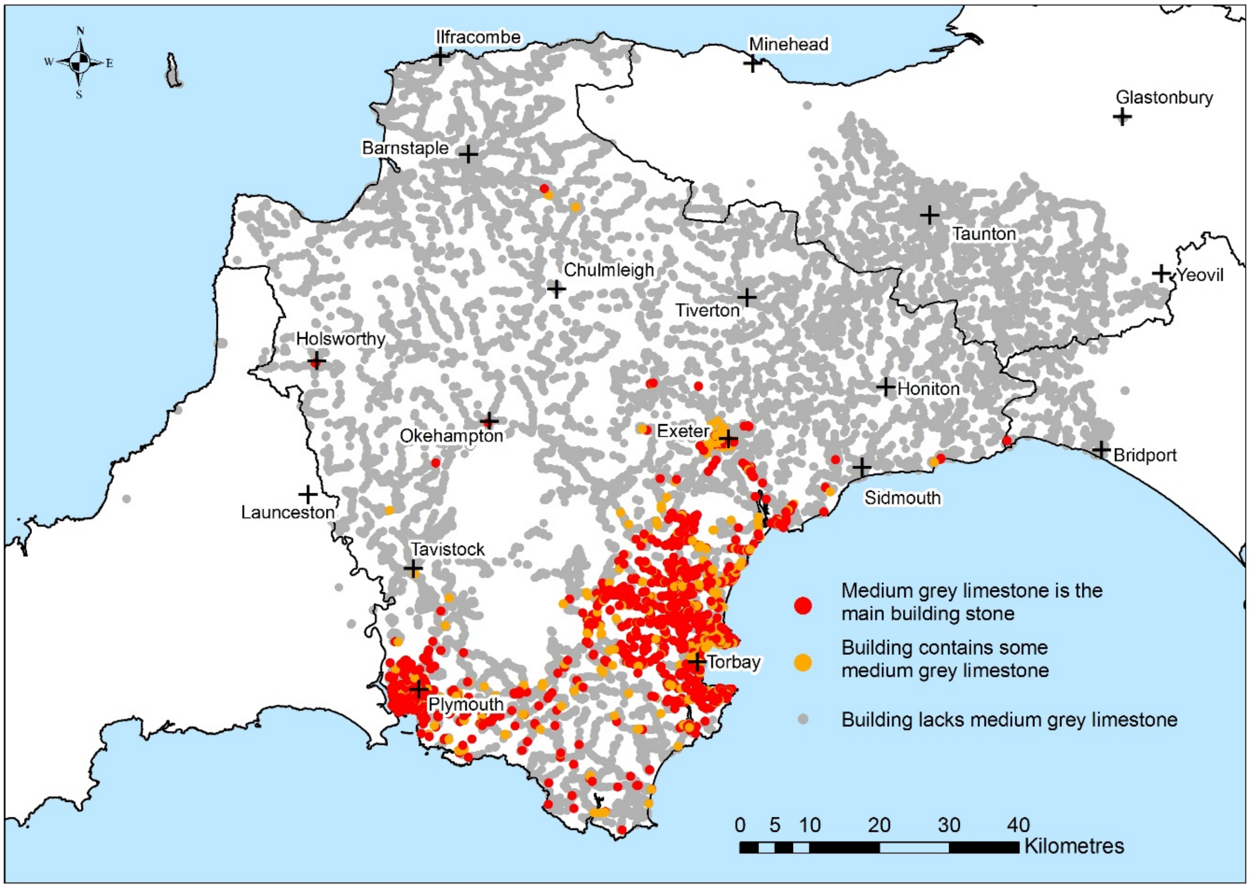

Figure 10. Distribution of medium-grey limestone from the Middle Devonian.

141, Red Breccia with Limestone Clasts (Permian)

This lithology code is used for Permian red breccia containing prominent clasts of medium- and pale-grey Devonian limestone in the Teignmouth and Torbay area (Figures 1 and 2). The clasts are of limestone, porphyry, vein quartz, slate, red and black sandstone and greywacké, more or less foliated, grey banded quartzite, schorl and murchisonite. Clasts are mainly angular but those of limestone and porphyry may be moderately to well rounded (Figures 2 and 3). The rock may be matrix- or clast-supporting. The long axes of clasts tend to lie in and define the bedding (Figures 1 and 3) and in some cases the clasts are imbricated. The bedding is accentuated especially in finer-grained variants by variation in the proportion, average size or composition of the clasts (Figure 3). The matrix is of poorly sorted coarse- to fine-grained sandstone with variable silt and mud content and carbonate cement. The grains are predominantly of quartz with subordinate feldspar and lithic fragments. The matrix is stained red or maroon through the presence iron oxide coatings on the clastic grains. The breccia contains bands and lenses of pebbly sandstone.

This breccia is distinguished from those represented by Code 85 (Heavitree Breccia and equivalents) mainly through the presence of obvious grey limestone clasts. It tends also to be better bedded and have a more sparry and less muddy cement. It has not been possible to relate this building stone type to any particular horizon in the Permian succession; it could have been won from any or all of the Teignmouth Breccia and underlying Permian breccia formations, or the Torbay Breccia. Its use lies generally to the south of that of breccia coded 85 (Figure 5).

Figure 1. Roadside wall, Old Mill Road, Chelston, Torbay.

Figure 2. Winsu Avenue, Paignton, Torbay. Very coarse-grained breccia with rounded limestone clasts.

Figure 3. Sea wall south of Redcliffe Hotel, Paignton.

Figure 4. Theatre, Palace Avenue, Paignton. Torbay Breccia with quoins and dressings of yellow brick and Ham Hill Stone.

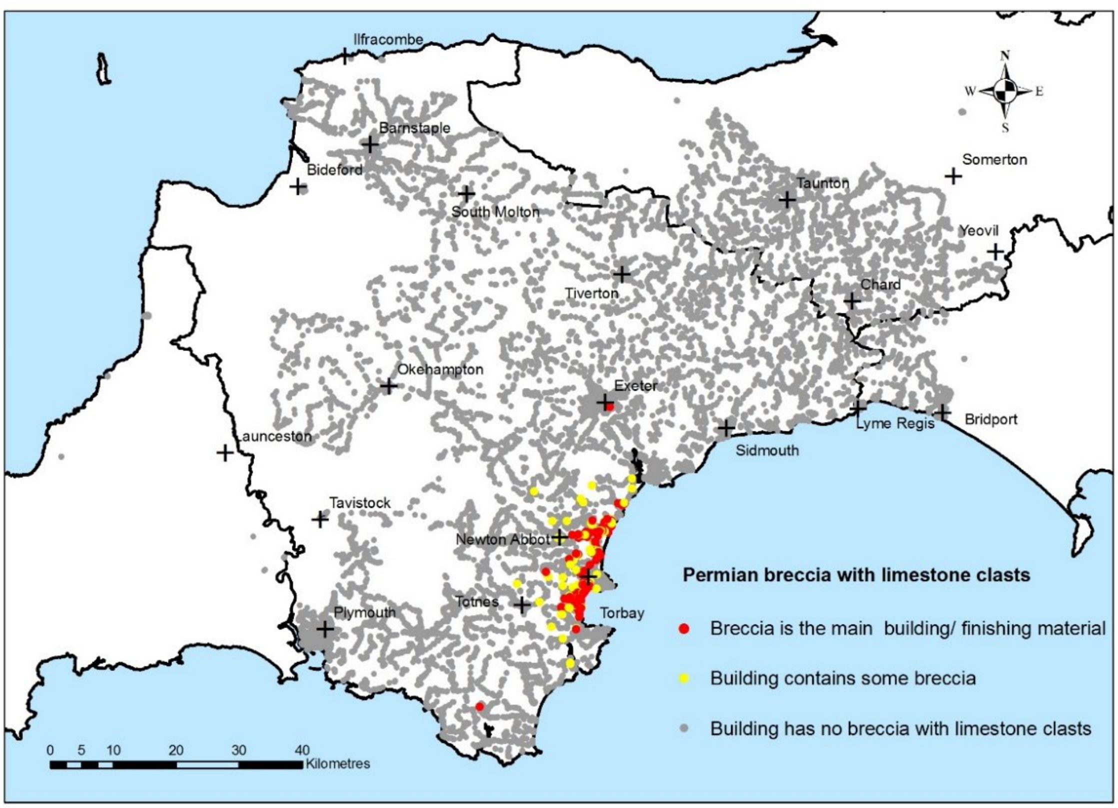

Figure 5. Distribution of Permian breccia with limestone clasts.

143, Italian Travertine

Travertine is a light-buff strongly bedded limestone formed as a hot spring deposit. It is also light-weight with an open texture and surprisingly strong, making it very suitable for building; it is widely used in Italy, from which country the stone used in Devon probably comes. Here its use seems to be restricted to the cladding of C20 buildings in the centre of cities, including the Odeon Cinema, Sidwell Street Exeter, Primark, Drake's Circus, Plymouth and Lloyd's Bank, Royal Parade, Plymouth. In the case of Plymouth, all the occurrences seen are in buildings put up to repair the bomb damage of the Second World War. See also tufa, Code 111.

Figure 1. New buildings along Royal Parade, Plymouth. The dressings at the entrance to Lloyds Bank are of travertine. Most of the buildings in the picture are finished in Portland Stone.

144, Tough Red Sandstone (Basal Permian)

Hard, tough red sandstone, distinct from that exposed as bands and lenses in the Permian breccia succession is widely though sparingly used for building in the Exeter-Teignbridge-Torbay-South Hams area at least as far west as Plymouth (Figure 19). It is medium-grained, usually well sorted with subangular to well rounded grains and typically lacks bedding or other sedimentary structures although in some cases, regular bedding defined by grain size and degree of cementation is observed (Figure 5). The grains are mainly of quartz but in many blocks quartz is accompanied by a scattering of chalky white grains probably of feldspar. Most examples of the sandstone are cemented by calcite but a significant proportion of blocks throughout the area where this rock-type is used, have a glassy finish, or scintillate in the sunshine (Figure 6), both characteristics being caused by the partial infilling of the voids between the grains by new idiomorphic quartz crystals. In these cases, vugs lying in the bedding planes may mark the locations where calcite rather than silica was the cement, now weathered out (Figure 5). A small proportion of examples are coarser-grained, with clasts up to granules in size, but poorly sorted and pebbly sandstones typical of lenses within the Permian breccias are absent. The sandstone is referred to by those in the building trade and by local architects as “red rock”.

The sandstone occurs as a minor constituent of limestone walls in Brixham and Exmouth (Figure 3). A very large proportion of limestone walls in Brixham have a few blocks of this sandstone (Figure 3) and in some cases, blocks of limestone with included fragments of sandstone occur (Figure 4). In these cases, it is believed that the sandstone is derived from Neptunian dykes within the Brixham Limestone (Richter 1966) and has been won “by accident” along with the limestone for use locally or for export by sea to Exmouth and perhaps other towns along the Exe estuary. The sandstone is also widely used for the quoins and dressings of medieval and early modern buildings in the Brixham-Chudleigh-Buckfastleigh-Totnes region (Figures 1, 2, 9 and 13). Clearly it was much sought after in those times for its combination of workability, toughness and resistance to erosion. The fact that the sandstone is not seen in outcrop except as Neptunian dykes might indicate that for this mode of use, it also came from Neptunian dykes. Another possibility is that the source of the stone at the base of the Permian has been worked out and this explains why it is no longer found *in situ*.

This sandstone is the main building material of the village of Bishopsteignton (Figure 7) and is also common in parts of Teignmouth, Ideford and Luton nearby (Figure 19). A very strong case can be made in the case of Bishopsteignton that the stone is local – it is very unlikely that stone that is so widely used for all kinds of building even the humblest in the village, would be carried from far away. The authors of the village design statement (Bishopsteignton Parish Council, 2006) suggest it was won from the base of the Teignmouth Breccia which crops out on the slope just above the village. Geological mapping by the British Geological Survey shows a sandstone at the base of the succession here (Selwood *et al*., 1984) and there are old quarries located within it. There is also a tradition repeated in the Bishopsteighton village design statement that the red sandstone for the Ideford Arch was won from the nearby Red Rock Quarry, also used for the subgrade of the original toll roads that cross at the Ideford Arch, which has only recently been filled in. Certainly, the sandstone crops out in a lane a short distance to the east. The sandstone can be traced northwards at the base of the Permian succession to the northern edge of the Newton Abbot sheet where it passes northwards onto the Exeter sheet and is there called the Knowle Sandstone.

Appleton (1875) notes the extreme hardness of the sandstone which he believed to have been won from quarries in the Waddeton and Stoke Gabriel area. It is true that the sandstone is widely used along the Dart estuary which is consistent with an origin in these localities, the stone being transported by boat along the shores of the estuary. Buildings, even quite lowly outbuildings, at Waddeton incorporate huge boulders of the red sandstone which would have been extremely difficult and costly to transport from a distant source (Figure 16). The listed building citation for Totnes church states that the red sandstone used in the church (Figure 9) comes from Stoke Gabriel. Slader (1968) in a list of quarries from which red sandstone was won mentions one at Galmpton Creek. The quarry used by the yacht chandlers here, and the one used to store boats lying to the west have both been examined without any red sandstone being seen. There are however, further quarries near the shore further west on private land that have not been visited.

Ussher (1903, p129) mentions the hard sandstones of the Waddeton and Brixham areas and the geological map shows outliers of Permian rocks at Waddeton and Stoke Gabriel. In the former case, a patch of scrubby woodland at GR287772,57385 corresponds to a small inlier of limestone from the Saltern Cove Formation surrounded by Permian outlier. These are also candidates for the source of the distinctive red sandstone used in the area and further afield.

Also noteworthy is the occurrence of 12th Century fonts with a distinctive palmate decoration made of this sandstone (Figure 18) and with a distribution in south Devon matching closely that of the same stone used for building, especially the dressings of churches (Woodcock, 2009).

Identical red sandstones identified in buildings of the Exmouth and Dawlish areas and originally coded 113 were combined with those with Code 144 in April 2012 since they are lithologically indistinguishable. They include a relatively large proportion of sandstone with silica cement. In at least some cases, a good case can be made that the sandstone was imported from the Brixham area along with the limestone with which it is associated.

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Figure 1. Parish church, Churston Ferrers. The porch, mainly composed of local limestone rubble, has red sandstone quoins and dressings.

Figure 2. Filled-in gateway with red sandstone dressings in the wall of Kingswear Priory.

Figure 3. Berry Lodge, Victoria Road, Brixham. Brixham Limestone rubble with a few blocks of red sandstone.

Figure 4. Embankment, King Street, Brixham. Brixham Limestone with included patches of tough red sandstone.

Figure 5. St Mary the Virgin, Higher Brixham. Quoins of red sandstone showing bedding defined by variation in cementation.

Figure 6. St Mary the Virgin, Higher Brixham. Homogeneous sandstone (typical) showing scintillations caused by reflections from prismatic faces of quartz outgrowths on the clastic grains.

Figure 7. Wall adjacent to Nos 6, 8, and 10 Teignview Rd, Bishopsteignton.

Figure 8. Tower of St Michael's church, Kingsteighnton. The walls are of grey limestone with a few blocks of red sandstone. The relieving arches over door and window are of decorative alternating limestone and red sandstone. The dressings are of Dartmoor granite with dark patches rich in tourmaline.

Figure 9. Tower of St Mary's, Totnes. The walls, buttresses and staircase are made of a mixture of red sandstone (smooth finish) and Devonian volcanic rocks (darker, rough finish) with dressings at eye height and probably also further up the tower of Beer Stone.

Figure 10. South aisle of St Mary's, Totnes showing a buttress finished in red sandstone above and Devonian volcanic rocks below. The window dressings are of Doulting Stone. The grooves in the sandstone are caused by archers sharpening their arrows during archery practice, commonly required after Sunday service in medieval and early modern times. The sandstone appears to have been the rock-type of choice for this task.

Figure 11. Vicarage Road, Stoke Gabriel. The house is mainly made of limestone probably from Brixham but with some blocks of red sandstone. It has decorative string courses of brick and quoins of red sandstone. While the red sandstone is mainly used for the dressings of medieval churches, along the Dart, closer to its sources, it is used for a wider range of purposes and in a wider range of building types.

Figure 12. St Mary's, Brixham. Sarcophagus made from a single bock of red sandstone lying beside the west door of the church.

Figure 13. Tower of St John's church, Littlehempston. The walls are rendered which sets off the deep red sandstone used for the dressings of the west window and door (now converted to a window) and the shedding parts of the buttresses.

Figure 14. Roadside wall, Dawlish Warren. Made mainly of pale limestone from Torbay but with a significant component of hard silica-cemented red sandstone, probably imported by sea along with the limestone.

Figure 15. Methodist church, Fore Street, Bishopsteignton.

Figure 16. Wall of outbuilding, Waddeton, incorporating boulders of red sandstone. The pale stone is middle Devonian limestone.

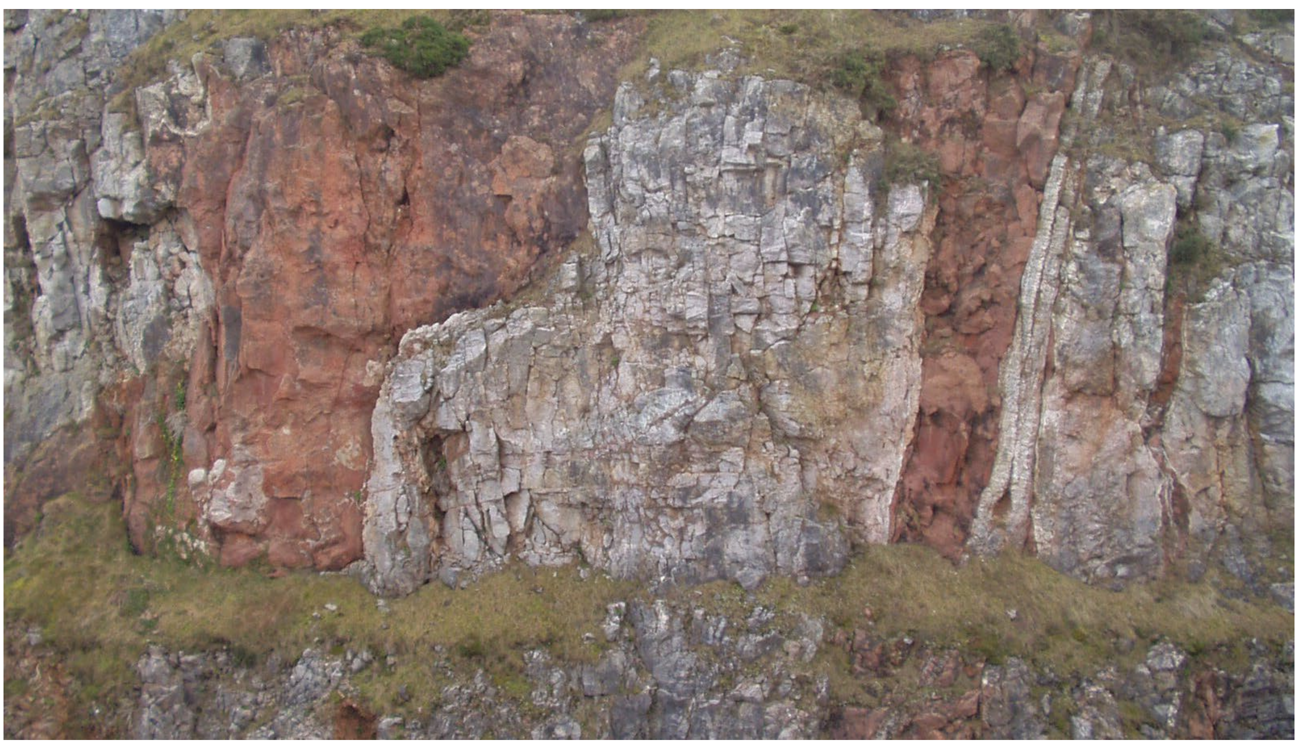

Figure 17. Neptunian dykes of red sandstone enclosed by the Berry Head Limestone, Berry Head Quarry.

Figure 18. 12th Century font with palm decoration made of red sandstone, St Peter's, Cornworthy.

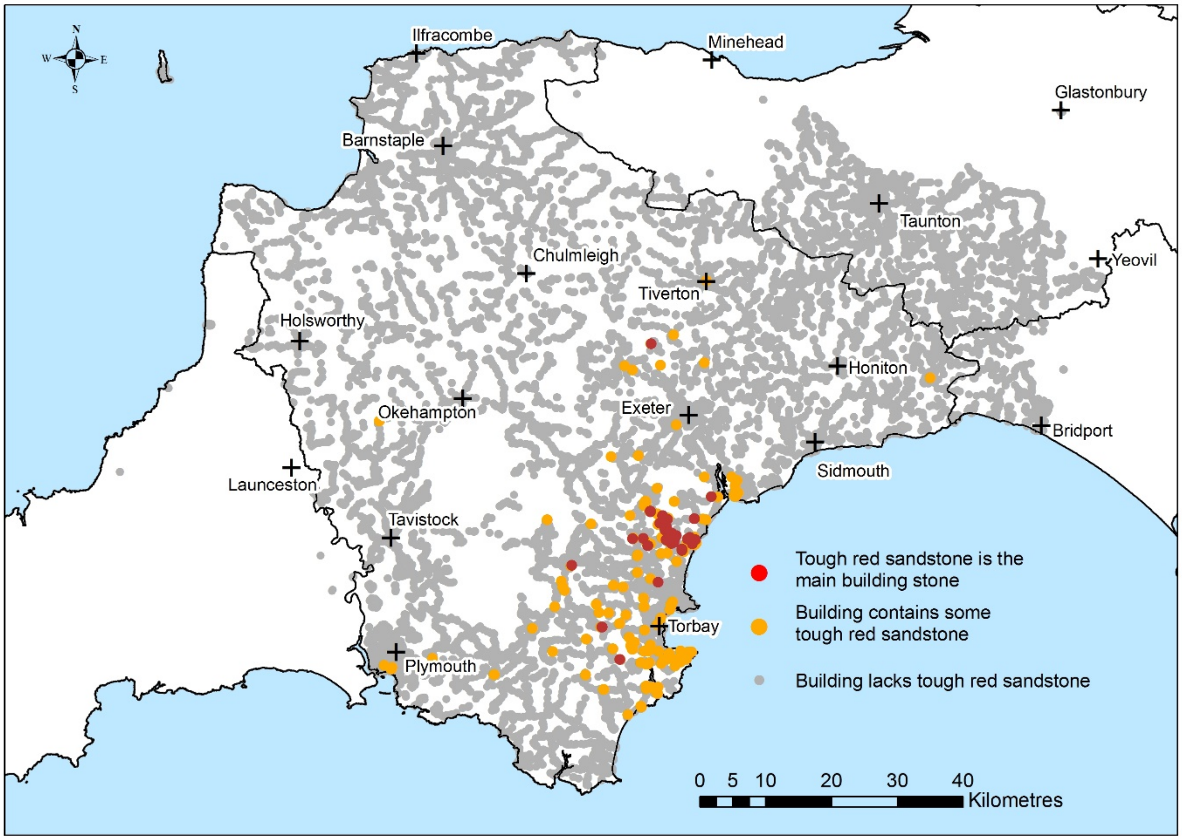

Figure 19. Distribution of tough red sandstone in buildings.

145, Olive-brown-speckled Sandstone (Ugbrooke Sandstone Formation)

The Ugbrooke Sandstone is a coarse-grained poorly sorted and sparsely cemented sandstone with a unique range of colours from olive-brown through olive-green to yellow and brown. The clasts are of clear quartz, yellow and orange quartz and/or feldspar and black slate or shale and other lithic fragments. The grains are subangular but the slate fragments are angular, up to small pebbles in size and tend to lie in the bedding. The type locality for the formation is an old quarry in the grounds of Ugbrooke House and the house and ancillary buildings make extensive use of the stone. It is also sparingly used in the adjacent villages of Chudleigh, Ideford and Luton. The coarse and rather open texture of the sandstone and the presence of black slate clasts distinguish the Ugbrooke Sandstone from other sandstones in Devon.

North wall of Ugbrooke House composed of a mixture of olive brown Ugbrooke Sandstone and grey limestone from Torbay with brick window jambs and lintels.

146, Teign Chert and equivalents

This code is assigned to chert from the Teign and Codden Hill Chert Formations and their correlatives, and to associated rock types including siliceous shale and slate, which may have been won from the chert formations or from the stratigraphically adjacent slate formations.

The Teign Chert is typically black and very fine grained with a shiny surface finish in its type area (Figures 1 and 2). However, pale grey alteration, in places picking out bedding or jointing is quite common (Figure 2). The rock may be bedded or laminated and crossed by a fine network of cracks and joints. The black material may be interlaminated with pale grey or orange chert and quartz and in some cases the rock shows this kind of discolouration along cross-cutting cracks. The rock is hard and resistant. Blocks usually have sharp edges and corners but because of its resistant nature, it is persistent in the surface deposits and building blocks drawn from these tend to be abraded and with somewhat rounded corners. The chert does not weather easily and the original colour is usually obvious on the surfaces of building blocks although some brown and ochre discolouration along cracks and joints does occur. Chert of this kind with discontinuous colour and compositional lamination is widely used for building in Wrangaton between Ivybridge and South Brent (Figure 3).

Further west along the south margin of the Dartmoor Granite, on its northern margin and in north Devon the building stone from this stratigraphic interval departs from this description. The predominant black colour is accompanied by pink, pale grey, toffee-coloured, red, ochreous or yellow pigmentation; interbedded "chert" of different colours and resistance to weathering is widespread (Figures 4-7). The stone is remarkable for its strictly planar colour and compositional lamination. Building blocks are typically slab-like, much shorter across the bedding planes than in them, although there are exceptions (eg top of Figure 4 and Figure 8). It is far from clear that the stone always contains much or indeed any cryptocrystalline silica that can legitimately be called chert. Much of the stone is a mudstone, siltstone or fine-grained sandstone. It is equivalent in age to the Bampton Limestone Formation (Code 139 qv) with which it has much in common especially the strong bedding.

St Paul's church, Filleigh and some other buildings in the village are made of a pale yellow or in some cases black, slate of good quality but with a strong penetrative cleavage (Figure 9). Some of the blocks contain concretions of chert around which the cleavage sweeps (Figure 10). The presence of chert and the proximity of the outcrop of the Codden Hill Chert has encouraged this building stone to be referred to that formation but it is unique and has not been seen anywhere else.

The code has also been used to refer to black siliceous slate and black impure limestone that are known to occur interbedded with the chert or occur in the stratigraphically adjacent formations. There appears to be a gradation from chert to siliceous slate which is distinguished from the chert by the presence of a weak cleavage and is less hard (Figure 11). Siliceous slate is especially common as a building material in the Ilsington-Liverton and Newton Abbot areas.

The distribution of buildings containing these rock types rings Dartmoor and the line of the North Devon Link Road, mimicking the outcrop pattern (Figure 12). Although by no means ideal from the point of view of building, the stone is very widely used perhaps because it is easy to shape into suitably sized and shaped blocks and is reasonably durable. There are further occurrences around Tedburn St Mary and Pathfinder Village, suggesting that there may be unmapped inliers of Teign Chert here beneath the Ashton Shale member of the Crackington Formation. Chert is also distributed among several of the formations mapped to the northwest of Dartmoor and these occurrences are also given Code 146 (see Appendix). While not always cherty, the fine colour and compositional lamination is a common and definitive characteristic of the building stone.

Appendix: North-west Dartmoor Fringes

The stratigraphy of this part of Devon is complex, caused by the conflation of complex thrusting and facies change from the Tavy Basin across the Laneast High to the Culm Basin (Isaac *et al.* 1982, Issac, 1983, Leveridge *et al.* 2006). The disposition of the various formations on the current BGS geological map is based to a significant extent on the work of Isaac described in the above papers with a further important input concerning the age of the various formations based on the conodont stratigraphy (Stewart, 1981).

Figure 1 sets out lithological characteristics of the formations described in Isaac, 1983 that might have been useful in identifying the unit from which a particular building stone was won. However, there are very few characteristics of value in this respect; black or dark grey slates and mudstones are common to nearly all the stratigraphic units as are intervals containing chert or cherty mudstone. Volcanic rocks are present in at least three units and carbonate rocks in four. The available descriptions in Isaac (1983) and the BGS lexicon lack enough detail to allow confident assignment of a stone to a particular formation. The references in the lexicon are unhelpful in many cases and just refer to the BGS map sheet on which the formation was mapped, usually No. 338, Tavistock. In contrast to rock-types observed in outcrop, building stones lack the field relationships that assist the geologist in arriving at a consistent set of stratigraphic units, and so it has not been possible to identify with any certainty the source formations from which building stone was drawn in this region.

For these reasons, the threefold division of building-stone types that have served reasonably well further east is mainly retained here rather than attempting a more detailed correlation with likely source formations. The scheme largely ignores the thrust systematics in the naming of formations and plays down the influence of depositional environment, concentrating instead on lithology as follows:

Youngest – flyssh. Crackington, Bealsmill, St Mellion Formations and Meldon Shale and Quartzite (part). Building stones thought to come from these formations are coded 152 (sandstone) or 171 (slate);

Middling – black slate interval. Newton and Teign Chert, Meldon Chert, Brendon Formation, Crackington, Lyford, Liddaton and Whitelady Formations, Burraton and Yealmbridge Formations. These are coded 171 if likely to be part of the Crackington Formation, 146 if cherty or strongly laminated, 177 if poorly cleaved and called mudstone rather than slate in the database descriptions and 128 if black slate not cherty or laminated. Brown and pale grey lustrous slates seen in Lewtrenchard on the outcrop of the Teign Chert are tentatively assigned to the Yealmbridge Formation but do not fit in this scheme; they are coded 193. This merely reflects lithological similarity with pale brown lustrous slate with this code used for building close to Start Point in the South Hams and in no way implies any stratigraphic correspondence.

Oldest. Tavy Formation and those slates mapped as Middle and Upper Devonian slates. Coded as 59.

The difference between slate coded 59 and the overlying units here as further east, is the coming in of significant intervals of black slate. It is accepted that the difference is not all stratigraphic and there is some interdigitation of green/grey and dark grey/black slate and anyway, it is not always easy to tell the colour of stone when it is in a building. Note also that code 171 falls in both middling and upper subdivisions. If a building in this region also contains sandstone, then the accompanying slate will be coded 152 unless there is overwhelming other evidence that it should not be.

In reality of course, further confusion is caused by stone imported from far away.

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	Slate	Sandstone	Chert	Volcanics	Carbonate	Age from BGS lexicon
Liddaton Formation	Dark grey, phyllitic, banded grey, greenish grey slate; siltstone and sandstone laminae	<10cm, graded; load casts, ripple drift, some thicker	Black slate, siliceous nodules			Famennian
Whitelady Formation	Pale, greenish, calcareous	Thin quartzite			Dolomitic, siliceous, well bedded, nodular; anastomosing clay lamellae	Fammenian
South Brentor Formaton	Black micaceous, pale greenish	<30cm, siltstone			Nodular	Fammenian-Tournaisian. Passes up into Lydford Fm.
Lydford Formation	Black	Thin siltstones and fine grained sandstone	bedded, lenses, intercalated with volcanics	Thin tuff, pillow lavas		Tournaisian-Visean
Greystone Formation (=Brendon Fm)	Black siliceous slates with chert; sooty black shale	Conglomerate	Black siliceous slates with chert. No chert in BGS description	Tuff, pillow lava; manganiferous; plentiful		Tournainsian
Fire Beacon Chert Formation (=Codden Hill Chert Fm)	Thin, black slate and mudstone		Chert		Limestone beds	Brigantian (Visean)
Meldon Shale and Quartzite Formation	Black slates and mudstones	Thin, clean-washed	Chert lenses		Limestone lenses	Tournaisian- Visean. Immed. underlies Codden Hill Chert
Lowerton Limestone Formation	Grey calcareous,black				Limestone turbidites	Not in BGS Lexicon
Brendon Formation	Black, dark grey	Thin, incl. greywacke	Loc. siliceous mudstone			Visean
Cotehele Formation (St Mellion Fm)	Subordinate shale	Preponderant sandstone				Not in BGS lexicon (Tournainsian - Arnsbergian)
Crackington Formation	Black and bluish-grey sandy micaceous shales	Up to 4m but typically much thinner; sedimentary structures				Arnsbergian (Namurian)-Langsettian (lowermost Westphalian)
Milton Abbot Formation				Agglomerate, tuff, pillow lavas (basic)		Visean
Bealsmill Formation (=age equiv. Ashton Shale member of Crackington Formation)	Dark grey mudstone	Preponderant, coarse, feldspathic; some conglomerate				Namurian

Figure 1. Lithology of formations from Isaac, 1983.

.Figure 1. Roadside wall, Canonteign Barton. The central block of black chert shows a typical network of joints and cracks. The block above shows pale surface alteration and slightly deformed sedimentary banding. The block towards the lower left of the picture shows the development of open folds of the bedding and an incipient axial plane cleavage.

Figure 2. Roadside wall, Canonteign Barton. Pale discolouration of narrow beds crossing normal black chert and also of cross-cutting joints.

Figure 3. Strongly colour-laminated chert. Wall at entrance to Santa Maria, Bittaford.

Figure 4. Typical colour and compositional banding and lamination. Equant blocks and ochreous blocks are also common. Chancel of St James' church Swimbridge.

Figure 5. Colour-laminated chert, house approx. opposite the castle, Lydford; the stone is here referred to the Brendon Formation.

Figure 6. Colour laminated siltstone or chert, north aisle of St Petroc's church, Lydford.


Figure 7. Laminated crimson or pink siltstone. Chancel of St Mary's church, Marystow.


Figure 8. South aisle of St John's church, Stowford. Banded cherty mudstone showing unusually broad bands of different composition and colour. The top of the plinth at the bottom of the picture is made of Polyphant Stone.


Figure 9. Entrance to St Paul's church, Filleigh, showing the yellow and black slate of which it is made.

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Figure 10. Detail of one of the blocks in Figure 9. The slate is strongly cleaved parallel to the compositional banding which sweeps round enclosed lozenges of chert.

Figure 11. Black and dark brown siliceous slate, 21 Jetty Marsh Road, Newton Abbot.

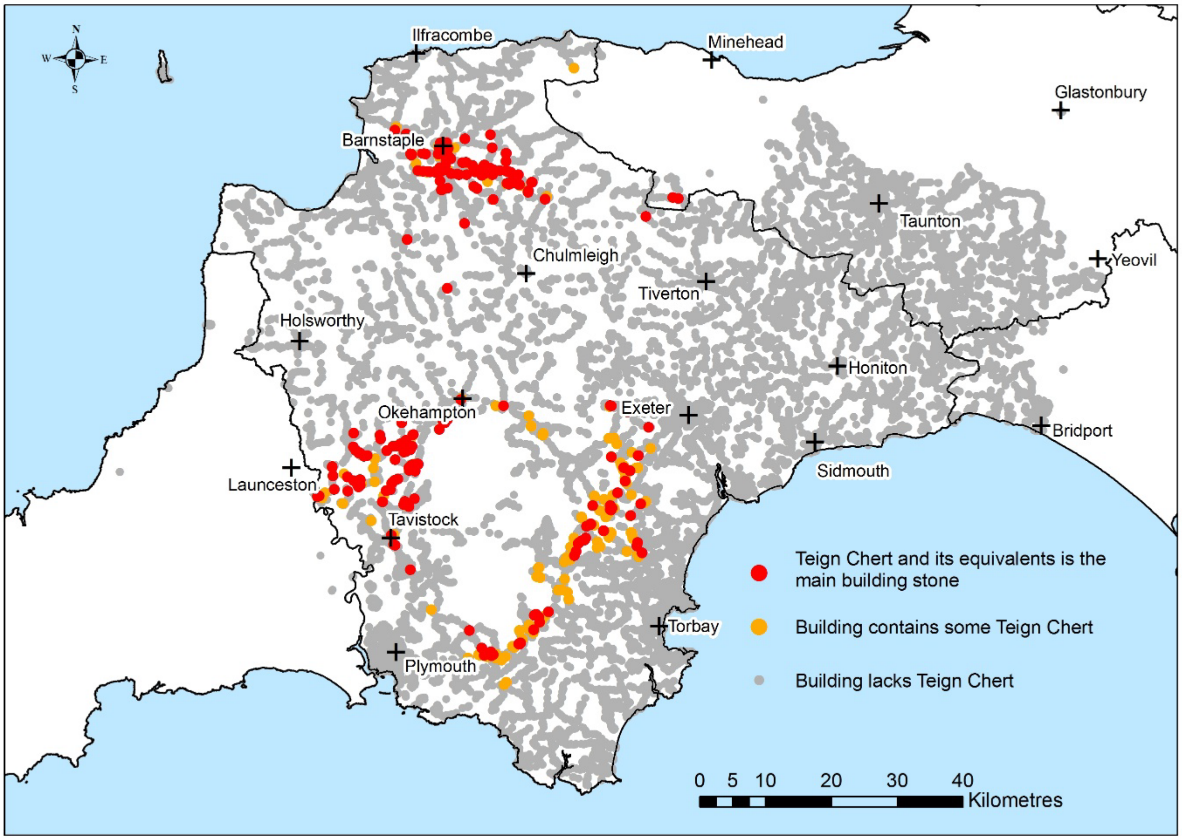

Figure 12. Distribution of Teign Chert and its equivalents in buildings.

147, Basalt

The code was created to group building stone won from Chipley Quarry, north of the River Lemon between Bickington and Newton Abbott. It is a black basalt, fine grained, and vesicular in about 50% of blocks. It is reported to be spilitic and displays good pillows in the quarry face. Its use is restricted to the vicinity of the quarry and adjacent parts of Newton Abbott. Further buildings containing black basalt occur at Tigley between South Brent and Totnes (Figure 3). The stone is presumably allied to other basic igneous rocks of Devon, including those altered by deformation and metamorphism (Code 91) and dolerite or microgabbro retaining at least in part, an igneous mineralogy and texture coded 165. It is distinguished from basalt from School Wood Quarry (Code 164) by lack of iddingsite.

Figure 1. Basalt from Chipley Quarry. Roadside wall, Chipley Farm.

Figure 2. Basalt from Chipley Quarry showing vesicles up to 3mm cross. Roadside wall, Chipley Farm.

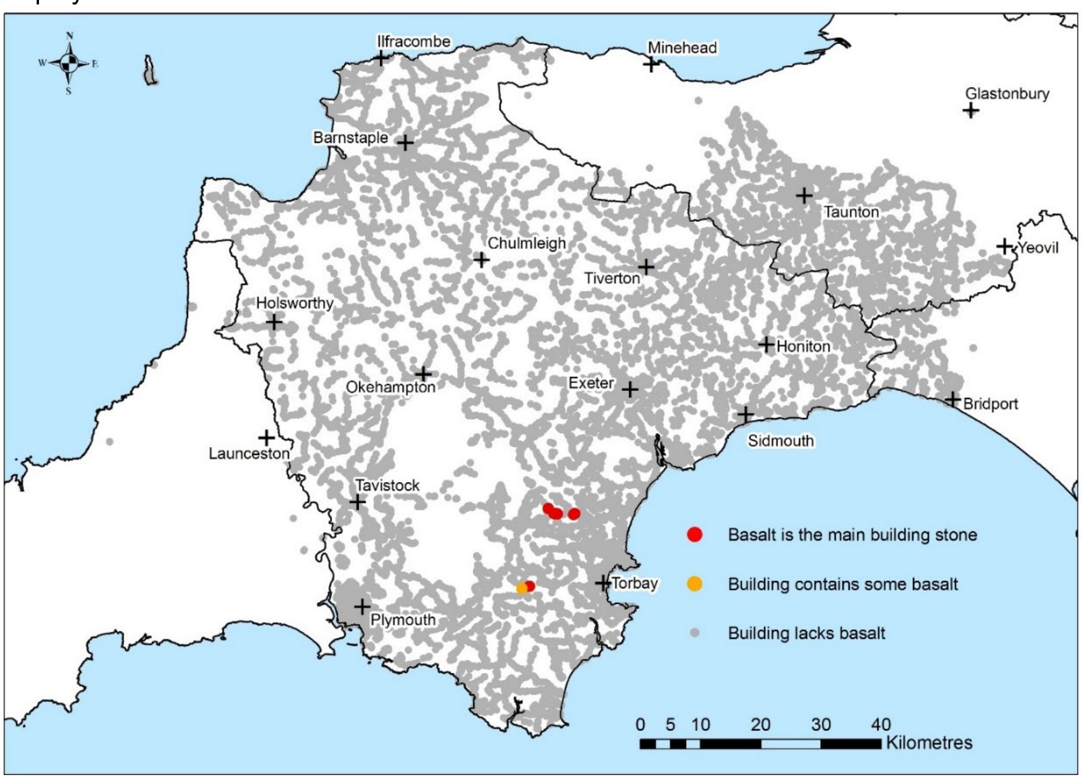

Figure 3. Distribution of basalt in buildings.

148, Hornfels

Rocks assigned Code 148 are black or grey, medium- to fine-grained, hard and homogeneous with a granular texture and usually lack cleavage or orientated fabric. Some examples give the impression of having had cleavage subsequently annealed by heating. Blocks tend to be equidimensional and because the rock-type is durable, it persists in the river gravels where it may be abraded and rounded and occur some distance from its bedrock source.

It is evident from this description that rocks believed to be hornfels generally lack distinctive features. In a very few cases, examples contain visible porphyroblasts of chiastolite or other unidentified mineral or are iron-stained probably after weathered sulphides, but otherwise, the rock-type, in the absence of thin-section evidence, is easily confused with dark fine-grained sandstone, siltstone and poorly cleaved hard mudstone from the Crackington Formation and its correlatives, parts of the Teign Chert Formation, schorl rock, basalt and fine-grained dolerite. Because hornfels occurs in the aureole of the Dartmoor Granite, confusion with schorl rock and black chert is a particular difficulty and many walls are recorded as containing mixtures of these rock-types and hornfels, emphasising the confusion.

In the vicinity of South Brent, these rocks are called "alvin", clearly a local variant of elvan. However, this term is known to cover a multitude of rock-types of different origins. Within Devon, hornfels is used for building close to the margin of the Dartmoor Granite and along the main rivers, at somewhat greater distances from the granite margin using stone collected from the river bed. Moorhaven Village, formerly Plymouth Lunatic Asylum, is composed almost exclusively of black hornfels from a local quarry (Figure 1) and the walls adjacent to the lane from Aish to Owley northwest of South Brent also show the rock-type to good effect.

Figure 1. Church, Moorhaven Village, formerly Plymouth Asylum. All the original asylum buildings are of this stone. The church also has grey limestone quoins and brick and Bath stone dressings.

Figure 2. Outbuilding immediately west of the Globe Inn, Buckfastleigh. The wall contains different kinds of granite plus a range of grey and black fine-grained rocks believed to include chert (with iron staining), schorl and hornfels, (grey with a greenish tinge).

Figure 3. Outbuilding, Scorriton. As well as pink granite, the wall contains black schorl rock, hornfels and sandstone from the Crackington Formation.

Figure 4. Cullaford Cottage, Scorriton, former home of Mary Wesley. The black stone in the wall is interpreted as hornfels. It is accompanied by Teign chert and black slate from the Crackington Formation.

Figure 5. Outbuilding adjacent to Owley Bridge, west of South Brent. The wall is made of granite, Teign Chert (banded bluish blocks) and hornfels (black).

Figure 6. Millers, Lane End, 4.3km northeast of Mary Tavy. The wall is composed of marginal varieties of Dartmoor granite and black hornfels.

Figure 7. Broken down wall, 200m east of the pub, Lundy. Morte slate partly annealed adjacent to the granite contact.

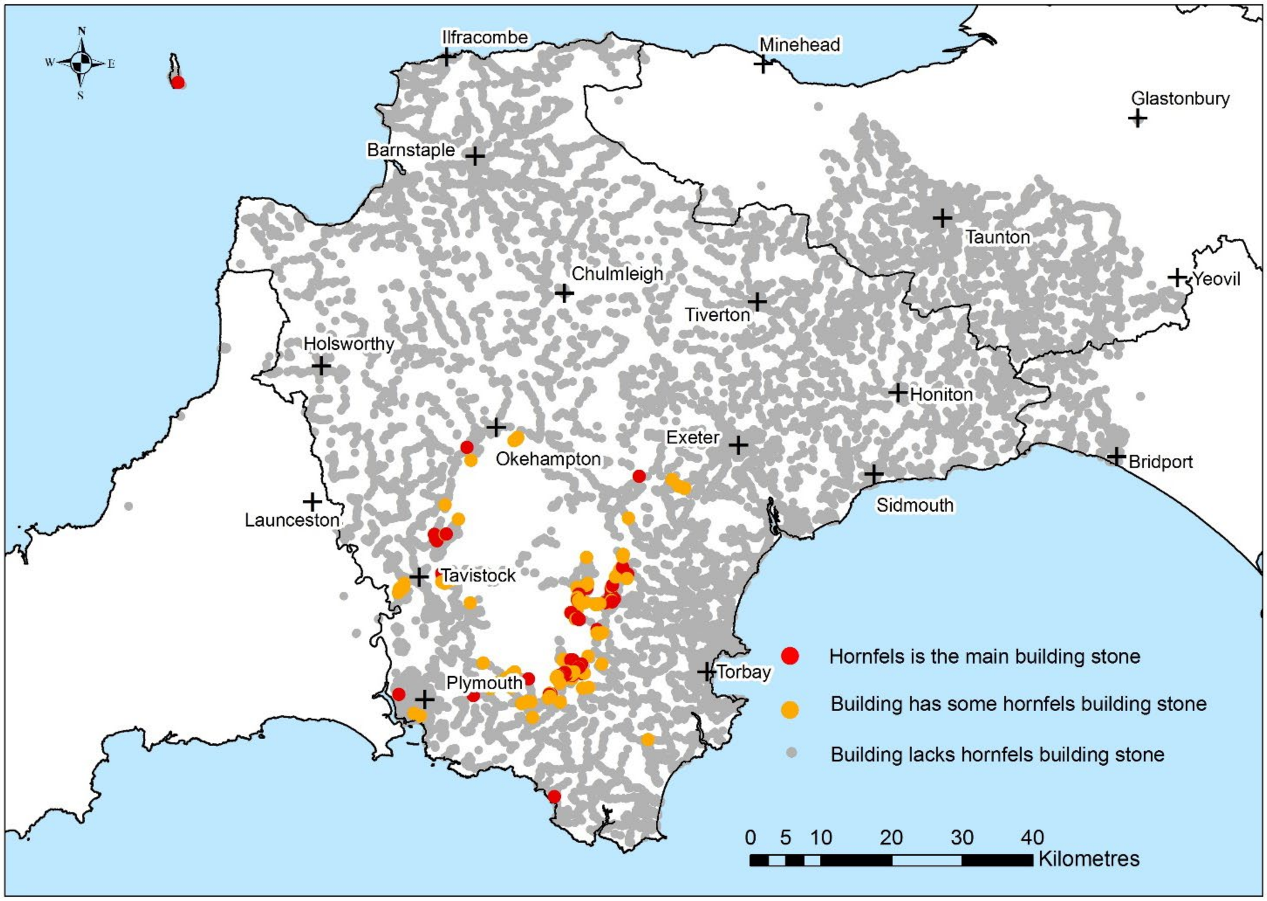

Figure 8. Distribution of hornfels in buildings

151, Red Breccia without Igneous Clasts

This rock-type very closely resembles other Permian breccias of Devon and Somerset (Codes 85, 125 and 141) except with regard to the clast rock-types. The colour is mainly brick red like Heavitree Breccia, but some blocks are maroon and match the Exeter volcanics in colour. The clasts are of green sandstone and siltstone and shale/slate. There is no granite, porphyry or murchisonite (cleavage fragments of sanidine), very few fragments of black rock-types and very little or no hornfels. There are few limestone clasts. This suggests that the breccia is earlier than the Heavitree Breccia and was laid down before the igneous rock-types associated with the Dartmoor Granite were unroofed and exposed at the surface. The breccia contains lenses of sandstone, maroon, brick red or drab; in the last case the clasts are green/grey like the matrix. Although it was supposed not to have been quarried, being too soft, the code could include stone from the Alphington Breccia, and the examples from the western end of the Crediton Trough, the Bow Breccia. Alternatively, given that individual layers of the breccias have very localised sources, it could represent local variants of any of the Permian breccias that, by chance, were derived from areas lacking igneous outcrops.
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The most striking example of this rock-type is in the tower of St Michael's and All Angels, Dunchideock.

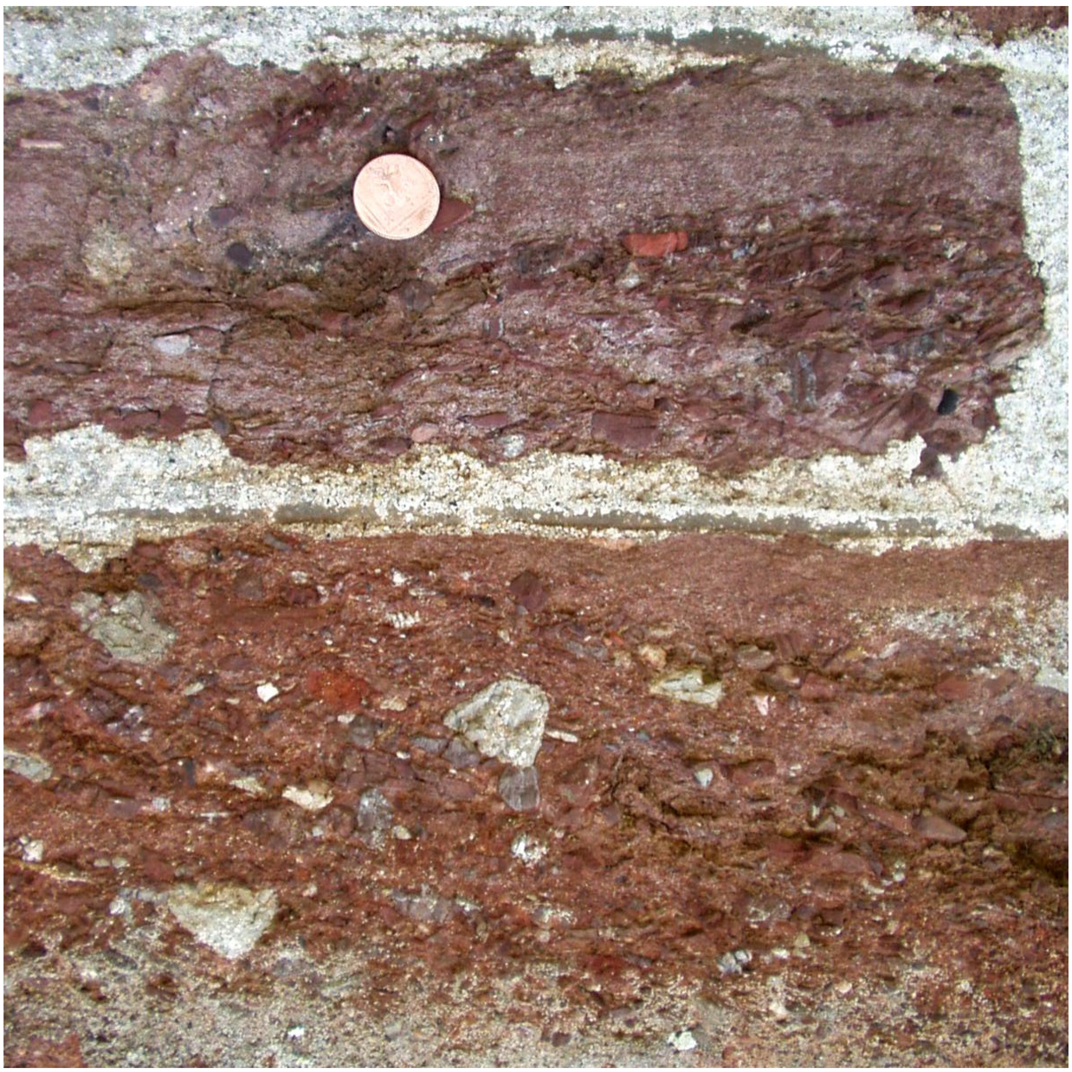

Figure 1. North aisle of St Bartholomew's church, Nymet Tracey, south of Bow. The breccia contains clasts of black and maroon sandstone, minor pale-grey limestone and vein quartz but no porphyry or murchisonite.

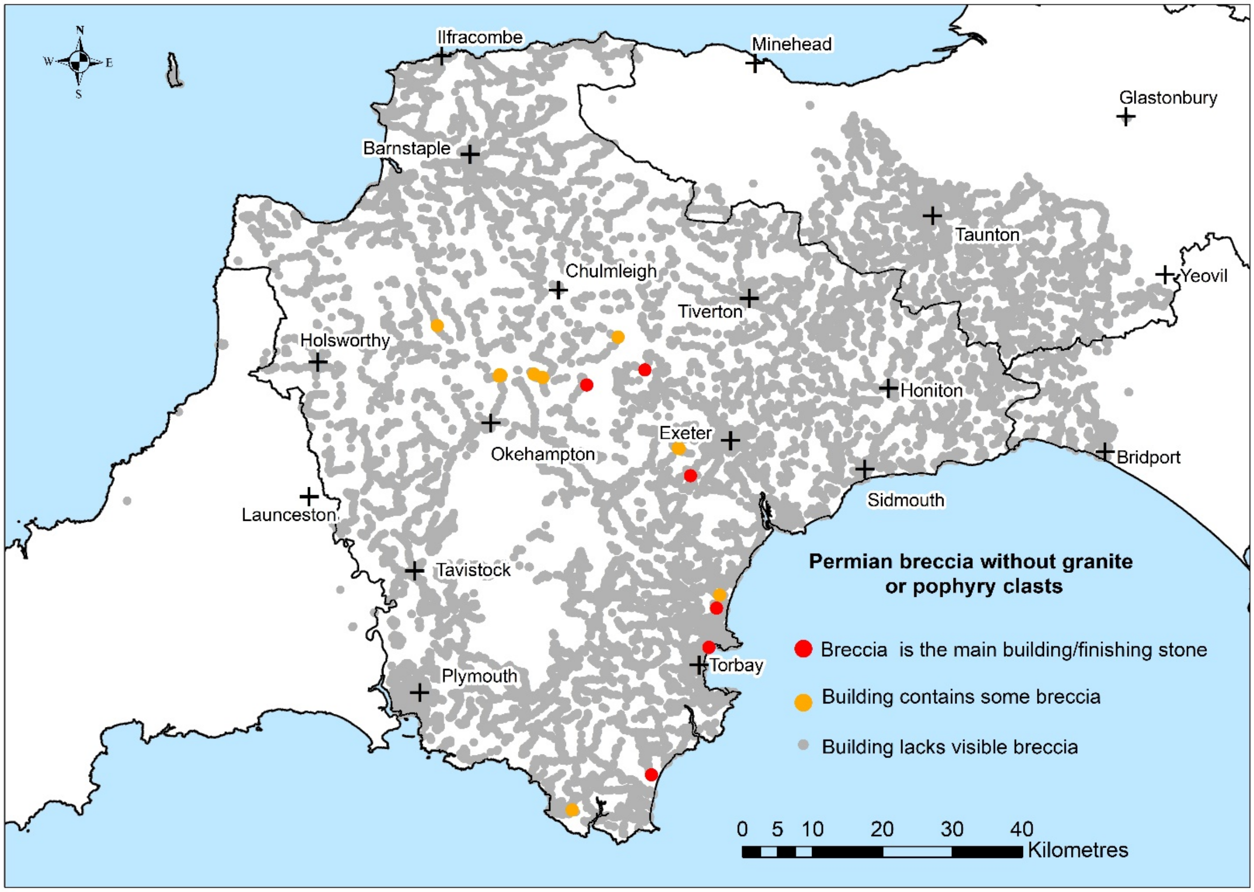

Figure 2. Distribution of Permian breccia lacking igneous clasts.

152 and 183, Medium- to fine-grained Sandstone and Siltstone mainly from the Crackington and St Mellion Formations.

Material code 152 has been applied to a range of fine-grained sandstones and siltstones believed to be taken predominantly from the Crackington Formation. The characteristics of these rocks, to which unfortunately there are many exceptions, are as follows:

1. Fine grain size compared to the Bude Formation sandstone and those elsewhere in the succession (Figures 1, 2 and 3). Some of the stone referred to the Crackington Formation is siltstone rather than sandstone.
2. Compact appearance; individual clastic grains can seldom be resolved with the hand lens (Figures 1, 2 and 3); grains appear either to be sutured together or cemented by a groundmass that cannot easily be distinguished from the grains that it encloses. Many examples are described as greywacké rather than sandstone but it is seldom possible to resolve lithic grains. Few examples are cleaved and where they are, the cleavage is expressed by close irregular jointing rather than a penetrative fabric. However, most building blocks are laid on their long dimensions, taken in most cases to be the expressions of bedding.
3. Sharp corners and edges (Figures 4, 5 and 6); the rock is resistant to abrasion because of its hard, compact and strongly cemented nature. This applies to quarried stone and is a characteristic confirmed by Ted Freshney (pers. com. 2010) who has unrivalled experience of these rocks through his mapping of them for the BGS. However, rounded pebbles from the Crackington derived from river terraces or gravel from the river bed are widely used, especially for paving (Figure 7).
4. Small size of blocks; many descriptions in the database comment on the small size of the sandstone blocks used which may be a consequence of the comparatively thin beds of sandstone in the Crackington compared to those in the Bude Formation (Figures 8 and 9). However, a minority of blocks may be up to 30cm thick (Figure 10).
5. Dark body colour; most descriptions note that the sandstone is black, dark grey or just grey (Figures 1, 2, 3, 4, 6, and 11). However, a large minority emphasise a range of other colours including olive green and olive brown, ochre, green-grey, olive drab, brown and many other variations. Weathering colours also show a wide range. Surface weathering obscures the nature of the underlying rock and in many cases, it is difficult to tell much about the fresh stone under these circumstances. It is suspected that stone from a single quarry has weathering characteristics in common – similar weathering characteristics have been noted within a single traverse – but it has not yet been possible to link these to any specific quarry.
6. Poorly cleaved; many examples appear uncleaved in the walling or at best, exhibit irregular and widely spaced fracture cleavage; however, it is generally possible to discern the cleavage direction and most building blocks have their long dimensions lying in it. Some building stone given this code is described as cleaved or foliated psammite. Planar fabrics are not obvious where they lie in the plane of the wall (Figure 12).
7. Poorly bedded; this combined with poorly expressed cleavage results in irregularly shaped building blocks quite typical of the Crackington Formation sandstone.
8. Sole marks of various kinds including ripples (Figure 13).

Of these characteristics, only Items 1, 2 and 3 are of much value in discriminating between sandstones from the Crackington Formation and those from the Bude Formation and elsewhere in the succession. Even in these cases, it has not been possible to apply them strictly, partly because it is not always possible to get close enough to a wall to determine the detailed characteristics of the stone and partly because sandstone from the Crackington does not display them everywhere. In more than a few cases, building stone that differs from this standard description can be matched with that from a close-by quarry or with the brash exposed in adjacent ploughed fields at localities that are shown on the geological map as underlain by the Crackington Formation.

A significant proportion of the occurrences consist of small flat cobbles with rounded corners and edges. These form a minor constituent of walls in the Exe valley and are widely used for paving where they may be associated with vein quartz (Figure 7). It is believed that these rounded pebbles have been collected from the alluvium or river terraces of the Exe. In the case of the renewed cobbled paving of Cathedral Close in Exeter, this is confirmed by one of the engineers concerned. The stone was taken from the bed of the River Exe opposite Thorverton.

Dark grey sandstone with accompanying slate crops out on both sides of the River Tamar around Calstock and is the main building stone of Cotehele Quay. The stone belongs to the St Mellion Formation which forms a klippe derived from the north sitting on top of the local succession (Whiteley, 1983). These rocks are indistinguishable lithologically from the Crackington Formation and although of slightly different age, building stone derived from them is therefore included in this description.

The grey sandstones and siltstones are poorly distinguished from other similar rock-types from the Devonian and Carboniferous succession of the Culm and North Devon basins. Because they outcrop nearby, most difficulty is experienced in distinguishing them from sandstones of the Bude, Bideford and Pilton Shale Formations. the Criteria 1, 2 and 3 listed above are of greatest value in this respect. They are distinguished from sandstone with a maroon body colour from the Crackington and Bude Formations coded 119 used near the Permian unconformity by their predominant grey colour but stone with both grey and maroon pigmentation has also been coded 152. They are distinguished from sandstone lower in the succession by poorly expressed cleavage, dark pigment and association with black and dark grey slate.

Buildings with this sandstone are, as expected, located on the outcrop of the Crackington Formation but stray also onto the outcrop of other formations exposed nearby, including the Permian rocks of the Crediton and Tiverton Troughs, the Pilton Mudstone and Bude Formations around South Molton, Molland and Brushford and the Pickwell Down Sandstone north of Braunton and Barnstaple. In the last case, it has proved very difficult to identify Pickwell Down Sandstone in strongly weathered situations and here some revision may be required.

Comparison of the mapped distribution of Crackington and Bude building stone with the mapped outcrop of these formations illustrates the extent of the confusion between the two even allowing for the fact that Bude sandstone may be used for building on the outcrop of the Crackington Formation and *vice versa.* (Figure 14). The British Geological Survey also experienced difficulty in distinguishing between sandstones from these two formations during the mapping of Devon; different authors have reached different conclusions about the correct assignment of sandstone to either the Bude or Crackington formations, resulting in mismatches of the geological boundaries at the joins of adjacent map sheets with different authors.

Reference

Whiteley, M. J., 1983. T*he geology of the St Mellion outier, Cornwall, and its regional setting.* PhD thesis, University of Exeter.

Figure 1. House on north side of road opposite Lana Park, Tetcott. Thin slabs of Crackington sandstone with brick quoins and dressings.

Figure 2. South side of the nave, church of St James, Luffincott. Thin slabs of black siltstone from the Crackington Formation with dressings of non-porphyritic granite.

Figure 3. Dark grey fine-grained sandstone with hackly fracture. Includes slab-shaped and equant blocks.

Figure 4. Dark grey fine-grained sandstone with sharp edges and corners. Alswear New Road, South Molton.

Figure 5. Chancel of All Saints church, Bradford. The dark grey sandstone blocks with hackly fracture and sharp edges, for example below to left of the coin are referred to the Crackington Formation. The khaki brown more rounded sandstone blocks are referred to the Bude Formation.

Figure 6. Chancel of the Church of the Holy Cross, Tetcott. Thin slabs of dark grey fine-grained sandstone with sharp edges.

Figure 7. Churchyard path, Church of Our Lady, Upton Pyne. Rounded cobbles of fine-grained sandstone probably derived from the Crackington Formation.

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Figure 8. Chancel of St Mary's church, Northlew. The walls are of thin slabs of dark grey Crackington Formation sandstone and subordinate Halwill Stone. The quoins are of Halwill Stone and the dressing of Halwill Stone and granite.

Figure 9. Methodist church, Broadwoodwidger.

Figure 10. Roadside wall, junction of Marine Parade and Anstey Way, Instow. Approximately equidimensional blocks of grey fine-grained sandstone.

Figure 11. Church outside Ashreigney, of dark-grey sandstone with painted brick quoins and dressings.

Figure 12. Grey sandstone laid with planar fabric parallel with the plane of the wall. South side of Yelland Road, Fremington.

Figure 13. Sole marks on the bedding surface of grey fine-grained sandstone. Width of large block, 40cms. Wall in village centre, King's Nympton.

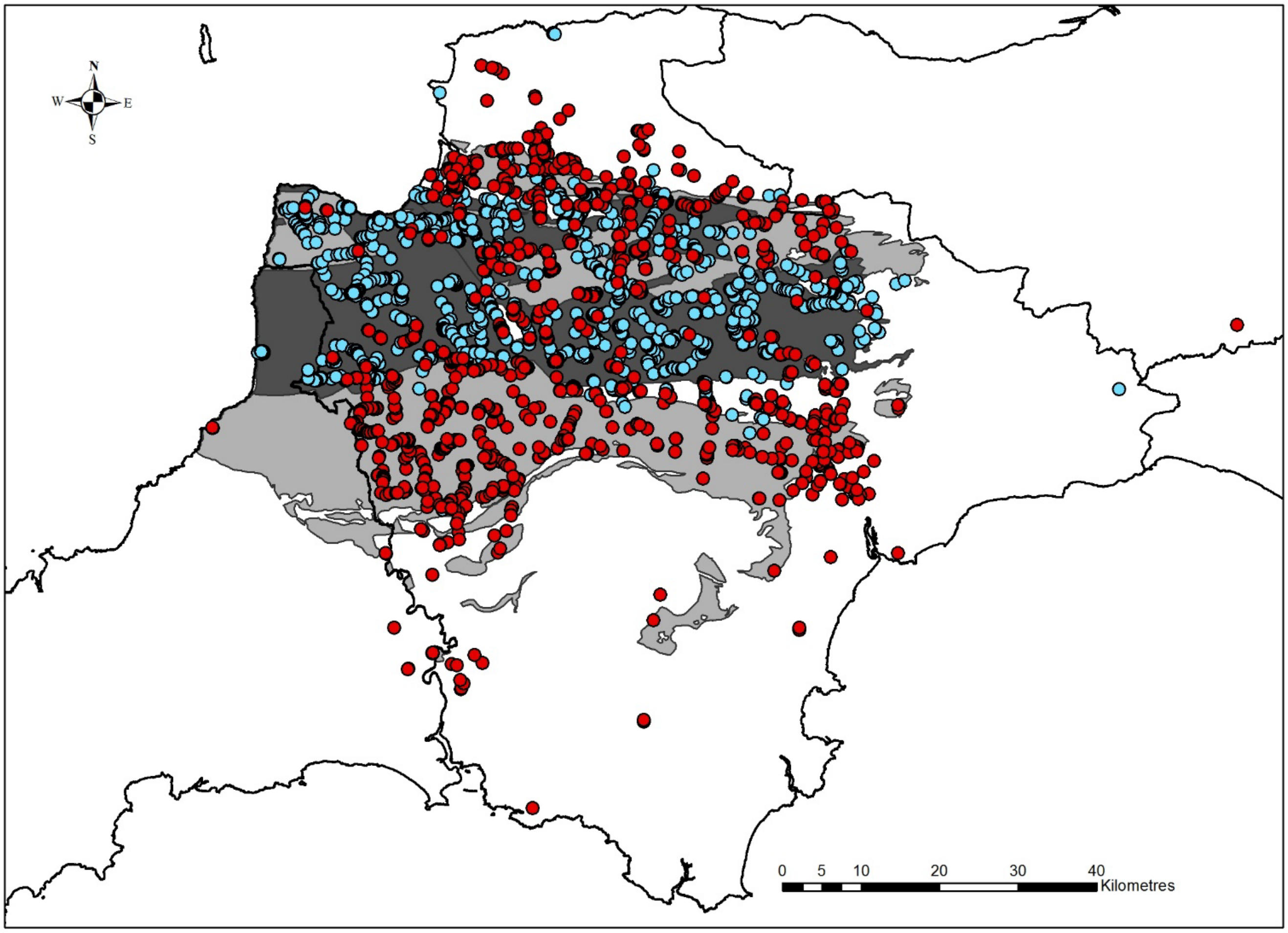

Figure 14. Distribution of Crackington and St Mellion Formation sandstone in buildings. Red symbols, Crackington and St Mellion Formation sandstone; blue symbols, Bude Formation sandstone; light grey pattern, outcrop of Crackington and St Mellion Formations; dark grey pattern, outcrop of Bude Formation.

154 and 205, Hatherleigh and Halwill Stone

The name Hatherleigh Stone is given to a group of lamprophyric rocks used for building, allied to the Exeter volcanics but occurring as dykes, shallow intrusions and volcanic necks. The dominant rock-type is yellow, pale fawn or buff when fresh but is very frequently partly covered in a layer of pink algae giving the rock its common pink appearance which allows identification even at a distance (Figure 1). The surface is commonly dimpled or pitted (Figure 1) and many but not all examples are strongly vesicular (Figure 2). Rarely, weathered surfaces show liesegang rings (Figure 3).

The rock is holocrystalline with an igneous texture and is medium grained with individual grains resolvable under the hand lens. It is composed mainly of feldspar with sparse dark minerals dispersed as small aggregates. It is usually markedly homogeneous (Figures 1, 4). This together with its workability has encouraged its widespread use for the quoins and dressings of buildings over a large area extending, within the area of study, from Bude in Cornwall to Hartland, Rackenford, Okehampton and Black Torrington (Figure 12).

Building blocks tend to be equidimensional, typically about 30cm on a side but this is a freestone, allowing considerable latitude in the shaping of blocks (Figures 1, 3 and 6). Because of this, walls made mainly of Hatherleigh Stone may be of coursed rubble, ashlar or snecked construction, in contrast to the mid-Devon stone with which it is frequently associated, Bude Formation sandstone, which is intractable and is usually laid as rough rubble. Because of these favourable characteristics for building, Hatherleigh Stone is widely used for the quoins and dressings of buildings otherwise of more lowly stone, especially sandstone from the Bude and Crackington Formations in mid-Devon (Figures 4 and 5).

The stone is an important construction material for older houses in Hatherleigh itself and in the surroundings. (Figure 12), where however, its appearance is more compact and yellow stone is joined by reddish and orange varieties with a hackly fracture (Figures 6 and 7). The main sources of this stone for Hatherleigh are the quarries at and near Hannaford, now long disused. There is a concentration of lamprophyre dykes around Hatherleigh but it is by no means clear that stone has been carried from here to the more distant localities where its use is recorded. Lamprophyre dykes have a wide distribution in both Devon and Cornwall and it may be that stone used in localities apparently distant from known quarries comes from a local source that has not been identified.

Closely related to Hatherleigh Stone is a similar kind of lamprophyre called Halwill Stone in the Strategic Stone Study (English Heritage and British Geological Survey, 2015). It is assumed to be won from quarries in a separate concentration of lamprophyre dykes near the villages of Halwill and Halwill Junction. The features that distinguish it from Hatherleigh Stone are not spelled out in the study. However, the lamprophyre stone used around Halwill tends to be more compact in texture with a smoother finish, seldom has voids and typically contains irregular inclusions filled with a mixture of an orange and a white mineral, neither of which have been identified (Figures 8, 9 and 10). It is possible that this is the Halwill Stone referred to in the Strategic Stone Study. It is quite easy to identify where the stonework has a sawn finish but has proved difficult to differentiate from Hatherleigh Stone in other situations. The distinction is retained in the coding of Devon building stone but they are grouped together since it is unclear how reliable the separate identifications are.

Vancouver (1969, p65) mentions a vein of freestone used for Thomas' house in the parish of Clawton and traced eastwards through Ashwater, Holwell (Halwill?), Beaworthy, North Lew and Hatherleigh. There can be no doubt that he is making a reference to Hatherleigh/Halwill Stone. He adds that besides being used in several churches, large masses of the stone are used for weighting the levers of cider presses, and that when quarried the stone is soft but hardens on exposure to the air. If he has the localities identified correctly, it would seem that there are some lamprophyre dykes in the area that were not mapped by the Geological Survey and that are now lost.

Hatherleigh Stone is widely used for all kinds of buildings in mid-Devon no doubt because of its excellent qualities but perhaps also because the local country rock is of such poor quality. It is incorporated in many medieval parish churches and was used also for the dressings of Okehampton and Lydford Castles and the gateposts (Figure 11) at the entrance to Dunsland, destroyed by fire in 1967.

References

English Heritage and British Geological Survey, 2015. *The Strategic Stone Study Database*. [Online] Available at http//www.bgs.ac.uk/mineralsUK/buildingStones/StrategicStoneStudy/EH_project.html [Accessed August 2015].

Vancouver, C., 1969. *General View of the Agriculture of the County of Devon,* 1808: Reprinted by David and Charles, 1969.

Figure 1. Chancel wall with snecked construction, St. Bartholomew's, Nymet Tracey. Pale fawn lamprophyre with characteristic pink algal encrustation.

Figure 2. Quoins of primrose yellow lamprophyre. The lower blocks show extreme dimpling marginal to vesicles. The upper block lacks these and has a smooth sawn finish. The walling is of dark sandstone from the Crackington Formation.

Figure 3. Rough ashlar walling showing liesegang rings. South aisle of St Mary's church, Black Torrington.

Figure 4. North aisle of St Andrew's, South Tawton. The filled-in doorway is dressed with huge shaped blocks of Dartmoor granite with a relieving arch of Hatherleigh Stone. The windows are finished with the same materials. The wall is a mixture of granite, Hatherleigh Stone and mudstone from the Crackington Formation.

Figure 5. The Old Police House, North Tawton, of Bude Formation sandstone with quoins and dressings of Hatherleigh Stone.

Figure 6. Snecked fawn and reddish Hatherleigh Stone in the wall of the house west of the churchyard gate, St John's church, Hatherleigh.

Figure 7. Wall of the hall east of churchyard gate, Hatherleigh. The stone here has a compact appearance and hackly fracture. Called sandstone in English Heritage listed building citation.

Figure 8. Window jamb of St Peter's church, Ashwater showing aggregates of reddish mineral believed to be characteristic of Halwill Stone.

Figure 9. Steps of Halwill Stone leading up to the lytch gate, church of St James the Less, Huish. The patterned cobbles are of Crackington sandstone.

Figure 10. Detail of Figure 9 showing the infilling of the voids.


Figure 11. Gatepost at the entrance to Dunsland, near Cookbury.

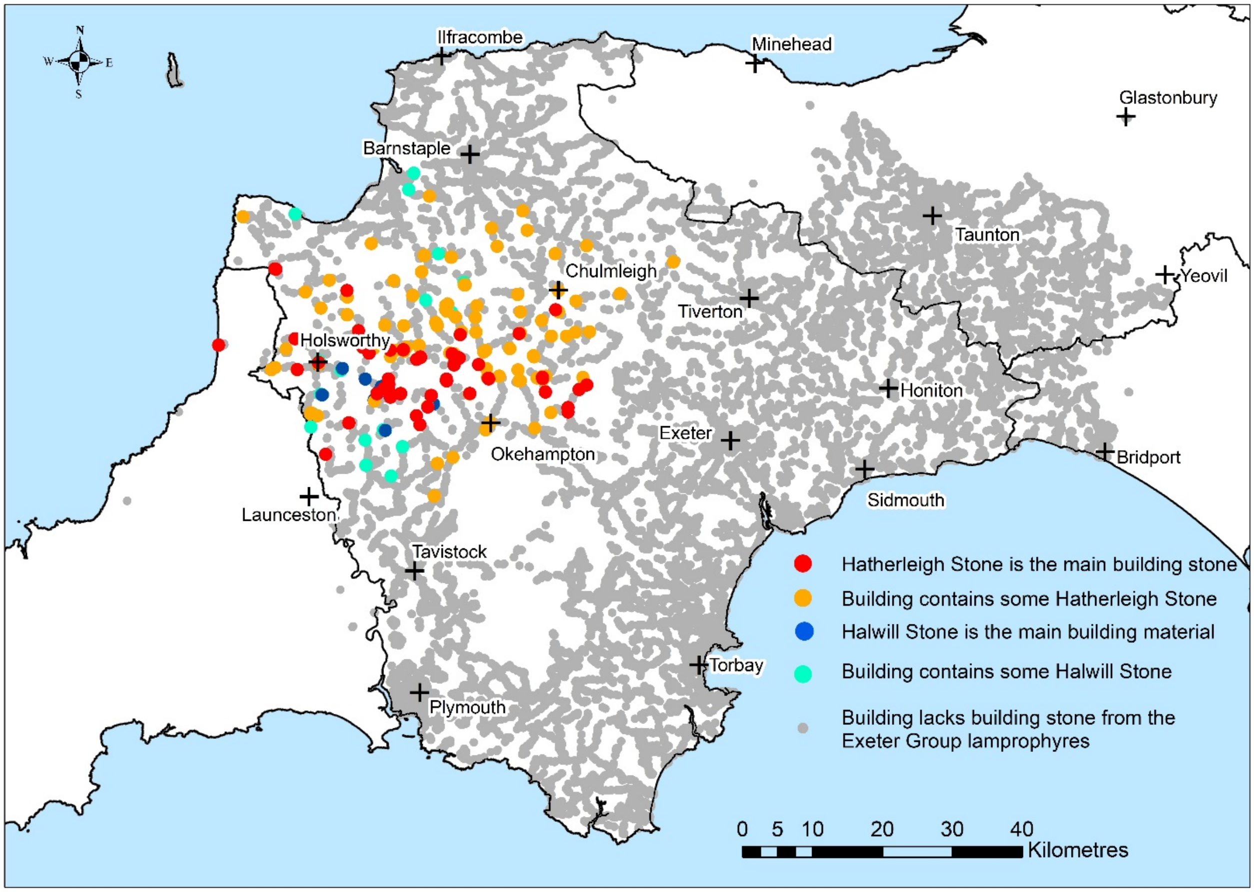

Figure 12. Distribution of Hatherleigh and Halwill Stone in buildings.

155, Porphyry

Porphyry is used for building around Teignmouth and Dawlish. It shows a wide range of colours including grey, yellow and ochre as well as the more typical pink and maroon (Figures 1 and 3). The groundmass is fine-grained to very fine-grained (but not glassy), and is usually unresolved under the hand lens, of pink quartzo-feldspathic material. In many cases it is vuggy. It encloses phenocrysts of euhedral chalky feldspar laths up to 2cm long, usually paler in colour than the matrix, ie cream or yellowish. In some examples, there are also rounded quartz phenocrysts up to 1cm across (Figures 2 and 4) and a few examples contain dark grey blocky phenocrysts, probably of pyroxene. The quartz phenocrysts are noticeably glassy and fresh-looking. Many of them have re-entrants of the matrix indicating that they were corroded during the process of extrusion of the lava. Where phenocrysts are present, the porphyry can be identified with confidence but in cases where phenocrysts and gas holes are absent, it is hard to distinguish between porphyry and quartzo-feldspathic rocks of sedimentary or metamorphic origin and fine-grained variants of the Dartmoor granite. Banded and laminated tough grey quartzo-feldspathic rock seen associated with porphyry at many localities may belong to this group. Porphyry is also associated with coarse-grained quartzo-feldspathic rock, either the arkose mentioned by Selwood *et al*., (1984) or possibly leucocratic granite.

All these rock-types represent clasts in the Teignmouth Breccia. They were probably collected from the soil profile or stream beds to be used for building rather than being extracted directly from the breccia. The porphyry boulders and cobbles used for walling are usually well rounded (Figure 1) and this is mainly a property of the clasts in the breccia although rounding by abrasion in present day streams or on the beach may have made a small further contribution.

De la Bêche (1839, p497) notes that this stone "would furnish a good material for moderately-sized vases."

References

De la Bêche, H.T., 1839. *Report on the Geology of Cornwall, Devon and West Somerset.* Longmans, London.

Selwood, E.B., Edwards, R.A., Simpson, S., Chesher, J.A., Hamblin, R.J.O., Henson, M.R., Riddols, B.W., and Waters, R.A., 1984. *Geology of the country around Newton Abbot*: Memoir for 1:50,000 geological sheet 339, New Series. HMSO, London.

Figure 1. Wall made up of rounded boulders of maroon porphyry and grey limestone, 81 Dawlish Road, Teignmouth.

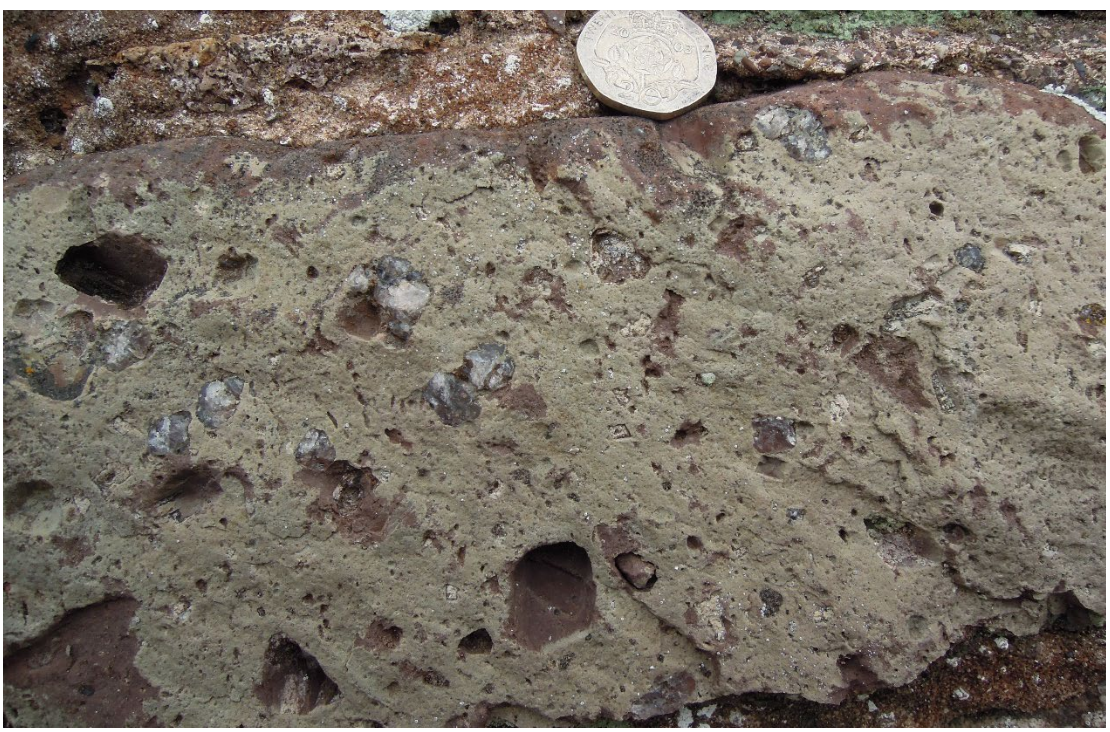

Figure 2. Porphyry with rounded phenocrysts of glassy quartz about 5mm across. House at entrance to the churchyard, Church Street, Dawlish.

Figure 3. Roadside wall, Holcombe illustrating the range of colours shown by the porphyry. The wall also contains pale grey limestone and one or two blocks of red breccia.

Figure 4. Dark grey porphyry with phenocrysts of chalky feldspar. House at entrance to the churchyard, Church Street, Dawlish.

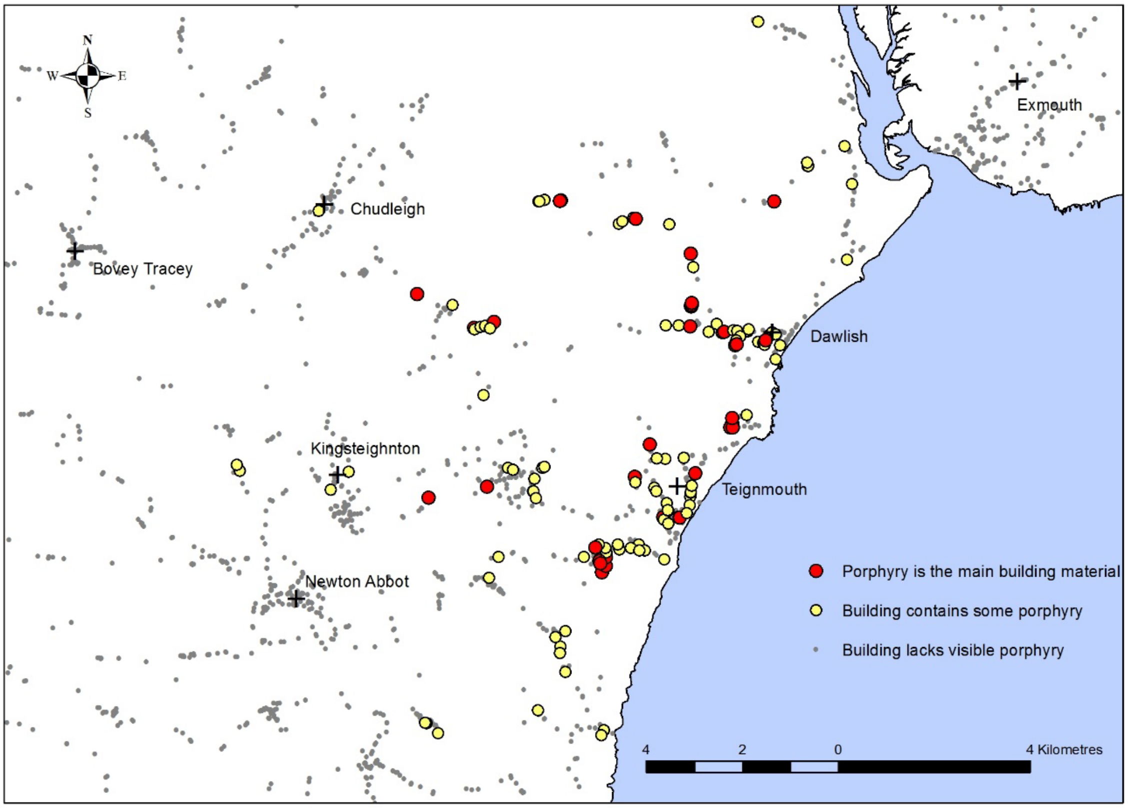

Figure 5. Distribution of porphyry in buildings.

156, Schorl Rock

Schorl rock is composed of fine-grained mixtures of black or very dark green or brown tourmaline and quartz. It occurs in at least three distinct modes in Devon all of which are represented in buildings:

(i) as pebbles and cobbles in the southern crop of the Budleigh Salterton Pebble Beds Formation where it is widespread as cobbles in the conglomerate but very subordinate to the predominant liver-coloured quartzite;

(ii) as pebbles and cobbles accompanying but subordinate to porphyry (Code 155, qv) and other rock types as clasts in the Permian breccias, especially the Teignmouth Breccia.

(iii) as a late stage crystallisation product or metasomatic alteration product occurring in both granite and country rocks at the margin of the Dartmoor Granite.

Code 156 applies to (ii) and (iii), both of which originate ultimately at the margin of the Dartmoor Granite. In the case of (ii), the stone has been involved in an intermediate stage as clasts in the breccias formed by wadis sweeping down the flanks of the Dartmoor mountains in Permian times.

The stone typically looks completely black or is speckled in black and white (Figures 1 and 2). In some cases, individual prisms of tourmaline forming compact aggregates are visible or can be resolved with a hand lens (Figure 3) but generally the rock is too fine grained.

It is generally homogeneous and typically lacks foliation or banding. Blocks of schorl formed at the margin of the Dartmoor Granite are veined by fine to coarse grained quartz or quartzo-feldspathic material. Where the veins are sub-parallel a sort of banding results. In other cases, the intermingling of schorl and quartz is irregular or has a speckled appearance (Figure 4). Where derived from the Permian breccias, schorl building stone forms subangular equidimensional pebbles and cobbles, abraded but less well rounded than the clasts of quartzite or porphyry accompanying it in conglomerate or breccia (Figure 5).

Schorl is distinguished from Teign Chert and its correlatives by a matt rather than shiny finish, somewhat coarser grain size, lack of true banding that originates from sedimentary bedding and more widely spaced and less prominent joints. It is distinguished from dolerite and basalt by finer grain size and lack of ochreous weathered crusts. It is distinguished with difficulty from hornfels of the Dartmoor Granite aureole since both are black fine-grained rocks and it has to be admitted that there is likely to be some confusion between the two, especially since they occur in the same parts of the county (Figures 6 and 7).

Most buildings containing schorl are concentrated on and close to the margins of the Dartmoor granite (Figure 8). Occurrences further from the granite margin around Okehampton and east of Plymouth represent cobbles and boulders of schorl that have been collected from the river beds to be used for building and are similarly derived ultimately from the granite outcrop. The occurrences extending east to the coast north of Newton Abbot represent schorl with the same ultimate origin but in this case transported from the granite outcrop by Permian flash floods and incorporated in the resulting Permian breccias.

Figure 1. Low wall made entirely of schorl rock, roadside between Cornwood and Lee Moor. The wall is about 1km long, evidence of the abundance of schorl rock in the surface deposits derived from the Dartmoor Granite here near its margin.

Figure 2. Wall at entrance to Druid Farm, Ashburton.

Figure 3. Schorl rock with unusually coarse-grained prismatic tourmaline crystals, roadside wall between Michelcombe and Scorrriton, south of Holne.

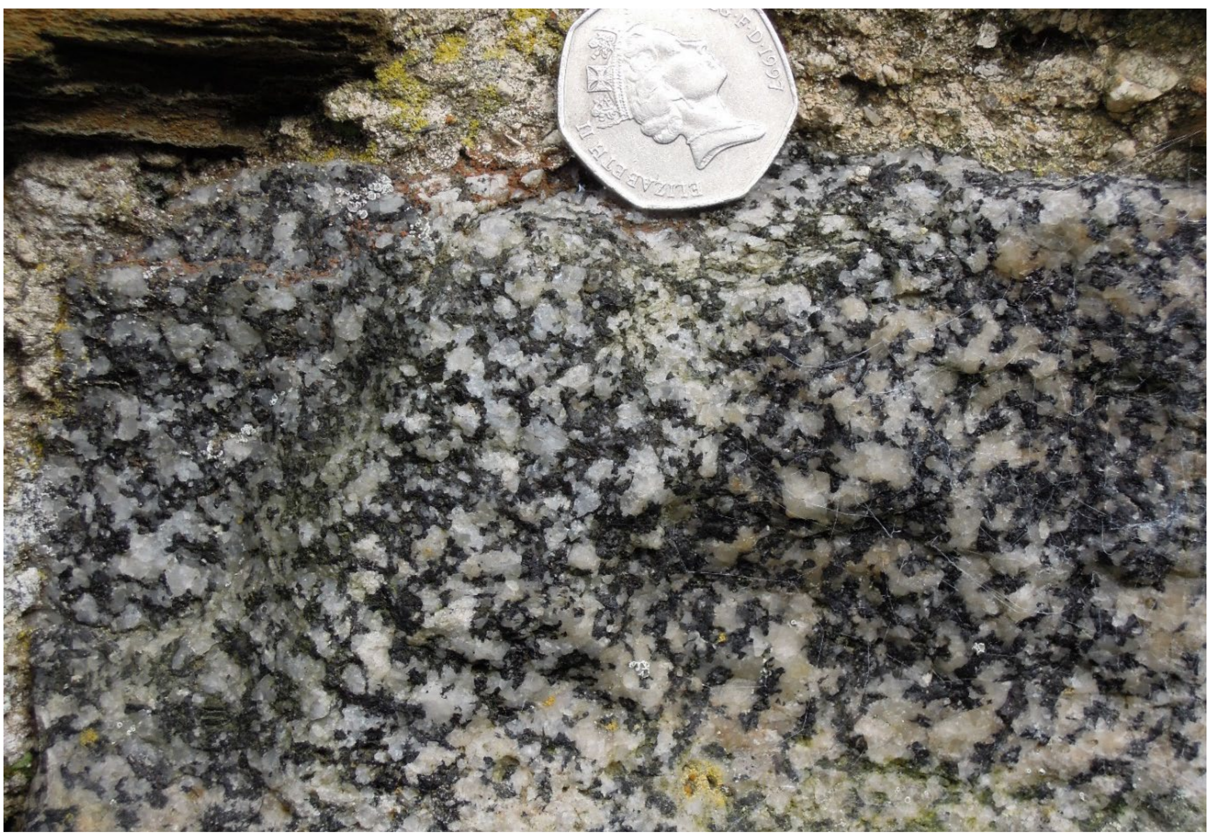

Figure 4. Unusually coarse-grained schorl rock, associated with marginal types of Dartmoor Granite. Outbuilding at Cheston Cross, north of Wrangaton.

Figure 5. Roadside wall, Holcombe. The pale grey blocks are of limestone from Torbay, the reddish blocks are of porphyry and breccia. The black blocks are of schorl rock derived from the breccia.

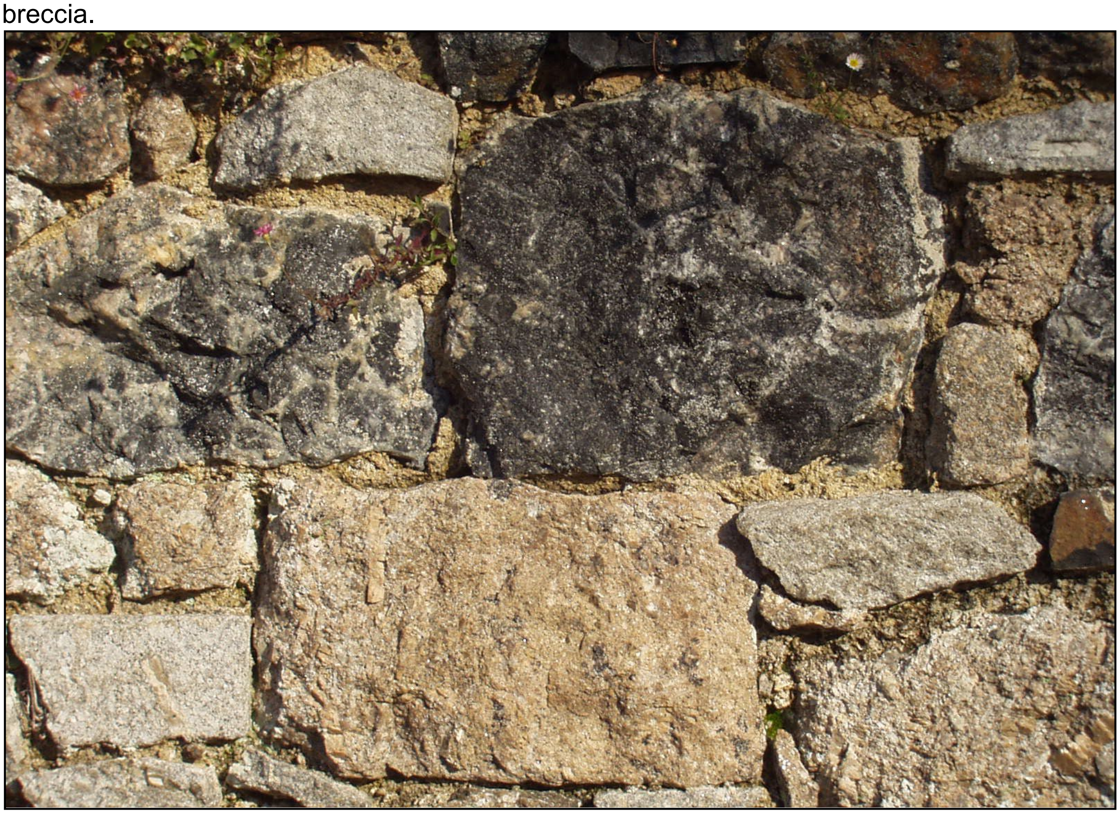

Figure 6. Wall at entrance to Church Style, Bovey Tracey. The large blocks marbled in black and white towards the top of the photo are of schorl rock. The other blocks are of Dartmoor Granite.

Figure 7. Wall at entrance to Church Style, Bovey Tracey. Pale blocks in lower half of the photo are of Dartmoor Granite. Very black blocks to left hand side are black chert. Grey blocks in coping and above left of coin are of schorl rock. The block with blackish surface only, diagonally between the schorl blocks and directly above the coin is granite peculiar to Bovey Tracey with fractures coated in black prismatic tourmaline crystals.

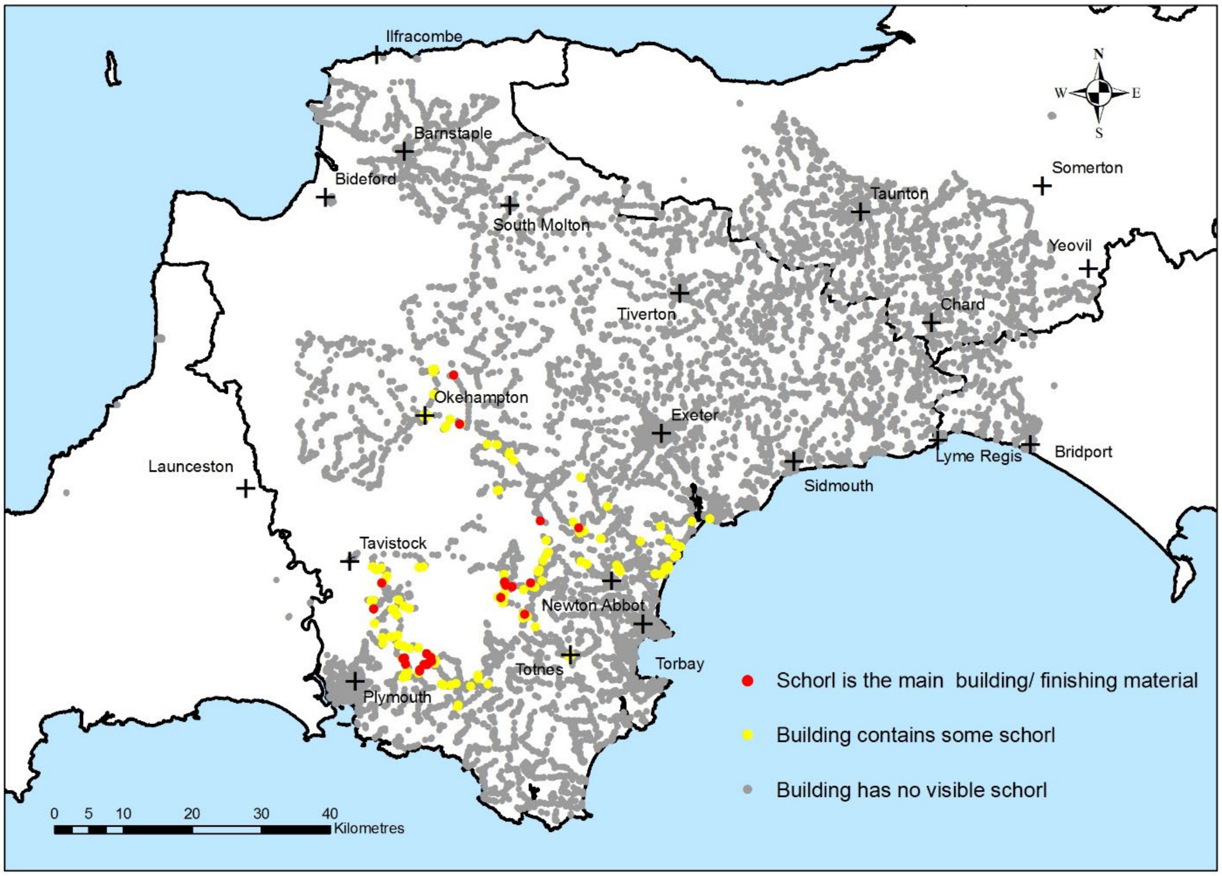

Figure 8. Distribution of schorl in buildings.

157, Spotted Slate

Strongly cleaved building stone of semi-pelitic composition is assigned this material code. The rock typically has a strong, regular planar foliation defined by layers rich in aligned micas separating layers rich in quartz possibly with some feldspar. The colour is grey, silvery, or grey-green (Figure 1), weathering brown (Figure 2), and the rock is variously described in the field notes as schist, phyllite or slate. The rock is coarser grained than most of the slate used for building in Devon, and is more strongly recrystallised with the growth of new mica.

Compared to most other building stone in Devon, the blocks are typically large, 60-100m in visible long dimension and 30cm thick and in many roadside walls, the blocks are usually laid as coursed rubble without any mortar (Figures 3 and 4).

In composition, the stone is semi-pelitic or psammitic, corresponding to muddy siltstone rather than mudstone or shale. Some but not all examples have on close examination, dark mica-rich spots developed on cleavage surfaces (Figure 5). According to one householder, the stone of this type used for his garden wall came from Yelverton within the aureole of the Dartmoor Granite (Yennadon Quarry?). This assertion is supported by the distribution of the stone, which is widely dispersed across the county except in the east but is concentrated in buildings around Yelverton, Dousland and Meavy (Figure 6).

The presence of mica-rich spots is a distinctive feature of this building stone and sets it apart from other slates. In the absence of spots, the psammitic composition, regular planar cleavage and large size of the blocks are distinctive. It may be that it has a whole range of different source quarries. However, it is believed that it was probably won from several quarries in the Yennadon area for older local buildings, but the wide dispersion of the stone and the preponderance of use as roadside walls points to a supply from Yennadon Quarry itself perhaps through a series of local government contracts for public works.

Figure 1. Grey semi-pelitic slate as large regularly cleaved blocks.

Figure 2. 1 St. Columba Close, Longford Lane, Kingsteignton. Strongly foliated slate or schist with brown-weathered joints and cleavage planes.

Figure 3. Large blocks of well cleaved grey slate. Roadside wall, Lewdon.

Figure 4. Roadside wall, Kirkella Road, Yelverton. The brown colour, large size of the blocks and strictly planar foliation/cleavage are typical.

Figure 5. 1 St. Columba Close, Longford Lane, Kingsteignton. Dark mica-rich spots are visible on cleavage surfaces.

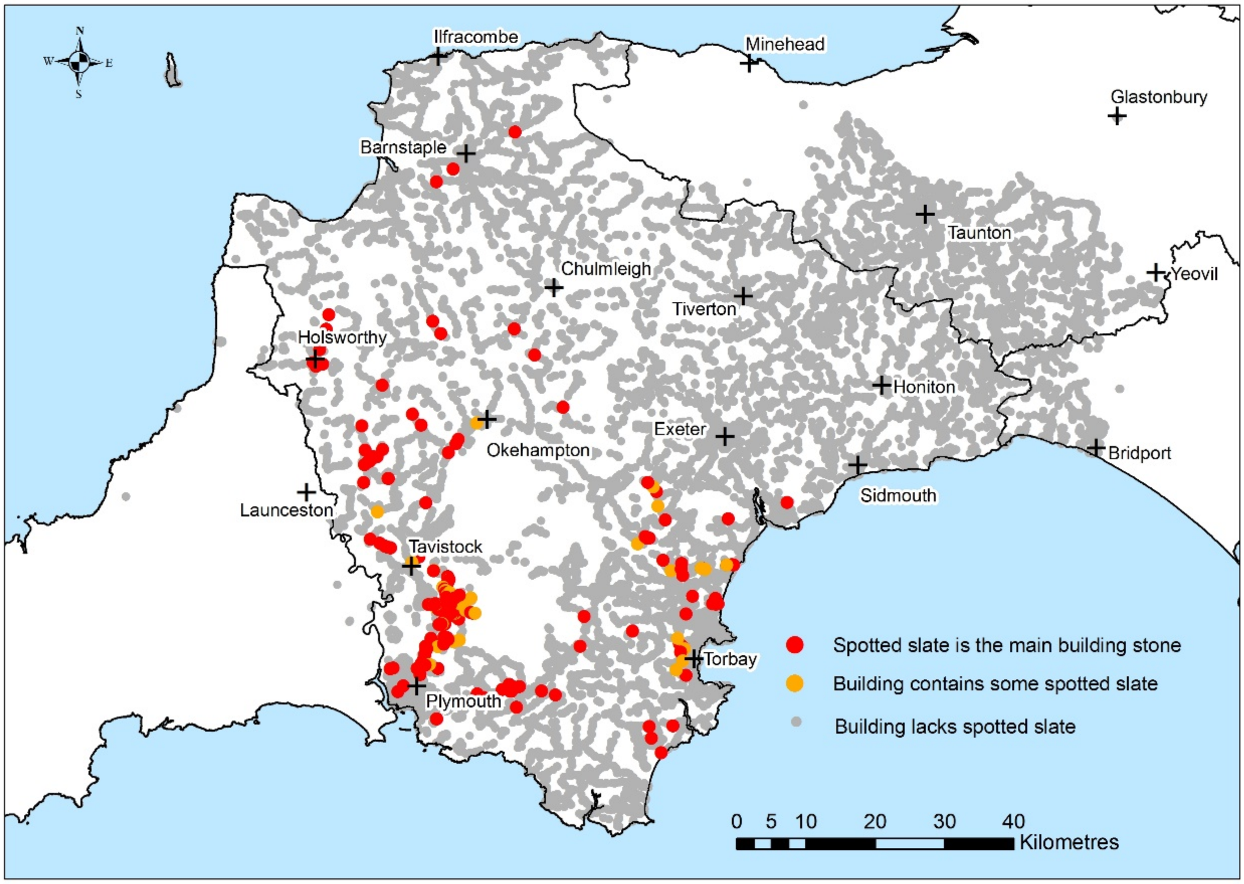

Figure 6. Distribution of spotted slate in buildings.

159, Staddon and Bovisand Formations

This code includes stone taken from areas mapped as Bovisand Formation interfolded with the Staddon Formation in the north part of the main outcrop of these formations, in a zone extending from Bovisand Bay south of Plymouth to Sharkham Point, south of Brixham (Figure 1). The code also applies to stone from areas mapped as Meadfoot Group near Meadfoot Beach and Ilsham in Torquay, in Chelston and Cockington and behind Paignton in the central part of Torbay. It excludes buff-weathered slate used for building in the southern part of the main outcrop including Kingsbridge (Code 187), which is referred to the Bovisand Formation only.

Dealing with the main outcrop first, the stone is characterised by mixtures in buildings of sandstone, mainly micaceous and foliated, and slate including psammitic, semi-pelitic and more rarely, pelitic varieties. The sandstone is fawn, grey or neutral in colour. Parts may be unfoliated and massive (Figure 11) but it is usually micaceous and foliated (Figures 10 and 12). The slates typically have a spaced cleavage consisting of layers and lenses less than 5mm thick rich in quartz sheathed in thinner layers rich in mica which may also form regular layers or may be anastomosing, surrounding the intervening lenses of quartzo-feldspathic minerals. The colour of the rock sequence is best described as variegated (Figure 7); it includes dark grey, light grey, and brown varieties (Figures 10, 11, 12), and purple and pink varieties but very characteristically, it also includes rock described as *olive* brown and pistaccio, and silvery slates not seen in the adjacent formations. Building stone of the country rock is accompanied by vein quartz which appears to be particularly plentiful in the Staddon Formation. The countryside of the Staddon Formation has scattered boulders of massive sandstone and vein quartz quite atypical of the slate country to north and south.

The presence of foliated micaceous sandstone and body colours with an olive cast serve to distinguish building stone from the Staddon Formation from Middle Devonian slates to the north and Dartmouth Group rocks to the south. While dark grey rocks are present, the general impression is of colours lighter than those typical of nearby formations used for building. It is more difficult to differentiate the slates in the absence of accompanying sandstone and some difficulty has been experienced in these cases with both the Middle Devonian slates to the north and the Dartmouth Group to the south. However, the Bovisand slates in buildings on this part of their outcrop tend to include rock with a higher proportion of quartzo-feldspathic to micaceous minerals, (psammitic and semi-pelitic as opposed to pelitic), with gradations to micaceous sandstone, than in any stone used for building drawn from nearby formations.

The Bovisand Formation also includes impure limestone that is used for building in a few places, most examples being seen in Modbury. The limestones are impure, and grade into calcareous slates (Figure 8) but at least one example includes impure limestone blocks up to 20cm thick (Figure 9). In other examples, the silicate and carbonate minerals are interlayered on millimetre scales. In Dartmouth and Kingswear, somewhat similar impure limestones may be from the Bovisand but could also be imported by sea from the Middle Devonian limestones of Torbay.

The stone used in the Meadfoot type area of Torquay is broadly similar (Figure 3) and can conveniently be compared with the country rock well exposed on Meadfoot beach. Dark coloured sandstone and slate predominate. Bedded varieties where the bedding is oblique to the cleavage appear to be commonly used (Figure 3) and some blocks contain clasts of black and dark brown slate. Similar stone is used sparsely on the high ground lying to the west of Paignton (Occombe and Churscombe).

The appearance of Meadfoot Group rocks in Cockington and Chelston is dramatically different because, it is believed, of staining close to the Permian unconformity. The main rock-type is sandstone, more or less foliated but generally finer grained than in the main outcrop area and lacking obvious visible micas. The colour is distinctive ranging from red and maroon through brick red and ochreous (Figures 4, 5 and 6). Leisegang rings occur in some examples. Blocks are angular with sharp edges and corners, have irregular shape and a hackly fracture where not cleaved and may be crossed by narrow quartz veins. Cross bedding has been observed in some blocks as have small inclusions of slate.

Stone coded 159 overlaps in age with the slates of the Kingsbridge area coded 187. The main distinguishing feature is the presence of foliated sandstone used for building in the former and its absence in the latter.

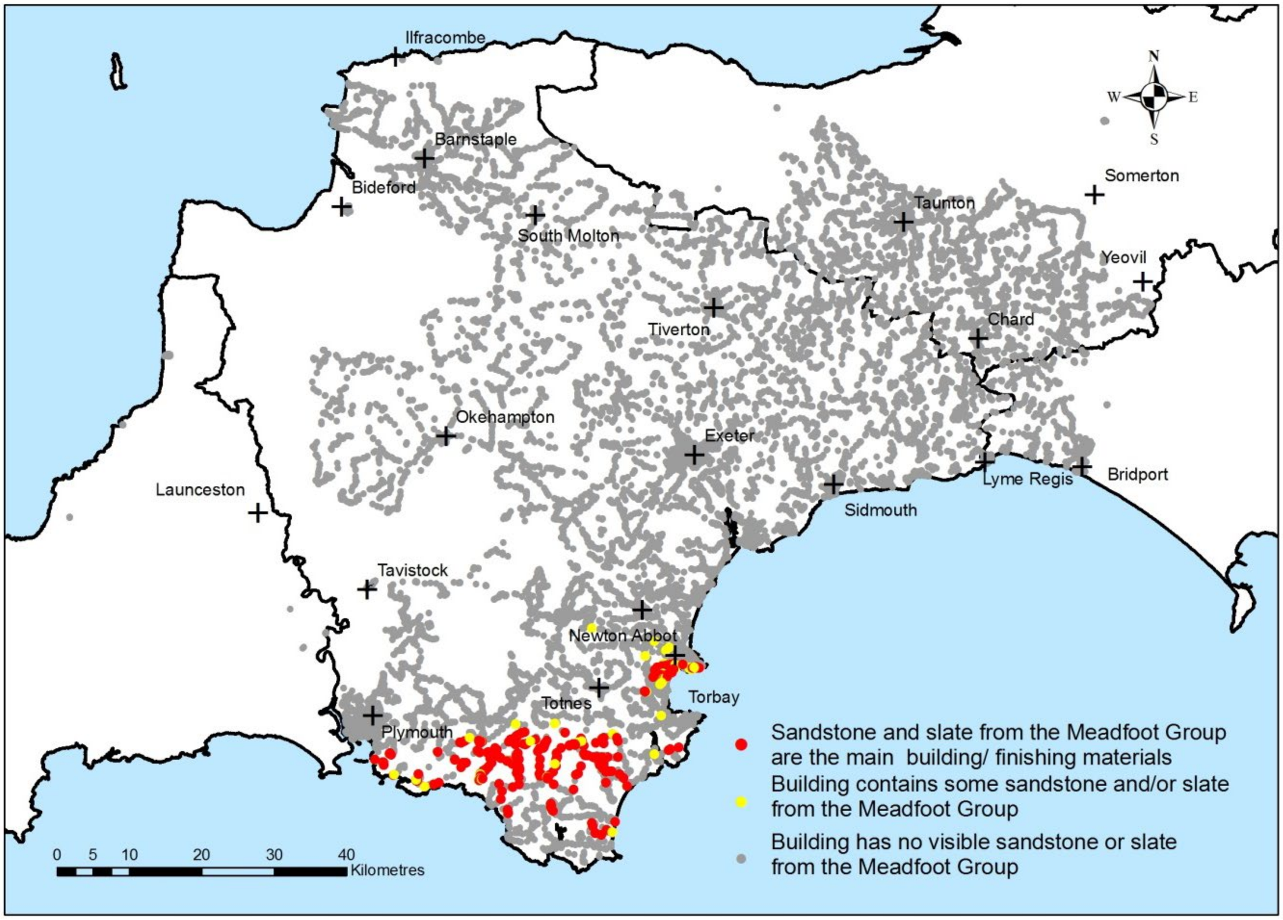

Figure 1. Distribution of Bovisand Formation and Meadfoot Group rocks in buildings.

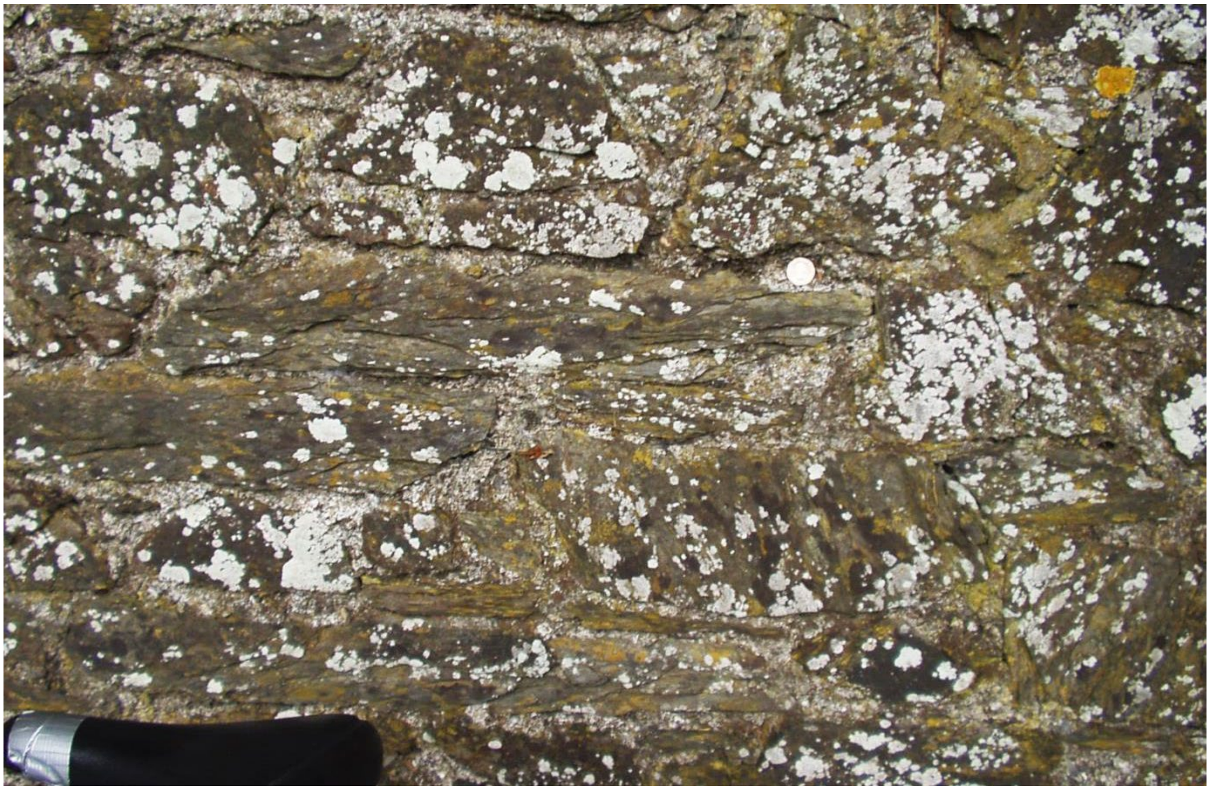

Figure 2. Embankment, Ilsham Marine Drive, Torquay. Grey-brown slate with some blocks of micaceous sandstone.

Figure 3. Dark grey slate and foliated sandstone from the Meadfoot Group, and pale grey Middle Devonian limestone. Note bedding oblique to the cleavage in the slate. North side of Meadfoot Sea Road, Torquay.

Figure 4. St Matthew's church, Chelston, Torquay. Red-stained sandstone and slate from the Meadfoot Group.

Figure 5. Embankment, Cockington Lane, Cockington, Torbay. The angular shape of the Meadfoot sandstone blocks is typical.

Figure 6. Embankment Langdon Road, Paignton, composed of mixed Meadfoot sandstone and Permian breccia, identical in colour.

Figure 7. The Old Inn, Halwell. Staddon Formation sandstones and slates showing typical variegated colours.

Figure 8. Neutral-coloured irregularly cleaved slate with lenses of carbonate mineral. Top right is a block of coarse grit, St George’s church, Modbury.

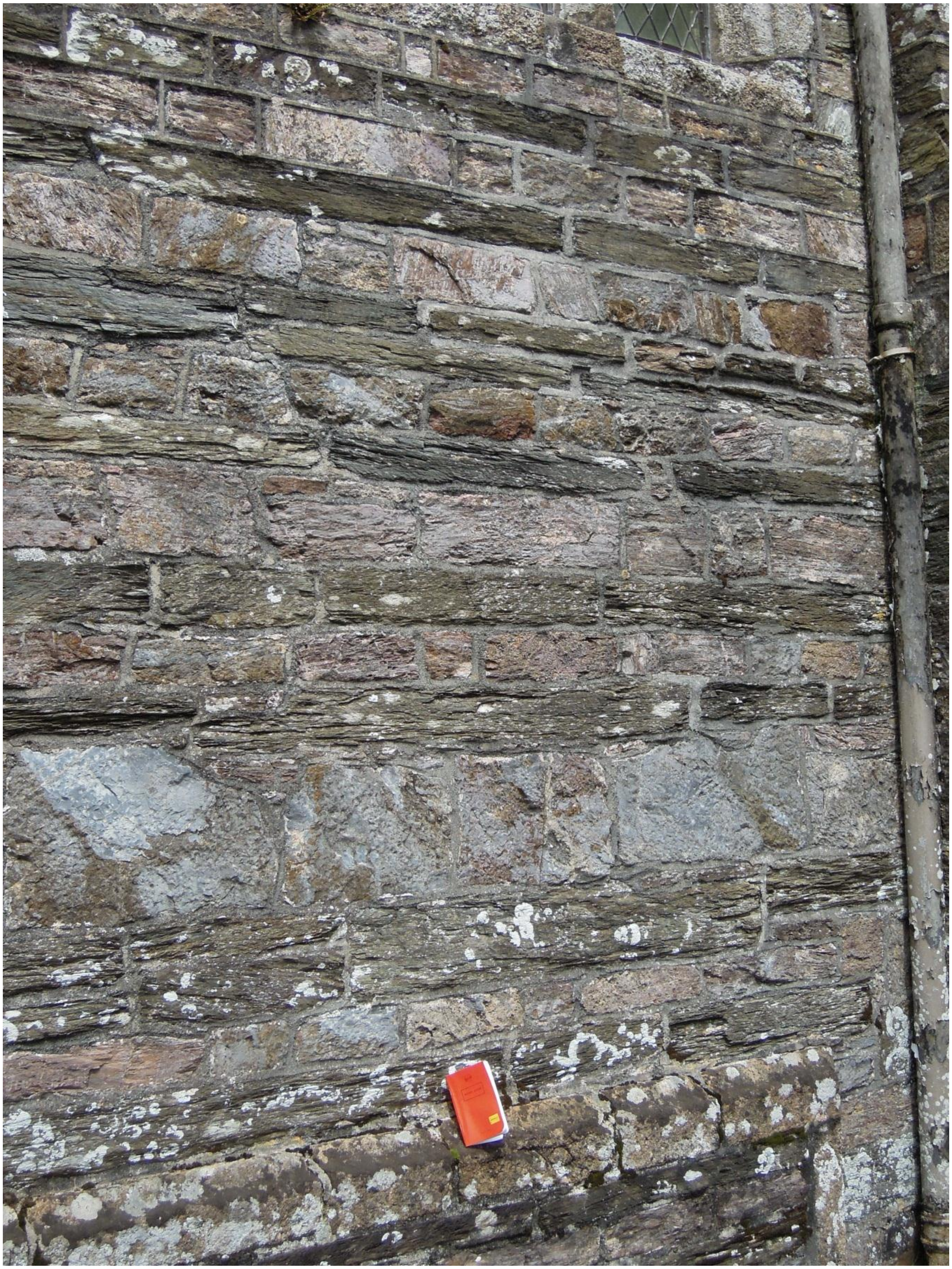

Figure 9. East end of south chapel, St George's, Modbury. Alternating courses of slate (thinnest), sandstone (intermediate) and impure limestone (thickest with bluish hue).

Figure 10. New wall at entrance to Knighton Combe, Modbury. Pale semi-pelitic slate and foliated sandstone, darker on joint surfaces.

Figure 11. Massive and foliated pale sandstone, entrance gateway to Hazelwood House Hotel, Loddiswell.

Figure 12. Typical Staddon Formation rock-types, Congregational church, Loddiswell.

162 and 163, Aplite, Microgranite, Elvan and other fine-grained types of Dartmoor Granite

Code 162 was created to describe the vuggy orange and buff granite seen in buildings in and around Doddiscombsleigh and was extended to rocks described as aplite, microgranite, elvan or felsite in buildings on and near the Dartmoor Granite outcrop. Code 163 was created to group the parts of the Dartmoor Granite contact rocks used in buildings at Bovey Tracey. On the south side of Dartmoor, these finer-grained rocks may be called “alvin”, clearly a corruption of “elvan”, or “river stone”, a reference to their abundance in the beds of the rivers draining the moor. The codes are therefore used for a variety of rocks of broadly granitic composition that are distinguished from the main Dartmoor granite by one or more of finer grain size, compact, non-porphyritic texture and paucity of dark minerals. Two varieties of these rock types have unique properties that set them apart and have their own Material Codes, Roborough Stone (Code 190) and Pentewen-type elvan (Code 208) to which reference should also be made. Meldon aplite should be added to this group but at the time of writing, no unequivocal examples of this rock used for building have been identified even although some are discussed in the literature.

Granite coded 162 displays a range of colours, from brown through buff, yellow, cream, pink and orange to green (enriched in epidote) and black. The rocks are composed mainly of quartz and feldspar with dark minerals as less plentiful components. Most examples are noticeably leucocratic where it is difficult to identify any dark minerals (e.g. Figure 7) but a fair proportion carry visible biotite, and tourmaline is also commonly visible and may be plentiful (Figure 3). In many cases the groundmass minerals cannot be resolved with the hand lens and the rock looks predominantly feldspathic. Muscovite has been identified in a few examples and greisen – granite altered by the passage of hydrothermal fluids and enriched in white mica – has been reported from a few buildings. While some examples have feldspar megacrysts (Figure 6), these are much less common than in the main Dartmoor Granite lithologies; the great majority of the examples seen are even grained. Both biotite and tourmaline may occur as small aggregates rather than individual grains but this habit is much less obvious in these rocks than in the main Dartmoor granite. A significant proportion of this range of rock-types has joints coated with black iron oxides and in some cases contain boxworks after sulphides, with the resulting widespread iron staining.

Code 162 is also used for altered-looking granite containing vugs seen in buildings mainly on the east side of the Dartmoor pluton and elsewhere near the granite margin (Figures 1 and 2). The vuggy granite is medium- to coarse-grained, and leucocratic, composed mainly of feldspar with no doubt quartz and some dark minerals. The colour is orange, brown or characteristically dung-coloured. Vugs have been seen in fine-grained types of the granite elsewhere also.

Microgranite of all kinds is differentiated from the main type of Dartmoor granite by much finer grain size and less prominent dark minerals. It is associated with the “normal” type of granite (e.g. Figure 4) and also with schorl, hornfels and chert (Figure 5).

The term elvan is usually taken to be equivalent to granite porphyry, i.e. a fine- or medium- grained granitic rock with phenocrysts of feldspar and/or quartz. While the term is widely used by non-geologists for rock-types found on Dartmoor, rather few of the finer-grained granitic rocks contain phenocrysts. This is in contrast to the situation in Cornwall where porphyry or elvan is widely used for building (http://www.bgs.ac.uk/mineralsuk/buildingStones/StrategicStoneStudy/EH_atlases.html, 2015; and Bristow, 2014). In Devon, it is cautiously concluded that these finer-grained types of granite are concentrated in buildings at the margin of the granite (and beyond it in the case of stone collected from river beds). Caution is required because rather few buildings have been examined in the centre of Dartmoor (but compare Figure 10 with Figure 8 of the entry for granite, Code 32). It is perhaps significant that elvan dykes, so prominent in the detailed geological maps of Dines (1956) of granite plutons further west are almost absent from his map of Dartmoor, although of course this may only be a function of the state of exploration for and exploitation of tin and tungsten in the various granite plutons.

Figure 1. Vuggy fawn and orange granite associated with black chert, outbuilding, Doddiscombsleigh. Some blocks have black ochreous joint coatings.

Figure 2. Vuggy dung-coloured granite composed of bladed feldspar with interstitial tourmaline, Place Barton, Higher Ashton.

Figure 3. Wall of outbuilding at Cheston between Ivybridge and South Brent, composed of leucocratic granite, including pink granite with dark spots richer in tourmaline (centre) and banded chert.

Figure 4. Chimney and flue (marked by the line of stones extending from the base of the chimney), Powdermills, between Two Bridges and Postbridge, Dartmoor; composed of a mixture of normal Dartmoor granite and aplite.

Figure 5. Parapet of Cullaford Bridge, Scorriton, made of a mixture of slate some of which is hornfelsed, Teign Chert and microgranite; many of the stones, especially of microgranite are rounded and have probably been collected from the stream bed.

Figure 6. Rounded boulders of pink microgranite probably collected from the river, with sparsely distributed feldspar phenocrysts noticeable towards the bottom right of the picture. Wall on north side of the B3372 near its junction with Plymouth Road, South Brent.

Figure 7. Cream-coloured microgranite with sparsely disseminated aggregates of dark minerals, and dark grey slate, wall on approach road to Derriford Hospital, Plymouth.

Figure 8. Brick-sized blocks of microgranite, probably reused setts, now used as the coping of a wall, north side of Eggbuckland Rd, Higher Compton, Plymouth. Reused setts like this are quite common in Plymouth.

Figure 9. The Cottage, Walkhampton. The lintels are made of single blocks of fine-grained granite carved to simulate relieving arches. The sills and quoins are made of the same granite.

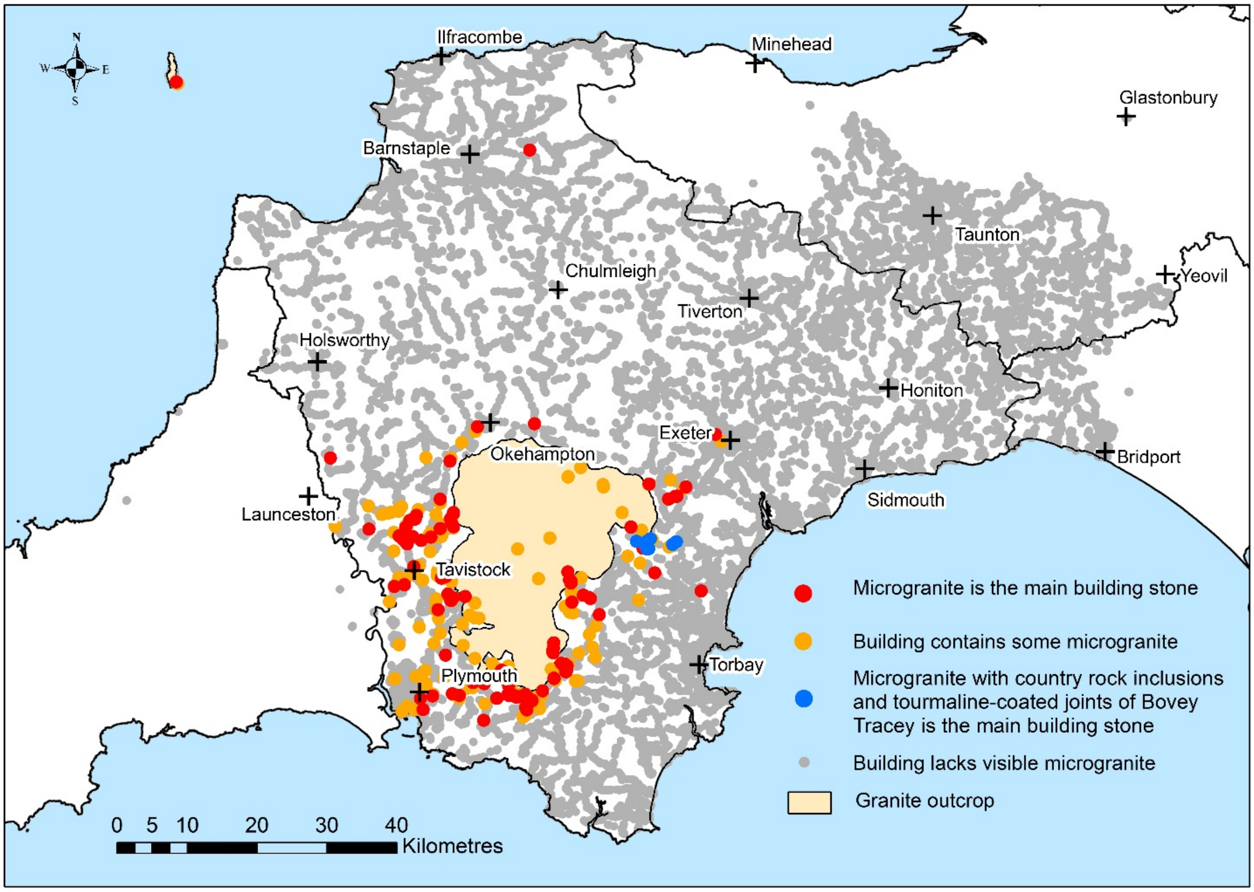

Figure 10. Distribution of microgranite in buildings.

An unusual kind of granite building stone, mainly seen in and around Bovey Tracey, is given the code 163. Walls made of this kind of granite contain also blocks of contact-metamorphosed slate and there are plentiful building blocks made partly or granite and partly of metamorphosed slate. Figure 11 shows some of St John's Cottages that are made of this rock-type and Figure 12 shows part of St John's church, also made of this stone but with quoins and dressings of more normal Dartmoor granite. The stone is quite widespread in Bovey Tracey. As well as the illustrated buildings, it is used in the large house south of St John's (Church Army house according to the listed building citation) and the building housing the Devon Guild of Artists next to Bovey Bridge.

This building stone is very likely to have a local source. The fact that some blocks contain both granite and country rock strongly suggests a source at the contact of the granite with the country rock. Whitstone Quarry satisfies this condition. The British Geological Survey memoir covering the area (Selwood *et al*., 1979, p79) confirms that the quarry is at the granite contact with the country rocks as does the brief description of the site in the Devon RIGS documentation.

Figure 11. St John's Cottages, east side of Newton Road, Bovey Tracey.

Figure 12. St John's church, Bovey Tracey. The black surfaces are coated with acicular tourmaline. The mason has scored the surface of some blocks to give a speckled effect.

References

Bristow, C. M. 2014. The geology of the building and decorative stones of Cornwall. In: Cassar, J.,Winter,M. G., Marker,B.R., Walton,N.R.G., Entwhistle,D. C., Bromhead, E.N. and Smith, J.W.N. (Eds), *Stone in Historic Buildings: Characterization and Performance*, Geological Society, London, Special Publications, 391, 93–120.

Selwood, E.B., Edwards, R.A., Simpson, S., Chesher, J.A., Hamblin, R.J.O., Henson, M.R., Riddols, B.W., and Waters, R.A., 1984. *Geology of the country around Newton Abbot*: Memoir for 1:50,000 geological sheet 339, New Series. HMSO, London.

164, Olivine Basalt from Dunchideock (Exeter Volcanic Series)

The basalt won from School Wood and adjacent quarries in Dunchideock is distinct from other rock-types of the Exeter Volcanic Series. It is a dark grey, medium-grained rock typically homogeneous, without any banding, foliation or obvious jointing (Figure 1). On close examination, it is possible to discern blood-red phenocrysts up to 3mm across of iddingsite after olivine (see for example Gay and LeMaitre, 1961), and in some samples biotite also (Figure 2). The rock is not obviously vesicular but some blocks contain trains of very small vesicles. The colour is mainly grey but almost all blocks have a hint of maroon in their pigmentation.

This rock-type has a very restricted distribution in buildings in and around Dunchideock, the estate buildings of Haldon House (now the Lord Haldon Hotel) and Ide. One occurrence has been identified in Exeter. It is distinguished at a distance from other medium-grained basic igneous rocks, especially dolerite from Trusham and nearby quarries, by a maroon cast to the predominant grey pigment. The presence of red iddingsite and lack of obvious groundmass plagioclase are characteristic where the rock can be closely observed.

Reference

Gay, P. and LeMaitre, R. W., 1961. Some observations of "Iddingsite". *American Mineralogist,* **46**, 92-111.

Figure 1. General view of the basalt, southeast wall of St Michael and All Angels, Dunchideock. The spots of altered olivine are just about visible. Width of circular lichens, 15mm.

Figure 2. Enlargement of Figure 1. Iddingsite shows as darker red spots about 1-2mm across.

165, Dolerite

The dolerite assigned Material Code 165 is typically dark grey or black where fresh (Figures 1 and 2), medium-grained, unfoliated and homogeneous. It is rather coarse-grained for a dolerite and could also be described as a micrograbbro. On fresh surfaces both dark grey or green-grey ferromagnesian mineral (pyroxene or hornblende) and paler green plagioclase can be separately identified. Plagioclase is unusually abundant for a rock of dolerite composition. Examples in buildings close to the Dartmoor Granite (Bovey Tracey and Hennock) tend to be green and the main dark mineral here is likely to be hornblende. The feldspar grains are more easily distinguished from the groundmass when weathered, by yellow and orange pigmentation. Some examples have feldspar phenocrysts. The weathered rock has a characteristic brown crust and from a distance does not look much like a basic igneous rock (Figure 2). Most examples of the stone are blocky with about equal dimensions of the visible faces. A few examples of rounded cobbles and boulders some with onion-skin weathering have also been observed in buildings. In these cases, the stone was probably collected from the surface rather than quarried at depth.

Variants of the typical rock-type include fine-grained varieties which tend to be very dark, almost black in colour, and foliated and closely jointed varieties. The dolerite in buildings is mainly concentrated in the Teign valley (Figure 4). It can be matched with the rock-types exposed in Trusham and nearby quarries. A further concentration of occurrences is in the Dart valley between Buckfastleigh and Totnes and there is one known use of the stone in Slapton and one in Brentor. In these cases, the dolerite looks exceptionally fresh (Figures 3 and 5).

Figure 1. Gateway to Bury Meadows, New North Road, Exeter. The wall includes dark grey dolerite, purple Pocombe Stone with carbonate veins and light grey Dartmoor granite.

Figure 2. South porch of St. James' church, Christow. The dolerite is black on freshly broken surfaces but shows characteristic brown weathering after exposure.

Figure 3. Outbuilding, Beara Farm, Buckfastleigh. Mainly composed of green-grey dolerite.

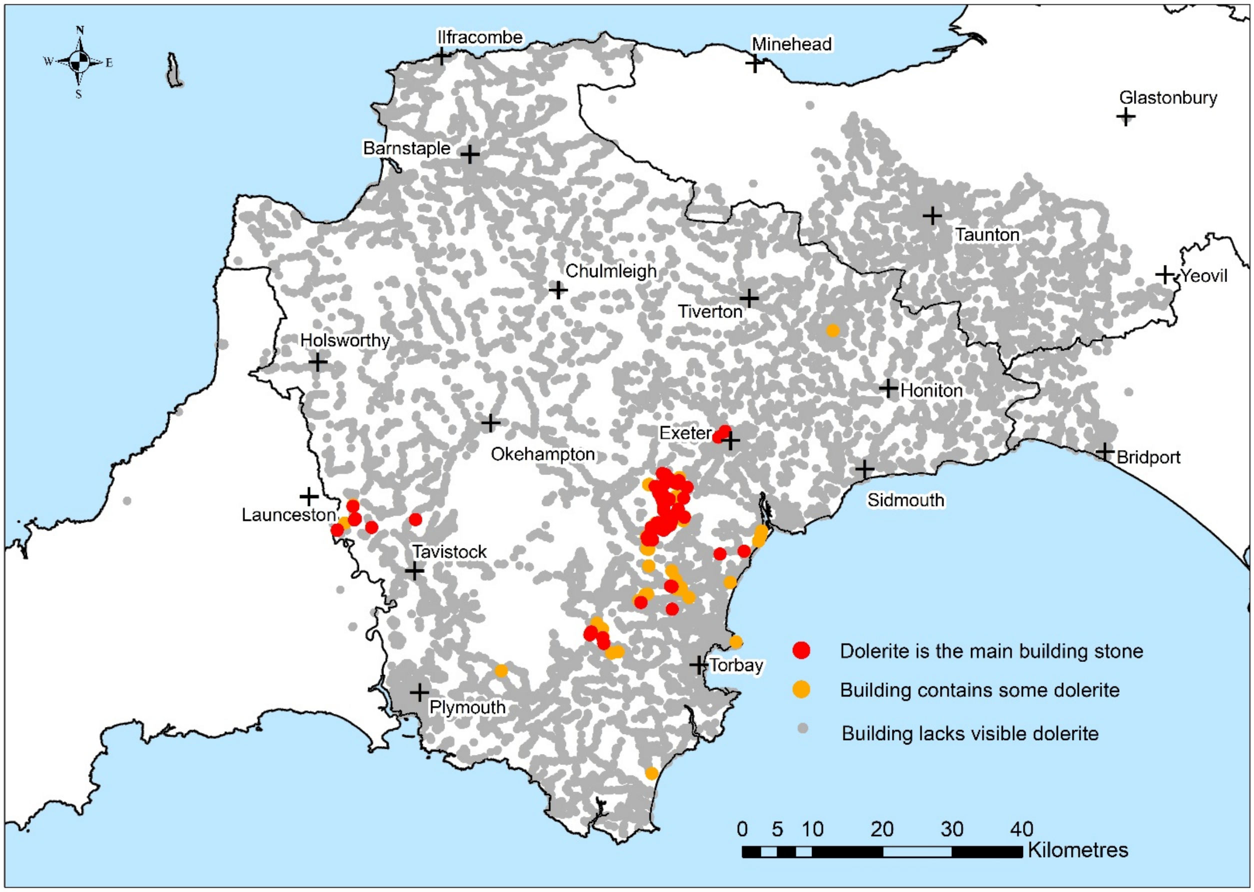

Figure 4. Distribution of dolerite in buildings.

Figure 5. Course of squared dolerite blocks laid below the coping, wall at churchyard gate, Slapton.

Dolerite coded 165 is distinguished from basalt from the Exeter volcanics of Dunchideock (Code 164) by green-grey rather than purplish-grey colour, higher proportion of feldspar, coarser grain size and lack of iddingsite. It can be distinguished from black chert, schorl rock and hornfels by its mineralogy and weathering characteristics but it has to be admitted that differentiating between these dark rocks is problematic especially where close examination is not possible.

The dolerite forms sills folded with the country rocks on the east side of the Dartmoor Granite and it is remarkable that it retains even in part, an igneous mineralogy and texture after such strong deformation. Basic igneous rocks elsewhere tend to be more thoroughly altered and are now best described as amphibolites (Code 91) although mapping by the BGS implies that all these rocks belong to the same phase of basic igneous intrusion that shortly predates Variscan deformation.

There are gradations between dolerite coded 165 and other basic igneous rocks coded 91. The distinction is likely to be arbitrary in many cases; for example, the dominant building stone in and to the north-east of Mary Tavy and Peter Tavy is a coarse-grained altered gabbro coded 91 where the main dark mineral is hornblende but this stone could as legitimately be coded 165 since it clearly originated as gabbro intruded into the country rock slate before the emplacement of the Dartmoor Granite.

166, Forest Marble (south Somerset)

The Cokers and Hardingtons of South Somerset are characterised by buildings made of pale yellow (Figure 1) to orange (Figure 2) calcareous sandstone, or sandy calcarenite rich in the shells of bivalves, thought to have been won from the Forest Marble although the stone might be from the Cornbrash (see for example, Howe, 2001, p.241). Most of the stone is primrose-yellow but some of the larger blocks have a greenish or grey core (Figure 3) suggesting that the predominant pigmentation is caused by weathering and oxidation. The stone is medium-fine-grained, and friable. It is made up of variable proportions of quartz and calcite; the calcite-rich varieties could be called calcarenite and the quartz-rich ones calcareous sandstone.

The bedding, which is irregular, is defined by the long axes of bivalve shells which may crowd the rock and appear to be largely complete with rather few examples of broken shells (Figure 4). Where the shells are less plentiful, the rock may be bedded and in some cases, cross bedded (Figure 5). The planar fabric is accentuated by patches of ochre clay up to 2cm long elongated in the bedding (Figure 5). In many examples the clay has fallen out leaving voids which mimic the shape of the inclusions (Figure 6). In other buildings, the stone is crossed by irregular thin bands of clay or ironstone knots.

The stone is of poor quality. The blocks are usually small, laid as random or coursed rubble with long axes lying horizontally and with rough surface finish. The difficulty of shaping the blocks means that many buildings made of this stone have quoins and/or dressings of Ham Hill Stone, or less commonly of good quality Forest Marble (Code 19, qv).

This variety of Forest Marble is distinguished from the better-quality material used here and in the Bridport area by finer grain size, paler pigmentation and the nature of the included fossils. Although plentiful, the bivalves appear to float in the sandy matrix. This contrasts with the Forest Marble of the Bridport area which is composed of fragments mainly of oyster shells which are close packed and are the main component of the rock. The stone resembles parts of Ham Hill Stone but the latter also has a fabric mainly composed of shell fragments. Howe (2001, p.241) mentions the use of tough shelly limestone from the Cornbrash for rough building work in East Coker which raises the possibility that this stone comes from the Cornbrash rather than the Forest Marble.

Reference

Howe, J.A., 2001. *The Geology of Building Stones.* Facsimile edition. Donhead Publishing Ltd.


Figure 1. Pale yellow rubbly limestone, Old Stable Cottage, East Coker. The orange block on lower left is of Ham Hill Stone.


Figure 2. Terrace opposite Burton Lane, Higher Burton, East Coker.


Figure 3. Larger blue-hearted block in roadside wall predominantly of poor quality stone, East Coker.

Figure 4. Irregular bedding defined by the long axes of bivalve shells. Old Stable Cottage, Higher Burton, North Coker.

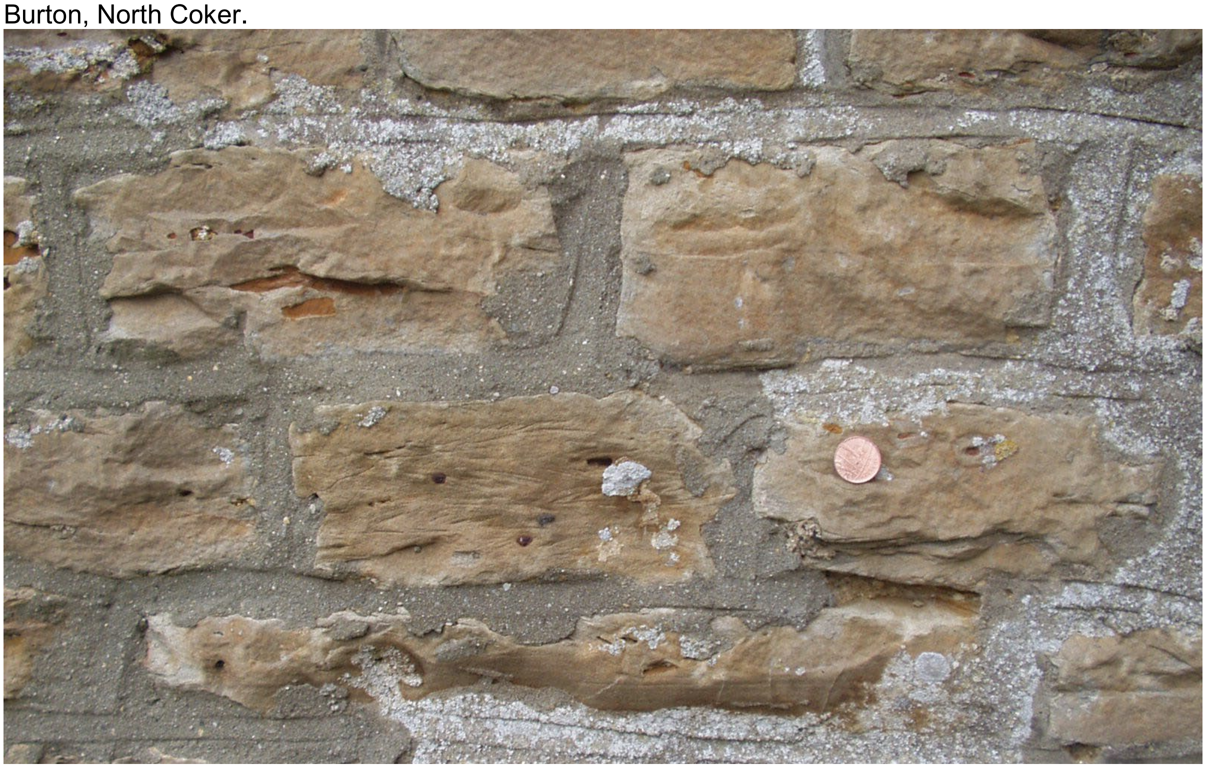

Figure 5. Orange cross-bedded sandstone with ochreous inclusions many of which have fallen out leaving voids. North side of St Mary's church, Hardington Mandeville

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Figure 6. Wall, north side of Rex's Lane, Barwick. The large block towards the top of the picture shows the characteristic voids.

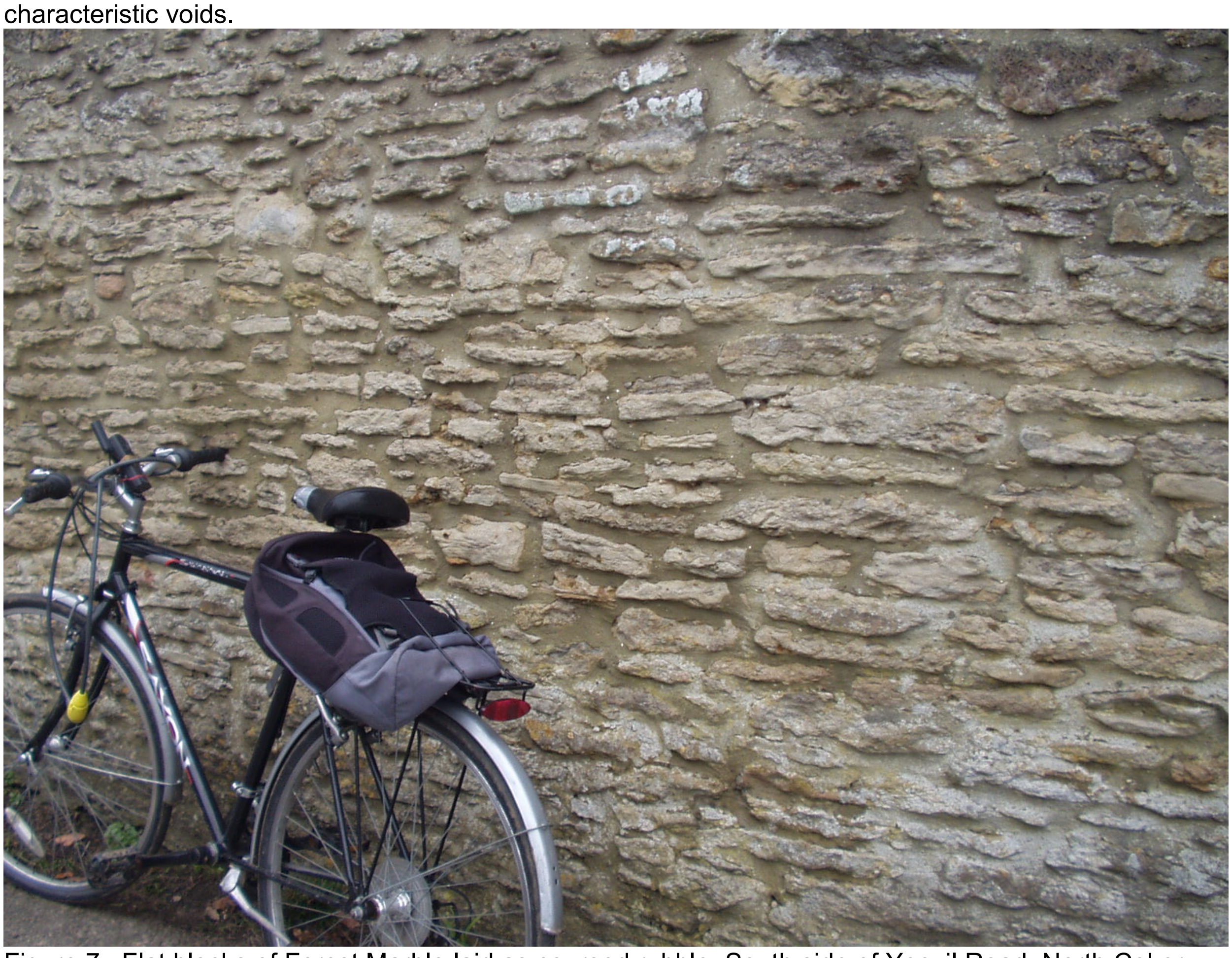

Figure 7. Flat blocks of Forest Marble laid as coursed rubble. South side of Yeovil Road, North Coker.

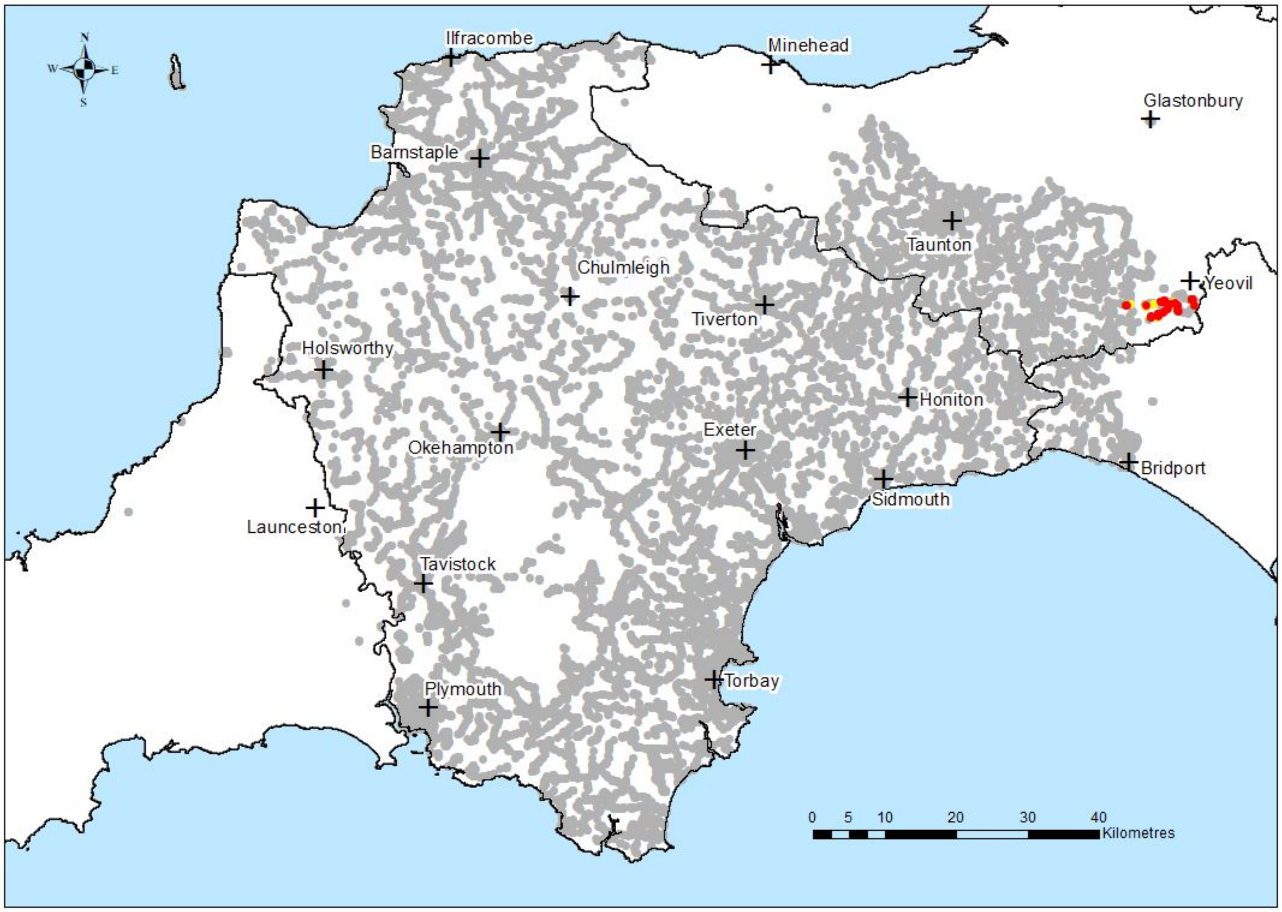

Figure 8. Distribution of buildings containing Forest Marble building stone coded 166. Red circles, Forest Marble is the main external building material; yellow symbols, Forest Marble is a subsidiary building material; grey symbols, Forest Marble not seen in the building.

167, Sandstone from Capton Quarry (Budleigh Salterton Pebble Beds Formation)

This rock-type is a medium-grained red sandstone with tough carbonate cement (Figure 1) enclosing scattered pebbles of Devonian/Carboniferous sandstone and slate and vein quartz (Figure 2). The hue includes a touch of pink (Figures 3 and 4). This, and the presence of angular fragments of Devonian and Carboniferous sandstone and slate distinguishes the stone from all others seen in the area. The pebbles however are not present in all examples of the stone and are sparsely distributed at best. The most reliable identifier is the pink cast of the pigmentation. Other kinds of conglomerate, also from the Budleigh Salterton Pebble Bed Formation (Code 127, qv) are also widely used in the Vale of Taunton Deane although there are no quarries currently operating. However, the clasts tend to be much larger than those in the Capton Quarry pebbly sandstone and include well rounded pebbles and cobbles of Devonian limestone. The presence of pebbles also distinguishing the stone from the Otter Sandstone, also widely use here in the past.

Capton Quarry is the only reasonably local current source of red sandstone building stone and its product is widely though sparsely used for the finishing of new houses and walls where a match with the red sandstone of existing buildings is required. This explains the location of the main use of the stone along the west margin of the Quantock Hills (Figure 5), where red sandstone from the Otter Sandstone Formation was formerly widely used but there are no operating quarries. The stone is also used in the lower Teign Valley and around Paignton, both places where there is a tradition of building in red sandstone and where, here again, there is no current local production.

Most examples of use of the stone are rock-faced, perhaps since the presence of pebbles makes neat sawing of the rock impractical. All of the buildings where the stone has been recognised are of relatively recent construction and the stone looks fresh in them. The reason for this is unclear. One possibility is that the stone has not been recognised in older buildings because it looks different. Alternatively, it might be that exploitation does not extend far into the past. An admittedly rather cursory glance through old maps shows no evidence of quarrying of the stone at the only quarry on the OS 6" map of 1887 and only the smallest quarry face north of the currently active quarry on the OS 6" map of 1902, and just the same on the 1929 map. So perhaps the preponderance of newer buildings using the stone is because the quarry has been operating for a relatively short space of time. Of course, asking the owner would likely provide an accurate answer.

Figure 1. Wall of red pebbly sandstone on a brick footing. New housing development, Higher Wood Farm, Stogumber.

Figure 2. Detail of Figure 1 showing the pebbly nature of some of the sandstone.

Figure 3. New wall at Kingston Court, Kingston St Mary. Modern wall with reused stone from many sources, in this case including Capton Stone, Morte Slate, Delabole Slate and grey limestone recycled from demolished buildings in Dunkeswell (information supplied by the builder).

Figure 4. Roadside wall between Totnes and Paignton.

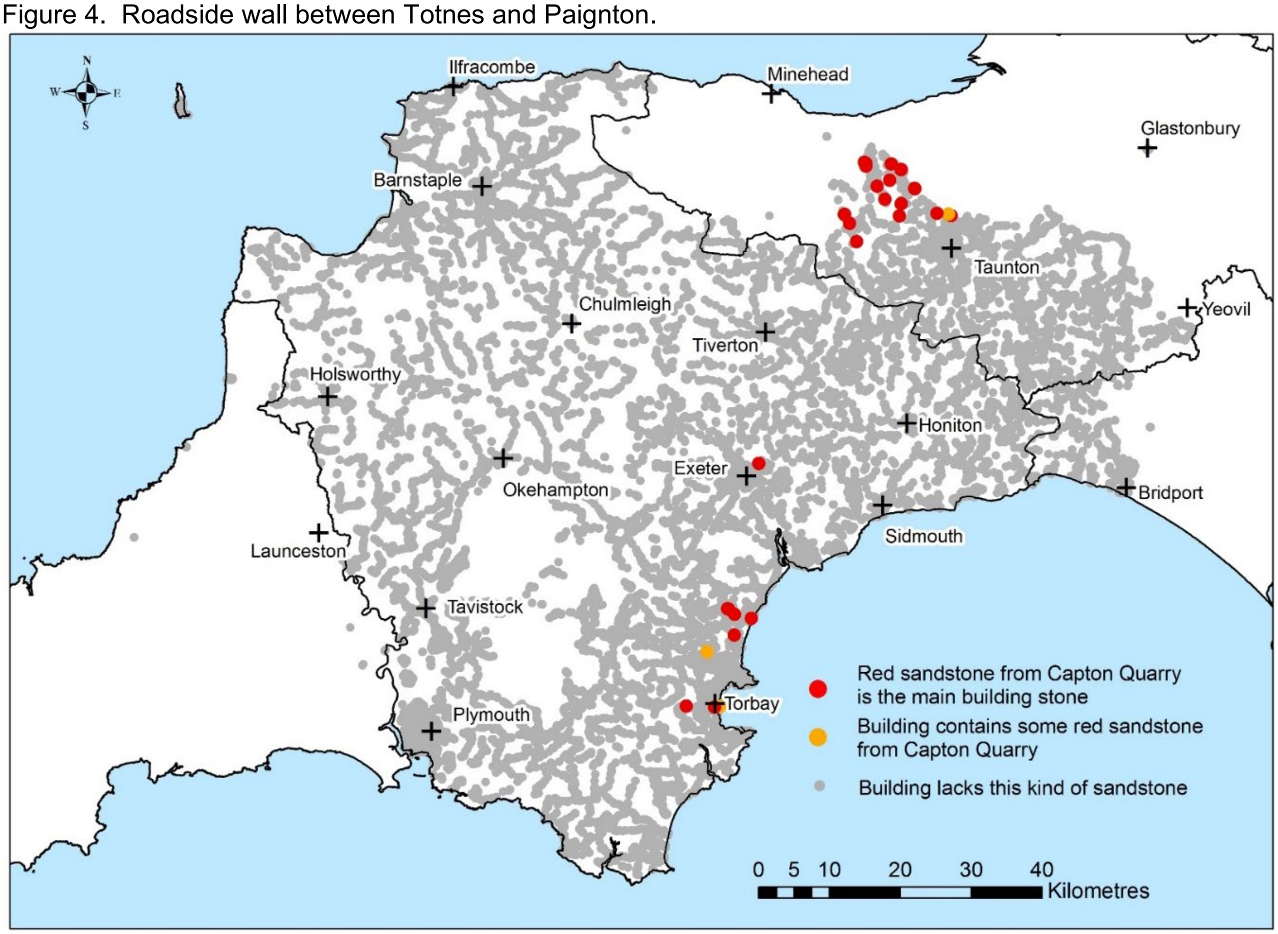

Figure 5. Distribution of buildings containing stone from Capton Quarry.

168, Limestone Breccia

This rarely used rock-type consists of jumbled angular fragments up to 2cm across, broadly equidimensional, of pale grey fine-grained limestone set in a matrix of similar material. It is linked to North Curry Sandstone by an intermediate lithology used for the quoins of St Pancras' church, West Bagborough, consisting of angular fragments of caliche set in a sandstone matrix. Its recorded distribution is restricted to the churches of West Bagborough, Crowcombe and Stogumber. Its use there may be consequent on the difficulty of finding quality dressable stone nearby. The texture of the stone resembles that illustrated in Ruffel *et al*., 2018, Figure 2. The distribution of limestone breccia of this type is shown by purple symbols on Figure 3. Its distribution lies to the northwest of the main area of North Curry Sandstone building stone, along the southwest margin of the Quantock Hills.

Reference

Ruffel, A., Benton, M., Simms, M. J., Tucker, M. E. and Wignell, P. B., 2018. Evaporite dissolution in the North Curry Sandstone Member (Dunscombe Mudstone Formation, Late Triasic Mercia Mudstone Group), Taunton Deane (Somerset), S. England. *Geoscience in South-West England*, **14,** 188-193.

Figure 1. White limestone breccia, church of the Holy Ghost, Crowcombe. The fawn stones towards the top of the photo are of Otter Sandstone. The central block of limestone looks as if it might have been dressed for a former use before being incorporated in the rubble of this wall.

Figure 2. Detail of Figure 1 showing calcite fragments.

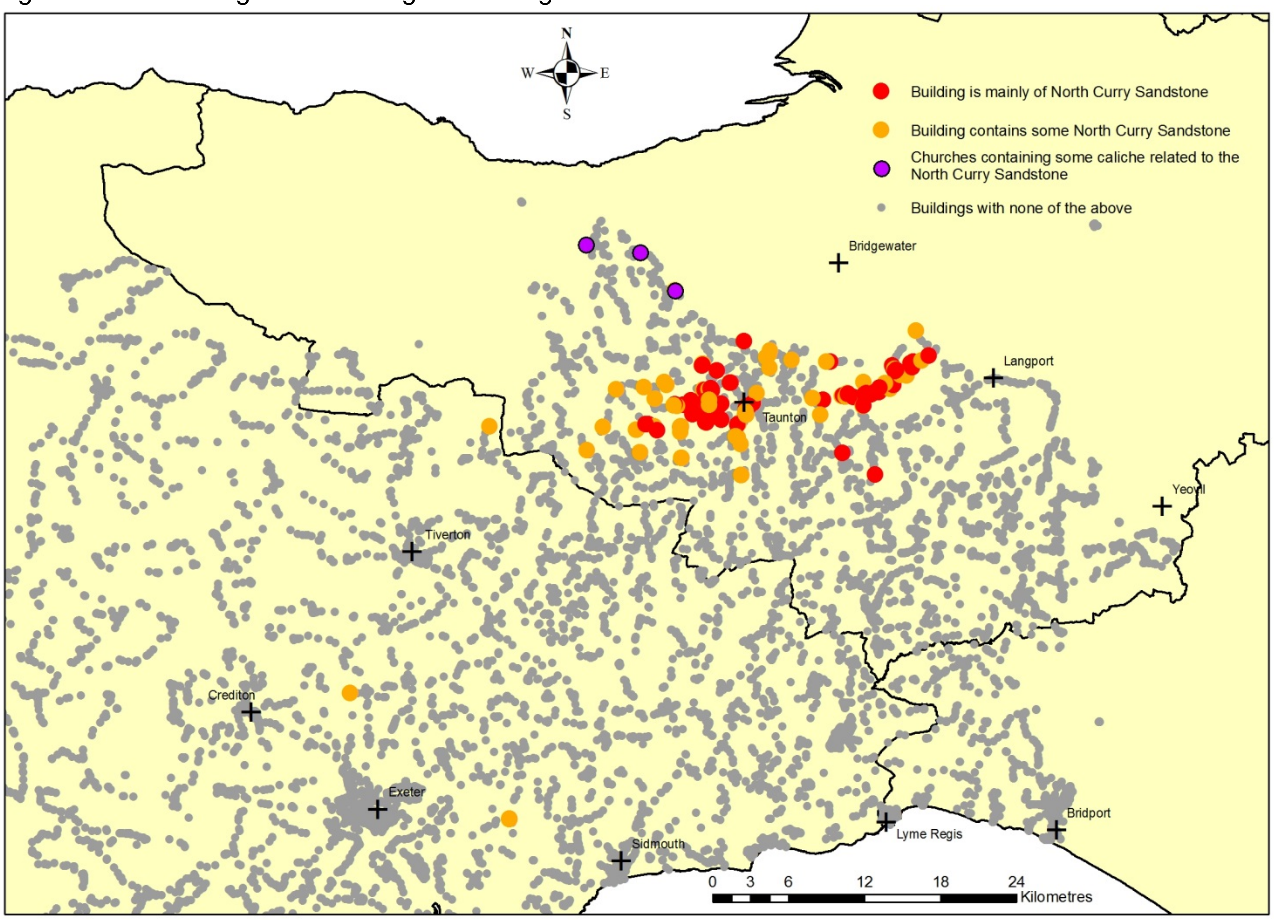

Figure 3. Distribution of North Curry Sandstone in buildings including limestone breccia variant.

Figure 4. Limestone breccia used as a subsidiary component of the walling, quoins and dressings of the tower of St Mary's, Stogumber.

169, Very coarse-grained Sandstone from the Hangman Grits

Very coarse-grained sandstone occurs in buildings close to or on the outcrop of the Hangman Grits in both North Devon and at the western edge of the Quantock Hills in Somerset. The stone is grey or dark red, in some cases partly stained red on fracture surfaces and is foliated in many cases (Figures 1 and 2). It is composed of angular quartz grains with very few other minerals and typically appears fresh on broken surfaces. A minority of the admittedly limited examples of the stone seen during the survey, contain scattered pebbles of slate (Figure 1).

Most of the examples seen are foliated or cleaved and the building blocks may be elongated in the plane of the foliation. The stone is used in the quoins and dressings of a few buildings but typically it is a minor constituent of rubble walls and is in nearly every case associated with the ordinary sandstone from the Hangman Grits coded 133. It is distinguished from other sandstone by its coarse grain size. This and an occurrence restricted to buildings on or near the outcrop of the Hangman Grits serves to distinguish this sandstone from other building stone types.

Figure 1. Grey coarse-grained sandstone, west end of Holy Trinity church, Ilfracombe. The central building block is very coarse grained and contains inclusions of slate.

Figure 2. Detail of the block in Figure 1 showing grain size and angular shape of grains.

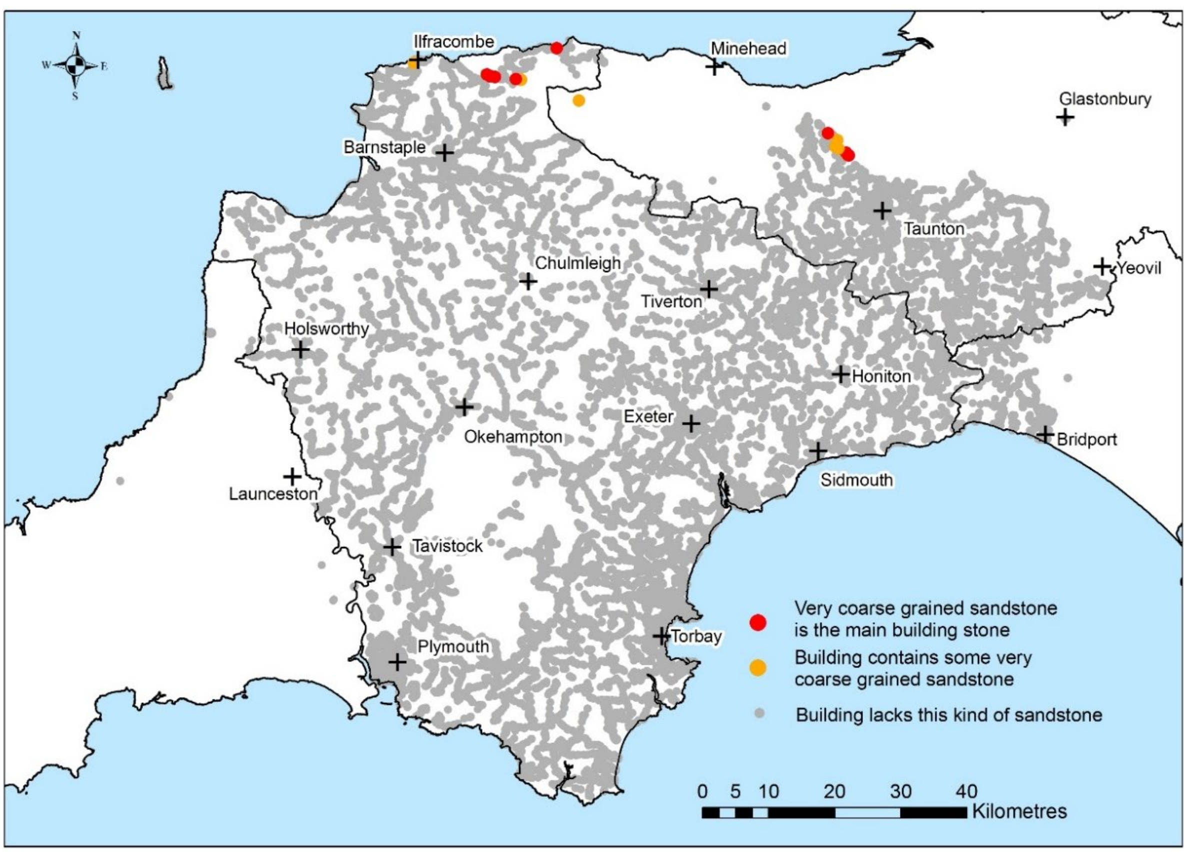

Figure 3. Distribution of very coarse-grained sandstone in buildings.

171. Slate mainly from the Crackington, Bideford, Bude and St Mellion Formations

The slate is grey, in many cases dark grey where fresh (Figures 1-3), but typically weathers to shades of brown, grey, buff and ochre (Figures 4-6). Sooty black slate, probably culm from the Bude Formation, is used in a few buildings (Figure 7). The slate is predominantly semi-pelitic and psammitic (Figure 8), composed so far as one can see in hand specimen, of quartz and clay minerals. The slatey cleavage is moderately well expressed but is dependent to some extent on the nature of weathering and presentation and some blocks assigned this code are described as mudstone with less well-expressed cleavage (see also Code 177). In other cases, those where the slate contains less clay, the cleavage is spaced. Sedimentary planar fabric is seldom observed but a few examples are described as colour-laminated. Part of the reason for this is that colour-laminated predominantly black mudrocks have usually been assigned to the Teign or Codden Hill Chert. Sole structures can be seen where building blocks are laid with the bedding parallel to the plane of the wall, which is rather common among this group of slates. In these cases, the visible part of the stone is of slate but the main (hidden) part is more likely to be sandstone.

The stone is generally incorporated in buildings as rubble (Figure 8), reflecting its poor quality but a significant number of walls and embankments are constructed with the cleavage vertical (Figures 10 and 11). Building blocks are typically thin across the cleavage compared to their other dimensions and are generally of moderate size. In at least half of the buildings where it occurs, it is accompanied by sandstone from the parent formation; one might conclude in these cases that inclusion of slate is fortuitous and the main target of the builders was the associated sandstone. Its use in walls about matches its use in churches, houses and outbuildings combined, reflecting once more the status of the buildings where it is mainly used and the poor quality of the slate as a building material.

Slate of this kind is widely distributed in buildings across mid Devon where the main outcrops of Crackington, Bude and Bideford Formations are concentrated. It also strays onto the outcrop of the Pilton Shale suggesting that some stone drawn from that formation has been given the code in error. It is much more common in buildings situated on the Crackington Formation than those on the Bude Formation (Figure 15). it is probable that Bude sandstone is sufficiently abundant and of good enough quality to make the wide use of the interbedded slate unnecessary on the Bude Formation outcrop.

The slate is characteristic of the valleys of the Alphin and Lilley Brooks between Exeter and Tedburn St Mary, extending west to Okehampton and beyond, north of the Dartmoor granite and of the Ashton Shale member of the Crackington Formation in its type area, perhaps because of the lack of better building material in these areas. It is otherwise sparingly used in and around Exeter. It is also widely used on the north crop of the Crackington Formation around and along strike from the Ansteys, but here the slate may also be derived from the Pilton Mudstone Formation.

The definition was extended in April 2012 to take in grey and black slates widely used for building in Buckfastleigh and Ashburton, and the areas to both north and south of these towns. In these areas, in contrast to the main areas, the slate is seldom associated with siltstone or sandstone. It is typically black or dark grey and varies from well cleaved to mudstone with poorly expressed cleavage. In these areas, its typical associates include hornfels, schorl, Dartmoor granite, microgranite and aplite. The first two of these are also black or dark grey and the slate is mainly distinguished by its cleavage.

Black slate in the South Brent-Ivybridge area was originally assigned Code 171 but it became apparent that this was an error. The geological map shows a passage from Middle Devonian slates into Lower Carboniferous rocks west of Ivybridge without any of the intervening black slates and cherts that represent this interval elsewhere and crop out widely around the margin of the Dartmoor Granite. Moreover, the black slate in the buildings of the area is in most cases accompanied by chert from the Teign Chert Formation. Black slate believed to be derived from the stratigraphic interval at and close to the Teign Chert is coded as 128 elsewhere. Consequently, the black slate here has been reassigned to Code 128 where the notes contain enough information to justify it.

Nevertheless, it is likely that slate assigned code 171 is drawn from several formations ranging in age from Upper Devonian to Namurian (Bashkirian) and may also include black slate parts of the Teign Chert Formation. In an attempt to map the distribution of these dark slatey building stones in a consistent manner and lacking any very distinctive features that could be used to distinguish them stratigraphically, the following rules have been used.

1. Black slate with a splintery texture associated with banded chert has been assigned to the Teign Chert Formation;
2. Well cleaved black slate associated with chert in buildings is assigned Code 128 (qv).
3. Grey slate associated with Middle and Upper Devonian limestone has been assigned to the Nordon Formation and retains its original code of 59. These slates tend to be less dark than those assigned Code 171 but because of the effect of weathering on the colour of exposed slate, this is not a very reliable discriminator.
4. Grey, buff and fawn slates of the Totnes area have also been assigned Code 59. They extend from Totnes through Ashprington and Cornworthy as far as East Cornworthy and towards Harberton and Harbertonford. These slates could be given their own code but in September 2013, an attempt to make this distinction was abandoned because of poor discrimination from other slates coded 59.
5. The balance of dark grey slates especially those on or near the outcrop of the Crackington, Bude and Bideford Formations retain the Code 171. This includes slate associated with sandstone used in the Cotehele area of east Cornwall and mapped as part of the St Mellion Formation.

Slate coded 171 is distinguished from slate from the Pilton Mudstone Formation by its association with sandstone thought to belong to the Crackington and Bude Formations; in most occurrences, there is little about the lithology of the slate itself that would allow a confident distinction to be made. It is distinguished from slate coded 128 and mudstone coded 177 by less dark pigmentation and less pelitic composition.

The Crackington Formation was examined in its type area at Crackington Haven in 2011 and 2013, the latter with Richard Scrivener and the Devonshire Association Geology Section. Figure 12 provides a general view of the outcrop on the north side of the haven. Dark grey and black slate greatly predominates over sandstone here, but sandstone is more prominent at other localities. The photo also shows the complex structure in the cliff on the north side of the bay with rapid changes in the attitude of the bedding caused by thrusting. Figure 13 shows details of the rock types. Bands of sandstone representing turbidite deposits with sharp bases against the underlying slate show load, groove and prod casts and tops marked by interlayered sandstone and slate. Figure 14 shows early folding of the sandstone beds with a penetrative axial planar cleavage developed in the slate.


Figure 1. Black slate, roadside wall opposite the pub, Whiddon Down.

Figure 2. Outbuilding, Halford Manor, Taw Green.

Figure 3. Station Road near Pinhoe Station, Exeter. The coping is of Mid-Devonian limestone a few blocks of which accompany the slate in the main part of the wall.

Figure 4. Slate and associated Bude Formation sandstone laid mainly with cleavage parallel to the plane of the wall showing a range of colours. Wall north side of road 1.5km southeast of Burrington.


Figure 5. Dark grey slate with ochre weathered surfaces. Bus shelter, Whiddon Down.

Figure 6. Dark grey and brown-weathered well cleaved slate, Roborough Lane, Ashburton.


Figure 7. Sooty black slate. Wall just inside the lane leading to St Paul's church, Fremington.

Figure 8. Wall at field gate near Hatherleigh, regularly cleaved grey slate.

Figure 9. Bears Lake Inn, Sourton. The walls, quoins and dressings are a mixture of slate and granite.

Figure 10. Roadside wall, east end of West Street, Bishop's Nympton.


Figure 11. Gammaton Road, East-the-Water, Bideford.

Figure 12. General view of the Crackington Formation in its type area, Crackington Haven.

Figure 13. Detail of the Crackington lithologies at Crackington Haven.

Figure 14. Development of penetrative cleavage in the slate, axial planar to early folding, Crackington Haven.

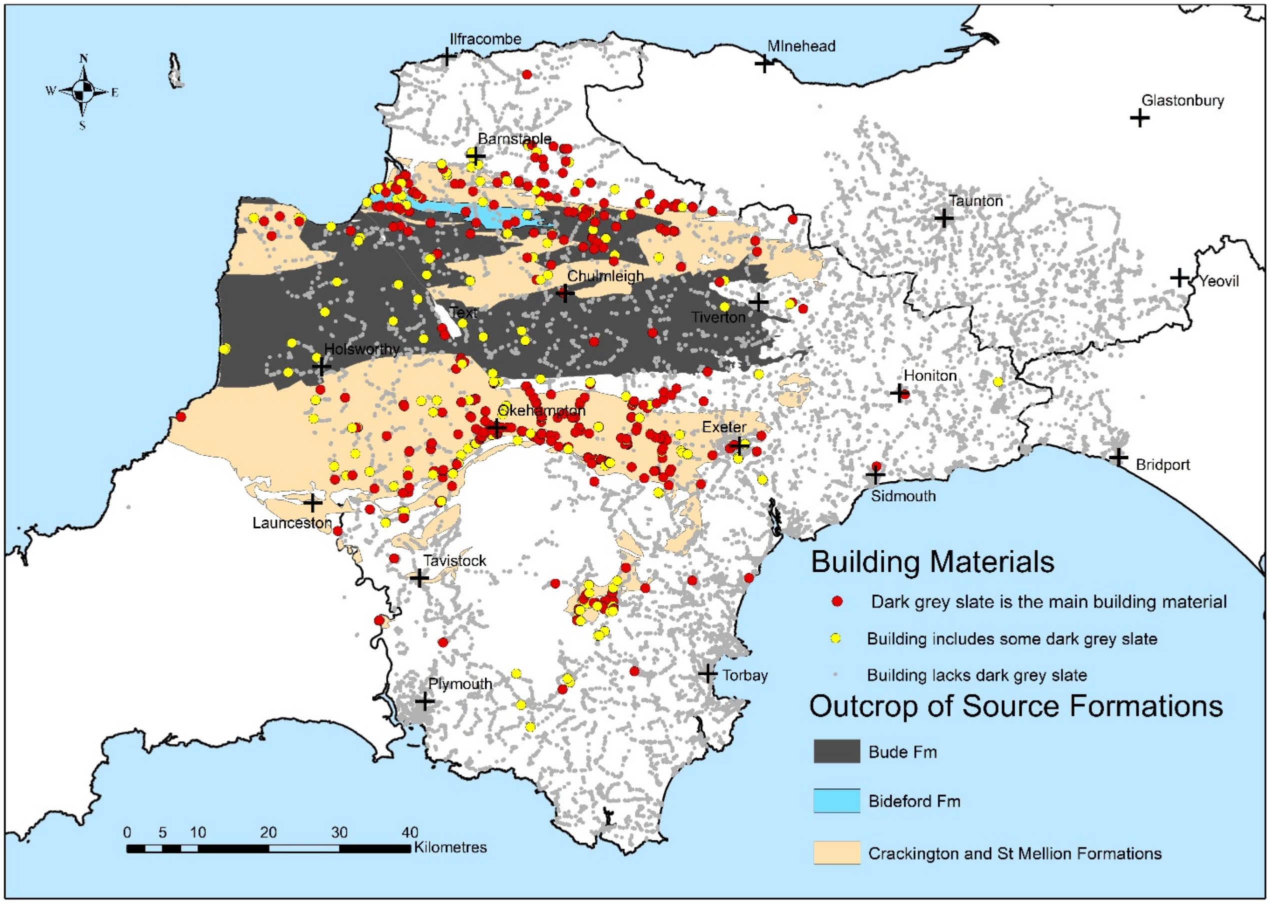

Figure 15. Distribution of slate from the Crackington, Bude, Bideford and St. Mellion Formations.

172, Sandstone mainly from the Bude Formation

The sandstone is typically grey and medium-grained with poorly developed bedding and crude fracture cleavage. The body colour is predominantly described as medium-grey, grey-green or olive-green but some of the stone is brown, olive-brown, purple or variegated (Figures 1, 8, 22). A large minority of examples extending from the Crediton Trough north as far as Rackenford are part maroon in colour, providing a link with the sandstones coded 119 (Figure 1) and a significant number of buildings are made of sandstone so dark as almost to merit its own Material Code (Figure 21).

The clastic grains are of quartz, feldspar and lithic fragments and some of the stone could be described as greywacké; some is micaceous. It is not always possible to resolve the clastic grains because of surface weathering, but where it is possible, the sandstone is typically medium-grained and although the texture is compact, individual grains can be resolved under the hand lens in many cases (Figure 13). Clastic grains tend to be subrounded to subangular. However, the code covers sandstones with a range of grain sizes from coarse- to fine-grained. The nature of the cement is seldom evident in hand specimen but is assumed to include some recrystallised quartz and other fine-grained minerals.

The rock is hard and robust but edges and corners tend to be more rounded than sandstone from the Crackington Formation (Figure 14) and some blocks show incipient onion-skin weathering or liesegang rings (Figure 15). Surfaces may show a hackly to irregular finish (Figure 16) or for homogeneous blocks, be conchoidal or have a feathered finish (Figure 12). Typical building blocks range from equidimensional to slabby (Figure 17) and are usually medium-sized although both small and large blocks are included in the field descriptions (Figures 10, 17). Because of the generally poor quality of the stone, it tends to be laid as rubble (Figure 18)) but buildings with Bude sandstone laid in courses are plentiful where the stone is of better quality (Figure 19). Blocks tend to be homogeneous and lack cleavage or foliation but there are many exceptions and cleaved, bedded and laminated sandstone is described at several localities (eg Figure 20). Blocks laid with bedding parallel to the plane of the wall exhibit load casts on the bedding planes in a significant number of cases (eg Figure 11).

Surface weathering shows the full range of colours (Figures 2-5). Distinctive boot-brown or leather-coloured fracture surfaces (Figure 6) have been noticed in several locations and may indicate stone won from a single quarry or group of nearby quarries. Black surface weathering also seems to be characteristic and obscures the body colour of the fresher rock underneath (Figure 9).

It is evident from this description that the sandstone from this formation exhibits a wide range of characteristics none of which are definitive and it has to be admitted that confusion with sandstone from the Crackington Formation is very likely indeed. It has been noticed that sandstone seen on a single traverse tends to be assigned to one or the other formation and the pattern is poorly matched to the outcrop perhaps indicating a lack of objectivity in the assignments made. The more reliable criteria used to make a distinction are:

1. The colours of the fresh stone tend to be less dark than those of Crackington sandstones; the weathered colours however show a very similar range.
2. Bude sandstone is medium- rather than fine-grained, in many blocks accompanied by incipient onion skin weathering.
3. Bude sandstone has more rounded edges and corners;
4. Khaki green and khaki brown pigmentation is typical of fresher rock underneath the weathered crust.

Criterion 4 was widely used during the survey for identifying stone from the Bude Formation. Many buildings extending from the Crediton Trough as far north as Rackenford contain sandstone that partly matches the above description but is partly maroon in colour, exactly like the stone coded 119. These rocks are included in Code 172. As with code 119, it is hard to reconcile the wide extent of stone with maroon pigment extending some 20km north of the Crediton Trough with Permian weathering at the unconformity and perhaps some other explanation should be sought.

Figure 23 illustrates the distribution of buildings containing sandstone referred to the Bude Formation. There is fair correspondence with the outcrop as might be expected of a poor-quality building stone, which discourages its transport to distant building sites. There is substantial overlap with the outcrop of the

Crackington and Bideford Formations. In the former case, this likely arises from a combination of misidentification of the stone in some cases and transport of stone for building from Bude Formation quarries onto the Crackington. In the latter case, it is very likely that in general, sandstone from the Bideford Formation has not been distinguished from that from the Bude (but see sandstone codes 206 and 207).

Figure 1. North aisle of St Mary's, Down St Mary. Blocks of fresh Bude sandstone showing the range of colours typically present including maroon, which forms a link with sandstone coded 119.

Figure 2. Garden wall of The Rectory, Black Torrington. Pale greenish and khaki Bude sandstone with darker weathered surfaces. The large block with the iron pin is a piece of Hatherleigh Stone.

Figure 3. Roadside wall at entrance to Churchill Gardens, Zeal Monachorum. Green, maroon, black-weathered medium-grained sandstone with orange, ochre and brown-weathered surfaces, closely resembling sandstone from the Crackington Formation (qv).

Figure 4. Village hall (formerly the school) and church of St Peter, Rose Ash, all of Bude sandstone showing typical weathered appearance.

Figure 5. Post Office and Stores, and Long Hall adjacent, Black Torrington. Khaki sandstone with red-weathered surfaces.

Figure 6. Village centre, Sheepwash. The boot-brown weathering is characteristic.

Figure 7. Medium- to fine-grained medium-grey micaceous sandstone with rich-brown-weathered fracture surfaces; the library, Bude, Cornwall.

Figure 8. Orange-weathered grey and khaki sandstone, South Molton United Junior School. The window dressings are of Ham Hill Stone.

Figure 9. Tower of St Margaret's church, Templeton. The walls are of Bude sandstone, the quoins, unusually, of Beer Stone. The dressings round the little louvred window are of lava from the Exeter Volcanic Series.

Figure 10. Detail of the tower of St Margaret’s, Templeton showing the range of sizes and shapes of sandstone blocks.

Figure 11. Load casts on the base of a small block of sandstone, St Margaret's, Templeton

Figure 12. Feathery ornamentation on the face of a homogeneous block of Bude sandstone. Patterns like this are quite common in the Bude Formation where the face of the sandstone block has not followed a pre-existing line of weakness. St Margaret's church, Templeton.


Figure 13. Red-weathered khaki medium-grained sandstone. Tower of All Saints church, Bradford.


Figure 14. South porch of Holy Trinity church, Milton Damerel. Dark grey and khaki sandstone blocks with rounded corners.

Figure 15. Sandstone blocks have grey-purple cores with yellow skin showing liesegang rings. Tower of All Saints church, Monkokehampton.

Figure 16. Olive sandstone and orange-weathered sandstone blocks that have split along joints are referred to the Bude Formation. Dark grey sandstone with hackly fracture is referred to the Crackington Formation. Length of knife on top of wall, 9cm. Roadside wall, King's Nympton.


Figure 17. Range of building block shapes, tower of St Mary's church, Woolfardisworthy.


Figure 18. Bude sandstone laid without courses (rubble construction). Roadside wall opposite The Rectory, Black Torrington.

Figure 19. Quality grey sandstone laid in courses. The stone used for the dressings is mainly Doulting Stone with Ham Hill Stone used for the string courses at the base of the façade. Methodist church, South Molton.

Figure 20. Grey and khaki sandstone; some blocks are bedded, some have ochreous orange-weathered surfaces. Church of St John the Baptist, Bishops Tawton, south side of nave.

Figure 21. The Bell Inn, Chittlehampton.


Figure 22. Terrace of C19 houses, South Street, South Molton. Khaki sandstone showing typical orange- and some black-weathered surfaces.

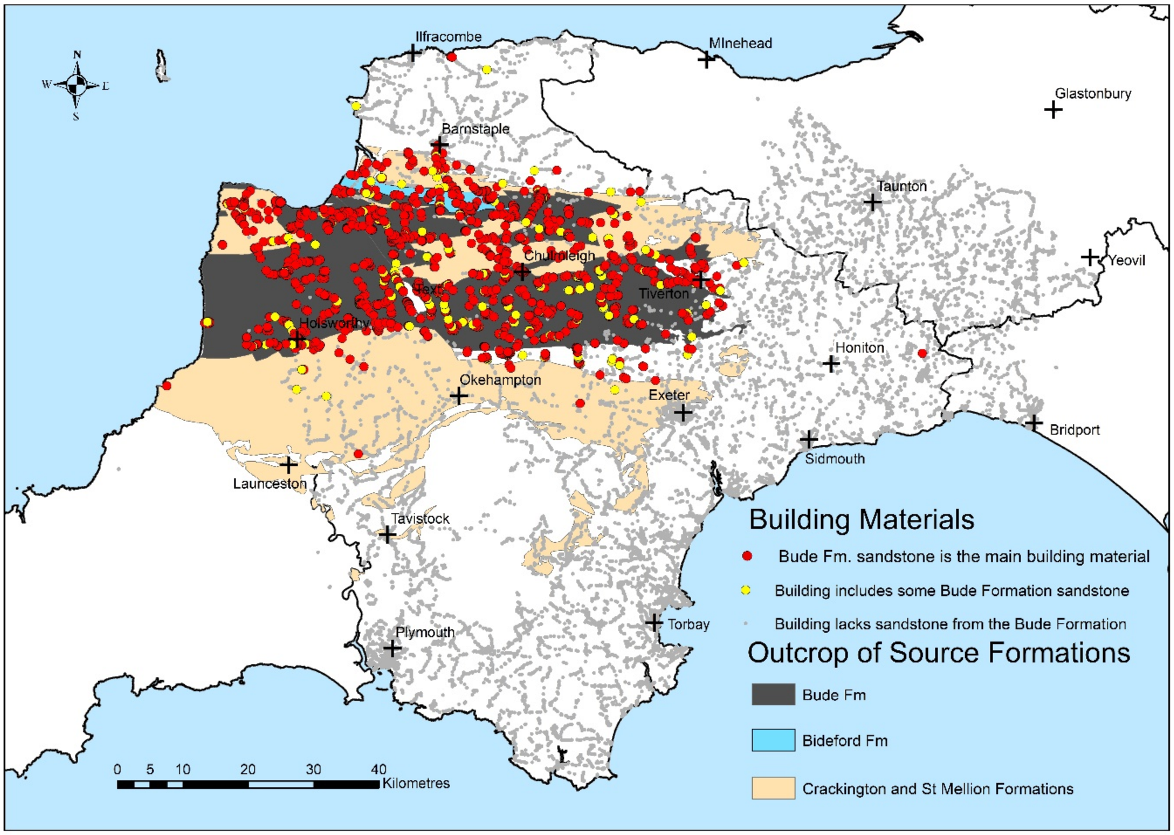

Figure 23. Distribution of Bude Formation sandstone in buildings.

176, Baggy Sandstone Formation

Confident identification of Baggy Sandstone used for building is currently limited to the western end of its outcrop area around Baggy Point, Croyde, Georgeham and Braunton. Similar stone from Molland and Twichen eastwards, especially in Brushford is less confidently referred to this formation.

The stone in its type area is a yellow or pale brown (Figure 1) medium- to coarse-grained sandstone with a sugary texture, in many cases containing mica. It forms moderately large equant blocks with rather rounded edges and corners reflecting its soft and friable nature (Figure 2). The sugary texture and rough weathering (Figure 4) and a clear distinction between matrix and clasts, distinguishes Baggy from sandstones higher in the succession. Many blocks lack obvious bedding but bedding lamination (Figure 6) and ripple-drift cross-bedding are observed in some blocks.

Somewhat similar sandstone doubtfully identified as Baggy in Brushford and Dulverton tends to be more strongly cemented and has much darker surfaces when weathered (Figure 5). Sandstone and siltstone similar to that illustrated in Figure 6 also occur near the top of the Pilton Mudstone on the south side of Croyde Bay. An occurrence of sandstone closely resembling Baggy occurs in St. Edmond's church, Dolton (Figures 7 and 10), far from the nearest outcrops.

Figure 1. South porch of St George's church, Georgeham. The walls are made of a mixture of Baggy and Pickwell Down sandstone. The quoins and dressings are of yellow Baggy Sandstone with some artificial stone repairs. The corbels supporting the porch roof are of Ham Hill Stone.

Figure 2. Wall on south side of Baggy Point. The pale brown colour and soft outlines are typical of Baggy sandstone.

Figure 3. St Mary's church, Croyde. Walls and quoins are of Baggy Sandstone. Dressings round windows and string courses are of Bath Stone.

Figure 4. West porch of St Brannock's, Braunton. The sandstone is coarse grained and rather friable.

Figure 5. Parapet of bridge over the River Exe at Dulverton, east side. Dark-grey-weathered sandstone. The body colour where the surface has flaked off is paler.

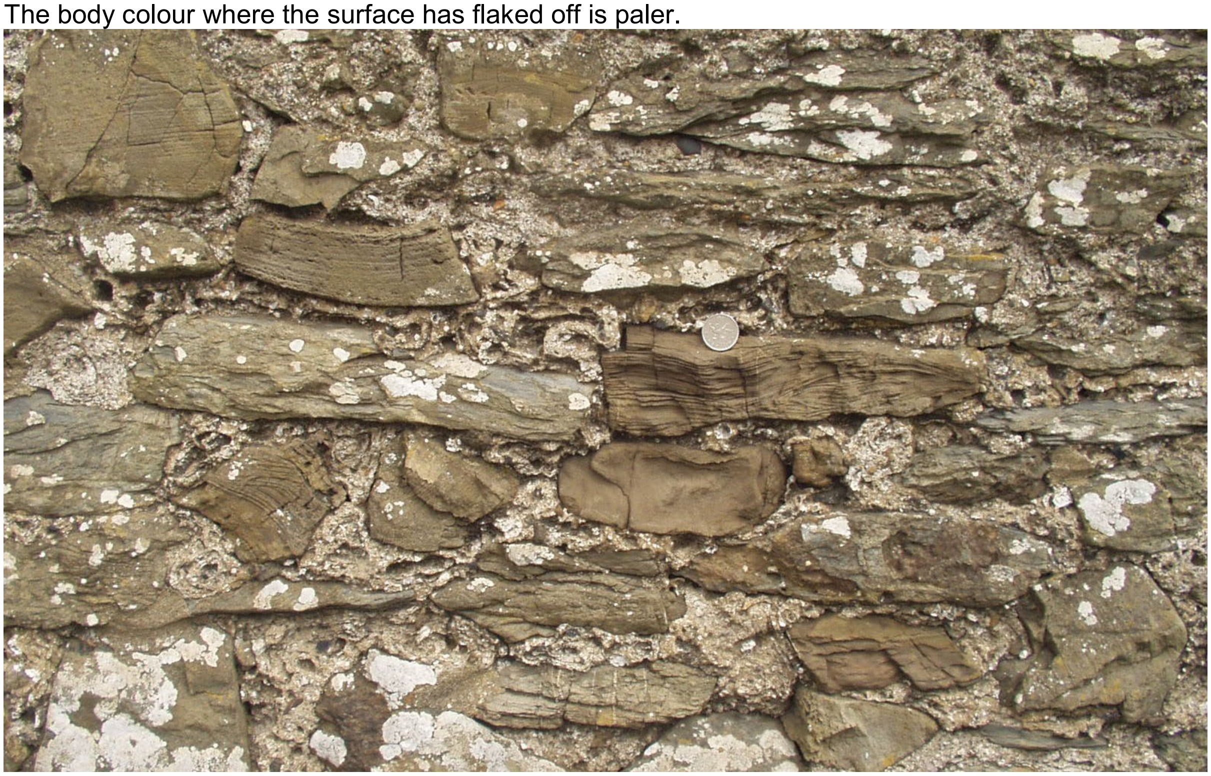

Figure 6. Thinly bedded brown sandstone, Sandleigh Tearoom and Garden, Moor Lane, Croyde

Figure 7. Fawn sandstone with faintly defined bedding. Dressings, quoins and wall of the south porch of St Edmund's, Dolton. The wall also incorporates Bude Formation sandstone.

Yellow sandstone referred to the Baggy Sandstone Formation is associated with purple sandstone from the Pickwell Down Sandstone in many buildings, including St Mary's, Barnstaple and the Methodist church in Marwoood (Figures 8 and 9). The association is so striking that one is tempted to conclude that the yellow sandstone comes from the same quarries as the strongly pigmented Pickwell Down sandstone. This is a possible explanation but in those buildings where it occurs, the attribution of the yellow sandstone to the Baggy has been maintained.

In west Devon the characteristic colour and friable nature are reasonably reliable indicators of stone from the Baggy Sandstone. Towards the east, these characteristics are absent. Stone referred to the Baggy Sandstone is weathered to dark hues and is hard to distinguish from sandstone from several other formations exposed nearby. The use of the stone is largely restricted to its outcrop (Figure 10).

Figure 8a. South side of St Mary's, Barnstaple. The walling, including the relieving arches and buttresses is made of Pickwell Down sandstone (dark colours) with subordinate yellow Baggy sandstone. The dressings are of yellow calcarenite resembling Bath Stone but lacking ooliths, tentatively identified as Caen Stone.

Figure 8b. Detail of the buttress in Figure 8a showing the mixture of purple Pickwell Down sandstone and yellow Baggy sandstone.

Figure 9. Doorway of the Methodist church, Marwood. Decorative dressings of purple Pickwell Down sandstone and yellow sandstone referred to the Baggy Sandstone Formation.

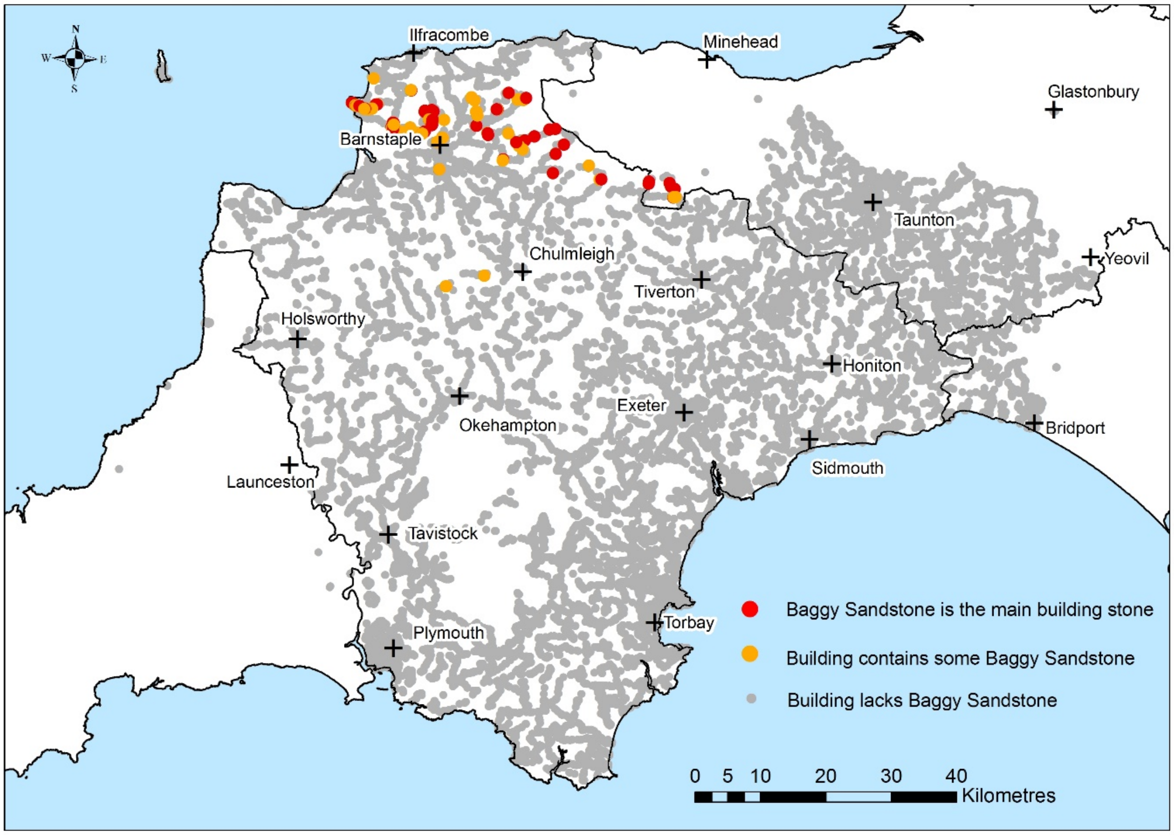

Figure 10. Distribution of Baggy Sandstone in buildings.

177, Black Mudstone (Pilton Mudstone Formation to lower part of Crackington Formation)

This code is used for poorly cleaved mudrocks of the Bampton Limestone and stratigraphically adjacent and equivalent formations including the Pilton Mudstone, the Doddiscombe Formation, the Codden Hill Chert, the Dowhills Mudstone Formation and the Ashton Shale. This building stone is also represented to the northwest of Dartmoor (see the appendix) The core characteristics of the building stone include:

(i) fine- to very fine-grained (Figure 1) so that in most cases individual clastic grains cannot be resolved with the hand lens although some building stone given this code is described as fine-grained sandstone or siltstone;

(ii) dark body colour (Figures 1, 2 and 3); most examples are described as black or blue-black;

(iii) compact texture and tough – clastic grains cannot be resolved; most examples can be scratched by a steel penknife but the rock is typically very hard and tough and may be siliceous; it is not calcareous;

(iv) sharp edges and corners; block faces tend to have a hackly fracture (Figure 2);

(v) blocky – building blocks tend to be equidimensional (Figures 2, 3 and 5) and in many cases there is a suspicion that one set of faces corresponds to bedding which is otherwise hard to see; while many examples are cleaved, the blocks tend not to split along the cleavage planes so that mudrock varieties are properly described as mudstone rather than shale or slate.

The rock-type shows a variety of weathered colours including red, purple, ochre, dull brown, and earth-coloured. Exceptionally, colour lamination and banding are visible (Figure 4); as a rule, it is difficult to relate this to bedding but this may be in part because it is hard to make out any primary characteristics which are masked by the dark colour of the rock and the obscuring effect of surface weathering and encrustations. Some examples have sole marks including load casts, visible where the stone is laid with bedding parallel to the plane of the wall, suggesting that some stone given this code is sandstone or siltstone rather than mudstone. Certainly, some examples occur well within the outcrop of the Crackington Formation and Pilton Shale and it is hard to believe that such poor-quality stone would have been brought far for the purpose of quite lowly buildings like farm walls and outbuildings. Some blocks have feathery figuring on broken surfaces, a characteristic most typical of sandstones from the Crackington Formation. There is also a suspicion, hard to confirm because of poor exposure, that some blocks may contain bands of mudstone so siliceous that they qualify as chert, and some others may contain bands of limestone.

The code was introduced because of the difficulty of identifying stone from the Bampton Limestone Formation where bands of chert or limestone could not be proved because of poor exposure but the stone otherwise resembled rock from that formation. The core characteristics listed above correspond well with mudrocks from the Bampton Limestone Formation and from the Codden Hill Chert but also from the Dowhills Mudstone Formation. Buildings that include mudstone of the type described occur widely also on the outcrop of the Crackington and Pilton Shale Formations and it may well be that mudstones from these formations also are included in the code which is therefore something of a sack term covering a substantial stratigraphic interval near the Devonian-Carboniferous boundary on the north side of the North Devon synclinorium (Figure 6). The stone closely resembles black slate coded 128 (qv) and has a very similar distribution both stratigraphically and in buildings. The only significant difference is in the strength of expression of the planar fabric.

Appendix: North-west Dartmoor Fringes

The stratigraphy of this part of Devon is obscure, caused by the conflation of complex thrusting and facies change from the Tavy Basin across the Laneast High to the Culm Basin (Isaacs *et al.* 1982, Issacs, 1983, Leveridge *et al.* 2006). The disposition of the various formations on the current BGS geological map is based to a significant extent on the work of Isaacs described in the above papers with a further important input concerning the age of the various formations based on the conodont stratigraphy (Stewart, 1981).

Figure 1 Appendix sets out lithological characteristics of the formations described in Isaac, 1983 that might have been useful in identifying the unit from which a particular building stone was won. However, there are very few characteristics of value in this respect; black or dark grey slates and mudstones are common to nearly all the stratigraphic units as are intervals containing chert or cherty mudstone. Volcanic rocks are present in at least three units and carbonate rocks in four. The available descriptions in Isaac (1983) and the BGS lexicon lack enough detail to allow confident assignment of a stone to a particular formation. The references in the lexicon are unhelpful in many cases and just refer to the BGS map sheet on which the formation was mapped, usually No. 338, Tavistock. In contrast to rock-types observed in outcrop, building stones lack the field relationships that assist the geologist in arriving at a consistent set of stratigraphic units, and so it has not been possible to identify with any certainty the source formations from which building stone was drawn in this region. For these reasons, the threefold division of building-stone types that have served reasonably well further east is mainly retained here rather than attempting a more detailed correlation with likely source formations. The scheme largely ignores the thrust systematics in the naming of formations and plays down the influence of depositional environment, concentrating instead on lithology as follows:

Youngest – flyssh. Crackington, Bealsmill, St Mellion Formations and Meldon Shale and Quartzite (part). Building stones thought to come from these formations are coded 152 (sandstone) or 171 (slate);

Middling – black slate interval. Newton and Teign Chert, Meldon Chert, Brendon Formation, Crackington, Lyford, Liddaton and Whitelady Formations, Burraton and Yealmbridge Formations. These are coded as 171 if likely to be part of the Crackington Formation, 146 if cherty or strongly laminated, 177 if poorly cleaved and called mudstone rather than slate in the database descriptions and 128 if black slate not cherty or laminated. Brown and pale grey lustrous slates seen in Lewtrenchard on the outcrop of the Teign Chert are tentatively assigned to the Yealmbridge Formation and do not fit in this scheme; they are coded 193. This merely reflects lithological similarity with pale brown lustrous slate with this code used for building close to Start Point in the South Hams and in no way implies any stratigraphic correspondence.

Oldest. Tavy Formation and those slates mapped as Middle and Upper Devonian slates, coded 59.

The difference between slate coded 59 and the overlying units here as further east, is the coming in of significant intervals of black slate. It is accepted that the difference is not all stratigraphic and there is some interdigitation of green/grey and dark grey/black slate and anyway, it is not always easy to tell the colour of stone when it is in a building. Note also that code 171 falls in both middling and upper subdivisions. If a building in this region also contains sandstone, then the slate will be mapped as Code 171 unless there is overwhelming other evidence that it should not be.

In reality of course, further confusion is caused by stone imported from far away.

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	A	B	C	D	E	F	G
1		**Slate**	**Sandstone**	**Chert**	**Volcanics**	**Carbonate**	**Age from BGS Lexicon**
2	Liddaton Formation	Dark grey, phyllitic, banded grey; greenish grey slate with siltstone and sandstone laminae	<10cm. With some thicker beds, graded, load casts, ripple drift cross bedding	Black slate , siliceous nodules			Famennian
3	Whitelady Formation	Pale, greenish, calcareous	Thin quartzite			Dolomitic, siliceous, well bedded, nodular; anastomosing clay lamellae	Famennian
4	South Brentor Formation	Black, micaceous, pale greenish	Siltstone <30cm			Nodular	Famennian-Tournaisian. Passes up into the Lydford Fm.
5	Lydford Formation	Black	Thin siltstone and fine-grained sandstone beds	Bedded chert as lenses intercalated with volcanics	Thin tuff; pillow lavas		Tournaisian- Visean
6	Greystone Formation (=Brendon Fm.)	Black siliceoius slates with chert; sooty black shale	Conglomerate	Black siliceous slates with chert. No chert in BGS description	Tuff, pillow lava; manganiferous; plentiful		Tournainsian
7	Fire Beacon Chert Formation (= Codden Hill Chert Formation)	Thin; black slate and mudstone		Chert		Limestone beds	Brigantian (Visean)
8	Meldon Shale and Quartzite Formation	Black slates and mudstones	Thin, clean-washed	Chert lenses		Limestone lenses	Tournaisian-Visean. Immediately underlies Codden Hill Cherts
9	Lowerton Limestone Formation	Grey, calcareous. Black				Limestone turbidites	Not in BGS lexicon
10	Brendon Formation	Black, dark grey	Thin. Includes greywacke	Mudstone locally siliceous			Visean
11	Cotehele Formation (St. Mellion Fm.)	Subordinate shale	Preponderant sandstone				Not in BGS lexicon (Tournaisean-Arnsbergian
12	Crackington Formation	Black and bluish-grey, sandy micaceous shales	<4m but typically much thinner; sedimentary structures				Arnsbergian- Langsettian (lowermost Westphalian)
13	Milton Abbot Formation				Agglomerate, tuff, pillow lavas (basic)		Visean
14	Bealsmill Formation (age equivalent of the Ashton Shale member of the Crackington Fm.)	Dark grey mudstone	Preponderant; coarse-grained, feldspathic; some conglomerate				Namurian

Figure 1 Appendix. Lithology of formations from Isaac, 1983.

Figure 1. Hard blue-grey cleaved mudstone, bridge parapet near East Anstey. Note the lens of white material to right of the coin, also seen in the Teign Chert of the Teign valley.

Figure 2. Dark grey blocky siltstone or mudstone, wall in front of Folly Cottage, Braunton.

Figure 3. Black and brown bedded mudstone, Westaway Plain, Barnstable. The blocks used for the coping appear better cleaved than those used for the main part of the wall but this may only be a consequence of their different situations in the wall.

Figure 4. Detail of Figure 3 showing colour banding in the mudstone.

Figure 5. Bus shelter, east side of A386. South of Bal Lane, Mary Tavy.

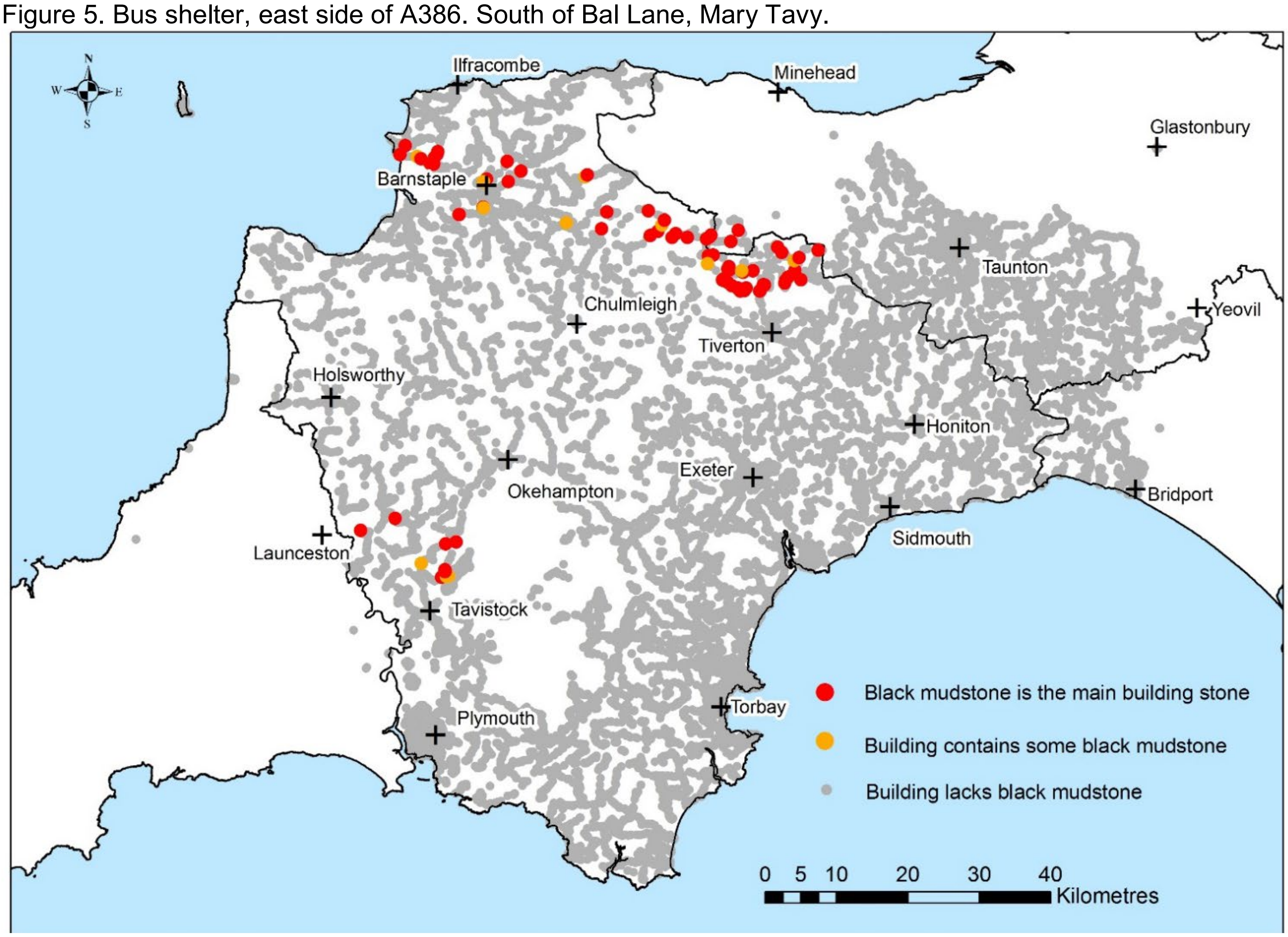

Figure 6. Distribution of black mudstone in buildings.

180, Upcott Slate

Slate believed to be extracted from the Upcott Slate Formation is characteristically coloured in shades of red, pink, green, violet and purple (Figures 1 and 2) but grey slate has also been given this code (Figure 3). It resembles stone from the Pickwell Down Sandstones Formation especially in the range of colours shown but is more slatey. It has to be admitted that it is not easy to distinguish from the latter. Where weathered, the stone tends to look just grey but like the Pickwell Down sandstone, there is a tinge of violet in some examples of the predominantly grey stone which is used to distinguish it from the many other grey slate building stones of the county (Figure 3).

It is composed mainly of phyllosilicates and quartz and may show lustrous cleavage surfaces. Slate given this code tends to be psammitic in composition (Figure 3) and some examples could alternatively be described as impure sandstone. Cleavage is well developed and tends to extend through the thickness of the building blocks (Figures 1 and 4). Colour banding parallel with the cleavage is observed in some blocks. As with most slatey building stones, the blocks tend to be elongated in the cleavage direction and are usually laid with the planar fabric more or less horizontal (Figures 1, 4 and 5).

The stone is used on or close to its outcrop (Figure 6), in all kinds of building but with some bias in favour of roadside walls, perhaps reflecting its poor quality and relatively lowly status. It is hard to differentiate from the Pickwell Down Sandstone and it must be admitted that there is likely to be confusion between the two.

Figure 1. Grey, green and red slate referred to the Upcott Slate Formation. Roadside wall, Lower Pit, Mill Lane, East Buckland.

Figure 2. Modern wall outside Chiltons House, East Anstey Common showing the colours present in Upcott slate.


Figure 3. Blocky psammitic slate with penetrative cleavage. The colour is grey but fresh surfaces have a touch of violet in the pigment. Entrance to Lower North Radway Farm, 4km northeast of North Molton.

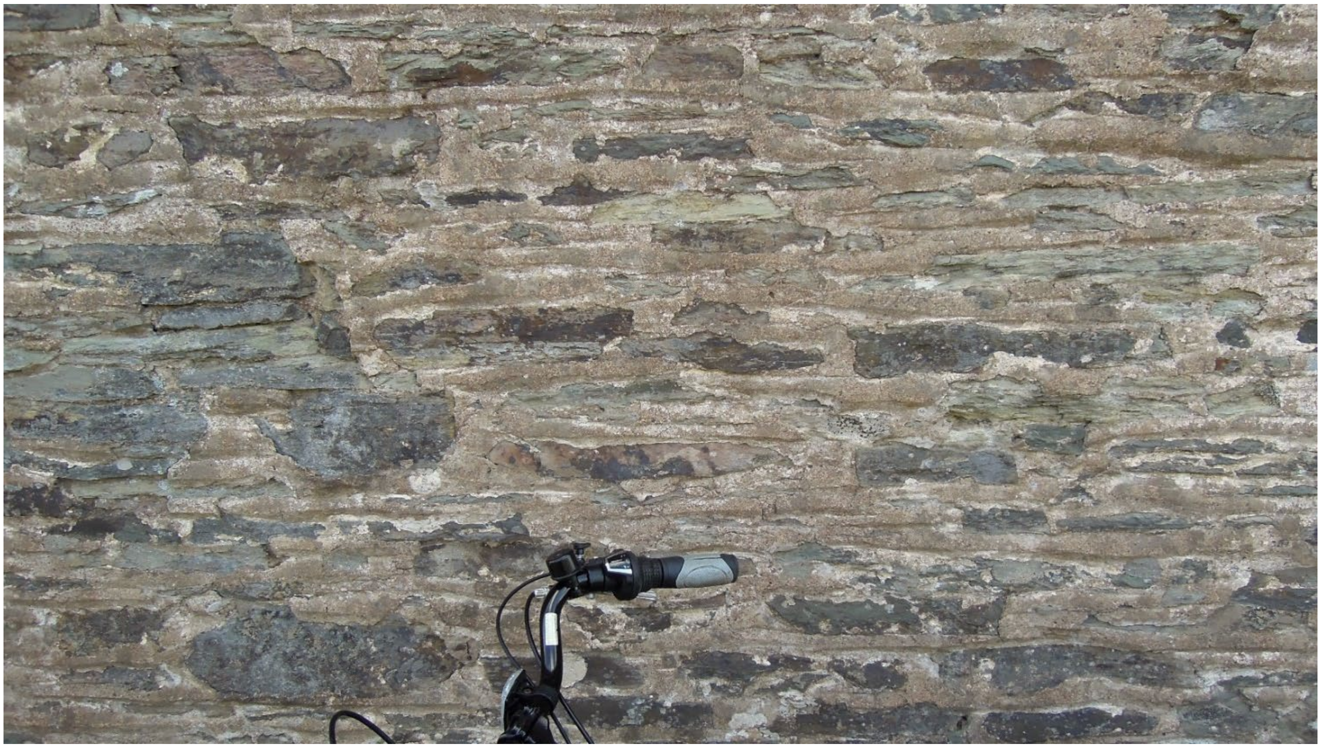

Figure 4. Slabs of Upcott slate elongated in the cleavage direction. East part of village hall, Loxhore.

Figure 5. Pink slate with strong penetrative cleavage. South porch of St Mary's church, Molland.

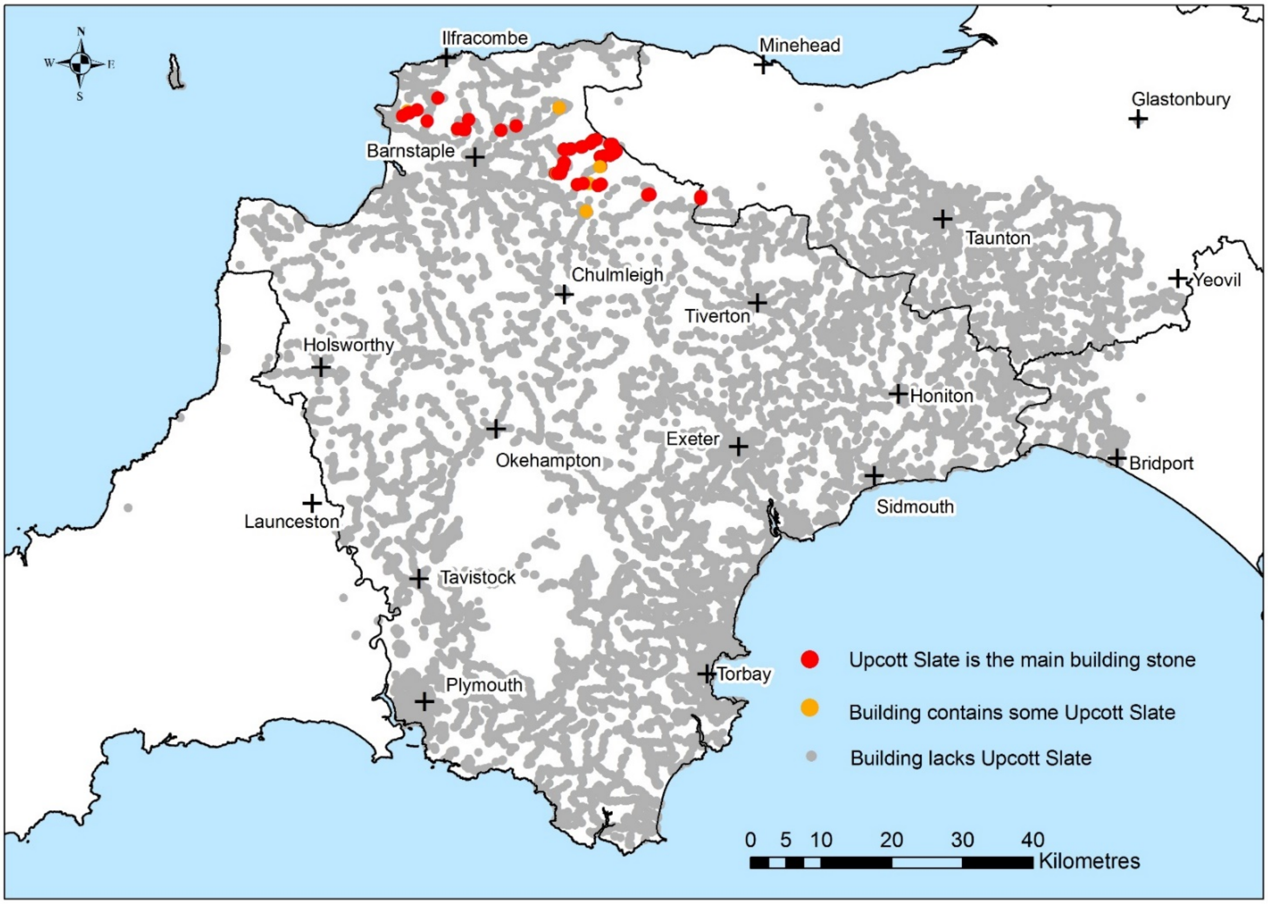

Figure 6. Distribution of Upcott Slate in buildings.

181, Imported Gneiss and Granite

This is a small disparate group of building stones, likely imported from different sources and restricted to coastal buildings. Many of the occurrences are in Topsham. They include muscovite granite (Figure 1) and lineated muscovite orthogneiss associated with gabbro (Figure 2). The beach armour at Beesands includes biotite- and leucocratic quartzo-feldspathic gneiss and basic agmatite. The single occurrence seen in Plymouth forms large boulders lying in the playground of Tor Bridge Primary School, of hornblende-epidote tonalite accompanied by hornblende gabbro and dolerite. Looking at the range of lithologies, some of these rock-types may come from The Lizard. The Topsham occurrences are completely foreign. Perhaps they originated as ballast for ships plying the wool trade with the Low Countries.

Attention is also drawn to granite used as beach armour in various places around the coast, coded 32.

Figure 1. Muscovite granite block in the wall of a house backing onto Hannaford's Quay, Topsham. The stone resembles granite from Lundy Island (Code 32, qv.).


Figure 2. Wall south side of Monmouth Hill, Topsham, composed of a mixture of foliated granite and gabbro.

182, Hanging Slate

Buildings where the walls are finished in slates hung vertically are widespread in Devon but with a concentration in the south and west; they are sparsely distributed in East Devon and adjacent parts of Dorset and Somerset (Figure 1). Hanging slate may be used in any part of buildings but there is a tendency for south and west walls to be finished in this way probably because these walls are the most exposed to rain driven by the prevailing wind. Buildings only partly covered in hanging slate cladding are in the great majority (Figure 2). A common arrangement is for the upper story to be slate-hung with the lower part of the building finished in some other covering including bare stonework (Figure 2). The sides of dormers, the areas beneath the sills of upstairs windows and the upper parts of gable ends are also preferred sites (Figures 3 and 4). Hanging slate is an important component of the visible parts of prestige buildings with a decorative finish (Figures 2, 5 and 6). A relatively small proportion of houses appear to be completely clad in hanging slate (Figure 7).

In most cases the source of the slate is not known but in some, the mottled surface finish, parts with a smooth shiny appearance and parts matt, indicates that they were won from Delabole Quarry. Some of the Devon quarries producing slate are listed in Hughes (undated). Hanging slate is a feature overwhelmingly of houses; of the 272 buildings where hanging slate was recorded during the survey, 231 are houses, 21 are churches and only 10 are outbuildings.

Reference

Hughes, T., undated. Slating in south west England. *Society for the Protection of Ancient England, Regional Advice Note 2.*

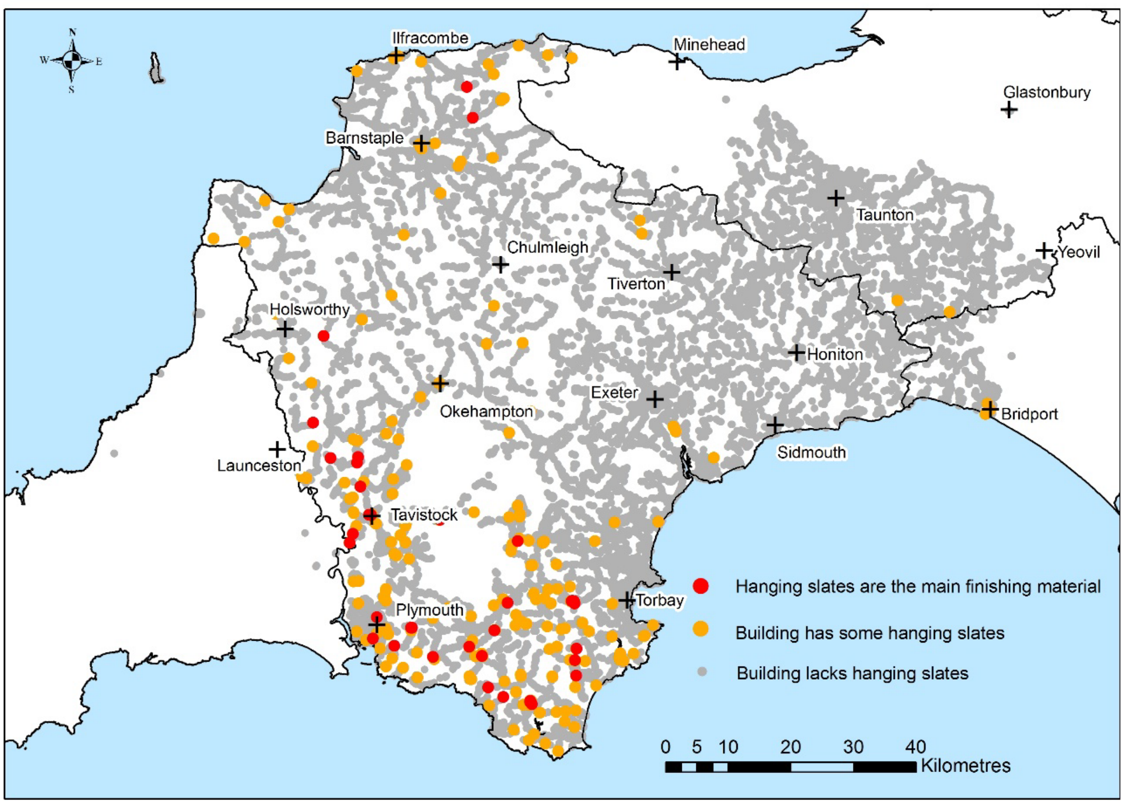

Figure 1. Distribution of hanging slate in buildings

Figure 2. 31 East Street, Ashburton. Upper floors finished in decorative hanging slate, ground floor of granite, limestone and slate.

Figure 3. Meavy parish hall. The sides of the dormers are finished in slate. The main stone is spotted contact metamorphosed slate (Code 157). The dressings include Dartmoor granite.

Figure 4. Holne Park House, Ashburton. Hanging slate is used between the upper storey dormers. The main building material is brick.

Figure 5. Decorative hanging slate, Fore Street, Kingsbridge.

Figure 6. York House, Dartmouth. Decorative hanging slate cladding between the timber framing.

Figure 7. House at the junction of Stanborough and Church Roads, Plympton. All visible walls of the main part of the house appear to be finished in hanging slate.

184, Limestone from the Bovisand Formation

This code represents impure limestone from the Bovisand Formation. The stone occurs mainly in the vicinity of Ermington and Modbury with one further occurrence to the east in the church at Blackawton (Figure 4). The typical lithology is impure limestone composed of grey, white or purplish translucent calcite interlaminated with brown-weathered silicate minerals which tend to stand proud of the surface of the building stone. The blocks tend to be small and thin, and the calcite may make up only a small proportion of the rock (Figure 1). Some examples are very strongly cleaved (Figure 2). Better quality limestone is used for decorative effect in the wall of the south chapel of St George's, Modbury (Figure 3).

In most cases the stone occurs in buildings associated with slate and foliated sandstone from the Bovisand Formation (Code 159, qv). The majority of occurrences documented during the survey are in churches which tend to be examined more thoroughly than other kinds of building. Because the stone is not obviously different from the associated slate and can easily be overlooked in a cursory examination, it may be more widespread than indicated in other kinds of building.

The limestone is distinguished from carbonate rocks from other formations by its association with slate and sandstone of the Bovisand Formation, the usually small size of the blocks, the presence of silicate minerals in laminae and lenses, the occurrence here and there of purplish limestone and its poor quality from the point of view of building.

Figure 1. Impure limestone and slate. Spire of St George's church, Modbury.

Figure 2. Strongly cleaved impure limestone or calcareous slate. The carbonate mineral is barely identifiable as narrow selvages between the silicate laminae. South porch of St George's church, Modbury.

Figure 3. East wall of south chapel, St George’s church Modbury. The notebook is lying on a course of granite at the top of the plinth. Then comes a course of slate, followed upwards by one of impure laminated limestone, followed by slate, followed by a thicker course of somewhat purer purplish limestone and so on to the top of the wall. The alternating courses pass round the quoins/buttresses without a break.

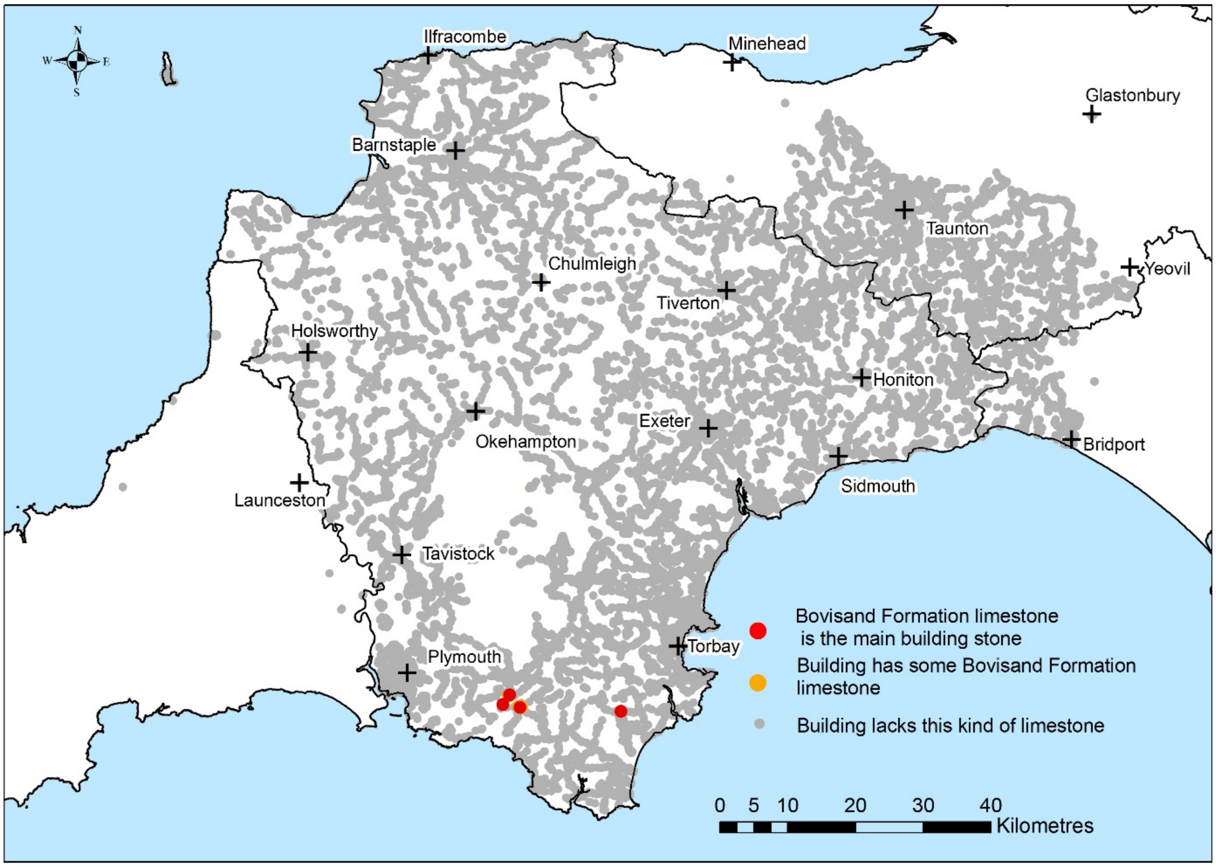

Figure 4. Distribution in buildings of limestone from the Bovisand Formation.

185, Dartmouth Group

Building stone from the Dartmouth Group consists of grey, green, pink and purple slate, normally either semi-pelitic or psammitic in composition (Figures 1 and 2). The more psammitic varieties are probably the equivalent of the siltstone and sandstone included in the description of the group in the BGS lexicon (2018) and the BGS memoir (Ussher, 1912). The slate includes grey, red, pink, purple and green varieties and is moderately to well cleaved depending on the composition (Figures 1, 3, 4 and 5); the cleavage tends to be regular, planar and penetrative but may appear in a minority of buildings somewhat spaced, with unfoliated rock between the cleavage planes (Figures 1 and 7). Some stone is described as silvery or phyllitic, reflecting the fact that cleavage planes are in some cases coated with fine mica. Red and green colour-mottling and green reduction spots in predominantly red slate are quite common. However, the predominant colour of the Dartmouth slates used for buildings is grey with the usual range of weathered colours – buff, fawn, dull, red and black, orange, brown and "stone" with grey being the most commonly encountered (Figure 3). The slate is composed of quartz and white mica with no doubt lesser proportions of other minerals not identified. Bedding is seldom obvious in building blocks but the more pelitic varieties may include lozenges of more psammitic slate and narrow siltstone and sandstone bands may define parallel colour lamination or cross bedding.

Building blocks are moderately large for slate and range in shape from the proportions of house bricks to blocks that are thin across the cleavage compared to the other dimensions (Figures 1, 2 and 8). Compared to other slate building stone in Devon, Dartmouth slate is seldom laid with the cleavage vertical.

Slate from the Dartmouth Group is distinguished from that of the Staddon Formation by the association of the latter with sandstone in buildings. During the course of the survey it was distinguished from the Meadfoot Group in general and slates from the Bovisand Formation in particular by the presence of stone with red pigmentation This criterion was reviewed during and after the survey and significant changes were made. There is confusion between these building stone groups if the criterion is applied blindly. It arises from:

(i) Slate from the Dartmouth Group is not all red; the intermittent nature of the red pigmentation means that individual building blocks and indeed, all the stone used for an entire building may lack any red slate;
(ii) stone from the Bovisand Formation also contains red slate. This has caused some uncertainty in the original mapping of the boundary between the Bovisand Formation and Dartmouth Group over much of the South Hams, especially in the western part (eg Ussher, 1912, p17). While the geological map has since been revised, the revision is not accompanied by a corresponding memoir. There is therefore no easily accessible record of the basis on which the boundary between Dartmouth and Bovisand has been redrawn.
(iii) because of surface weathering, it is not always easy to distinguish between red pigment that is an original property of the building stone and that of secondary origin, causing more uncertainty in the correct assignment to the source formation.

These difficulties were recognised at the time of the survey and extra fields were added to the input database form to store additional information about slate building stone. The extra information and the way it was used is set out in the appendix.

References

BGS Lexicon of Named Rock Units, 2018. http://www.bgs.ac.uk/lexicon/, last accessed March 2018.
Ussher, W.A.E., 1912. The geology of the country around Ivybridge and Modbury. *Memoir of the Geological Survey of England and Wales*, **349.** HMSO, London.

Figure 1. Outbuilding, Rock Lane, Aveton Gifford. Red and green slate. Brick-shaped blocks (bottom of photo) are of psammitic slate or cleaved micaceous sandstone; Semi-pelitic blocks towards the top are more strongly cleaved and thinner.

Figure 2. Old School House, Fore Street, Aveton Gifford. Grey and fawn brick-sized blocks of cleaved micaceous sandstone.

Figure 3. Typical grey colour of weathered Dartmouth slate but the red pigmentation of the fresh rock is revealed where the stonework is cleaned by acid rainwater draining from the metal glazing bars of the east window. The buttresses and dressings are of Polyphant Stone. Church of St Lawrence, Bigbury.

Figure 4. Red and pale grey semi-pelitic slate, Carehouse Cross, Stokenham.

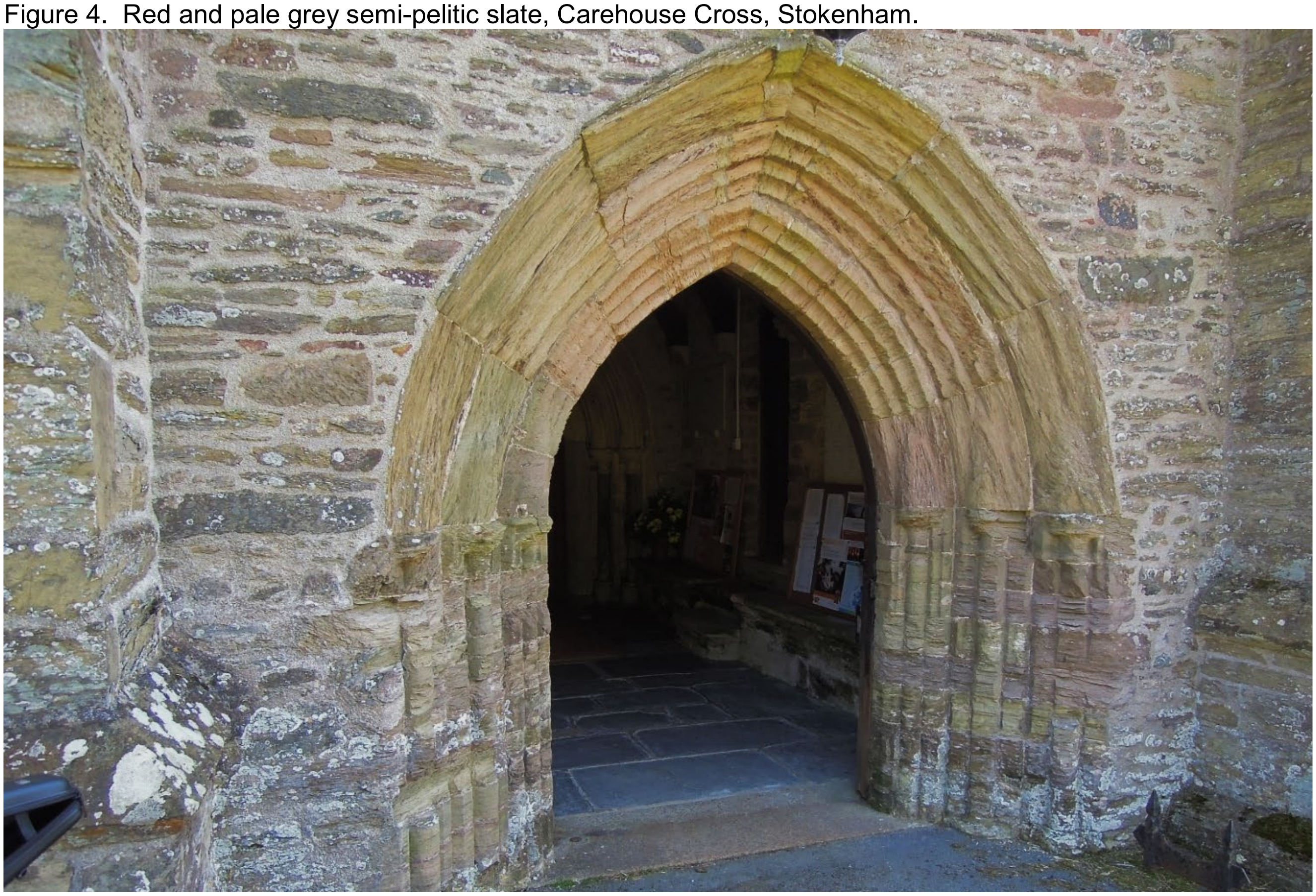
Figure 5. North porch of St Andrew's, Aveton Gifford. Dressings are of fawn, red and purple slate from the Dartmouth Group; walling shows the range of colour, size and shape of stone from the Dartmouth Group.

Figure 6, Coping of roadside wall, Poole, 663m north of Slapton church. The slate shows red mottling and spaced cleavage.

Figure 7. Green and red slate showing spaced cleavage. Wall at road junction (GR 267676, 43136), Thurlestone.

Figure 8. North aisle of St Lawrence' church, Bigbury showing the typical range of colour, and size and shape of building blocks from the Dartmouth Group.

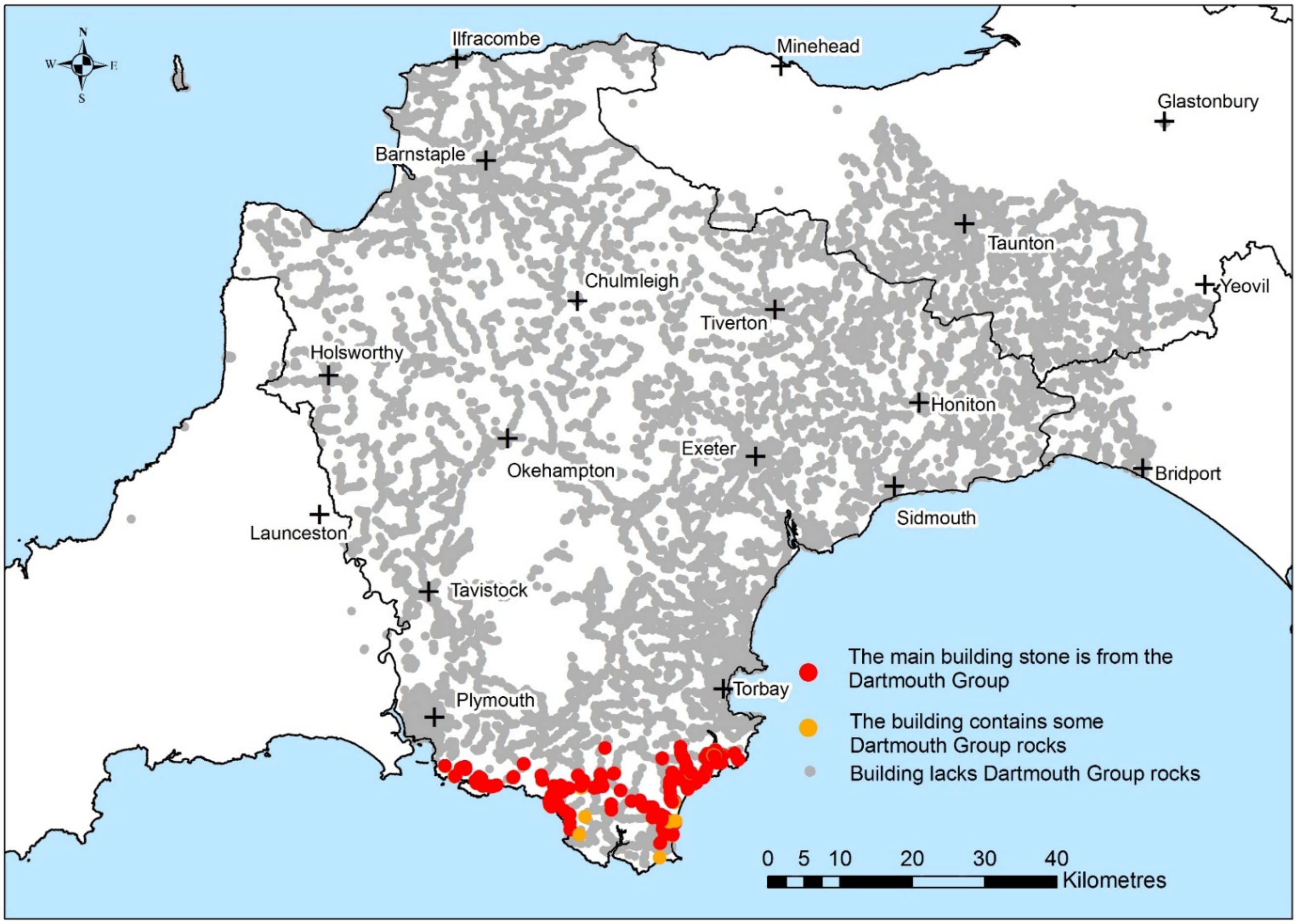

Figure 9. Distribution of Dartmouth Group rocks in buildings.

Appendix: Meadfoot and Dartmouth Group Slates

Very considerable difficulty was experienced in distinguishing between these two groups of slates. There seems to be considerable overlap of their properties. The initial solution south of the outcrop of the Staddon Grits was to map any slate that had some red pigment not thought to be due to weathering as Dartmouth and the balance as Meadfoot. The outcome was the mapping of many buildings apparently incorporating Dartmouth slate on the outcrop of the Meadfoot Group and *vice versa*. While this is of course possible, nevertheless considering the low status of some of the buildings involved, for example roadside walls, it seems unlikely that the builders of the past would have taken the trouble to carry the stone for them very far and much more likely in these cases that the stone was local. Moreover, the BGS memoir for the area includes a discussion of whether the presence of red pigment is a reliable indicator of slate from the Dartmouth Group (Ussher, 1912) and concludes that it is not. To compound matters, the pink pigmentation of the Dartmouth Group is not everywhere present; it is perfectly possible for building stone from that group to lack any red or pink slate, making this characteristic unreliable as an indication of stratigraphic origin.

The geological map for most of this area has been revised by the BGS since the days of Ussher but there is no accompanying memoir. This is unfortunate for it would be helpful to have a description of the criteria used to distinguish between these groups of slates for the purpose of geological mapping in the South Hams. The BGS lexicon stresses the quartz-rich nature of Dartmouth Group 'slates' which helps to distinguish them from adjacent formations.

In an attempt to resolve the difficulty, an analysis of the properties of the slate building stone used south of a line from Bovisand Bay in the west to Dartmouth in the east was undertaken in 2016. North of this line, slate of the Meadfoot Group is associated with sandstone in buildings (Staddon Formation) and is fairly easily distinguished from stone from the Dartmouth Group where any sandstone associated with slate contains considerable proportions of phyllosilicates and is mainly identified as psammitic slate in this study.

The criteria used for characterising the slates were developed during the course of the survey, when it became apparent that a more systematic approach was needed to distinguish between the different kinds of slate used in Devon. The initial objective was to distinguish between Middle Devonian and younger slate used for building south and west of Dartmoor with a particular emphasis on differentiation between the Kate Brook Slate and its correlatives, and slate from the Crackington Formation. This was extended to assist in distinguishing between slate from the Meadfoot Formation and that from the Dartmouth Group. The criteria (Tables 1-5) were copied from existing narrative descriptions of the stone. This explains why some of them are a bit short on intellectual rigour.

Tables 1 and 2 Colour

ID	Colour
1	Grey
2	Dark Grey
3	Black
4	Olive
6	Green
7	Red/purple
8	Silvery
9	Pale
10	Buff

Table 3 Composition

ID	Composition
1	Pelitic
2	Semipelitic
3	Psammitic

Table 4 Association

ID	Association
1	Sandstone
2	Limestone
3	Hornfels
4	Volcanics

Table 5 Cleavage

ID	Cleavage
1	Penetrative/strong
2	Spaced - fracture
3	Not very good

Table 6 Weathering

ID	Weathering
1	Red-black
2	Black
3	Buff/fawn
4	Orange
5	Dull
6	Stone
7	Ochre
8	Grey
9	Rich brown
10	Dark

Details were entered into the database through drop-down lists which allowed a choice only from the entries in these tables or a null record.

Two colour tables were created to allow both dominant and subordinate body colours to be systematically recorded. Red pigment used during the field work to identify the slate as being from the Dartmouth Group is recorded in the first colour table; red pigment described in the narrative notes was entered in the second colour table. In most occurrences red was subordinate to other colours in the fresh building stone.

The characteristics were mainly entered into the database well after the end of the fieldwork, from the details recorded in the narrative summary for each record. However, in the case of original pigmentation, a decision was made part way through the fieldwork that the presence of red slate was the most reliable indication that it came from the Dartmouth Group and thereafter, an effort was made at each building to check whether the stone used had any red pigmentation of this kind. Red pigmentation may be recorded in both colour tables (Colour1 and Colour2).

Given the nature of the survey, very few of the observations record a complete set of the characteristics in Tables 1-5 but it was thought nevertheless that an investigation of how they might, individually or in combination, improve on the simple assignment of slate to one or other group based on the presence/absence of red slate.

A critical premise of the following analysis is that for ordinary building stone, the more lowly the building, the less likely it is that the stone for it has been brought from a distant source. The ranking of buildings for this purpose is outcrop (which of course is not a building), wall, outbuilding, house, church, with the stone of walls/embankments being the most likely to be local after actual outcrops, and that of churches the least likely. There is some evidence that this holds for some kinds of stone (eg Barr, 2016, p. 41 for Dartmoor granite). Table 6 shows the outcome of a rough count of buildings containing red slate by the formation on which they fall.

Table 6. Count of buildings containing red slate in Colour1

Building type	On Meadfoot Group	On Dartmouth Group
Outcrop	2	1
Wall	14	13
House	2	15
Church	4	4
Other	3	0
Total	25	33

Table 6 is unhelpful. Only *houses* built on the Dartmouth Group show preferential use of red slate. Other kinds of building and buildings of all types added together show no very marked bias. The implication is that there is nothing to be gained by an analysis of the data on the basis of the kind of building that incorporates slate. Table 6 also shows that a building containing red slate is almost as likely to fall on the Meadfoot Group as on the Dartmouth Group.

The analysis showed that the weathering characteristics (Table 5) and the nature of the planar fabric (Table 4) are unhelpful in distinguishing between these building stones as were the data entered into the second colour table. Table 7 shows a summary of the results of analysis of the colours of slates entered as Colour1 and Table 8 shows the analysis of the composition of the slates.

Table 7. Partial summary of the colour of slate building stone by the formation on which the building falls

	Meadfoot Group	Dartmouth Group
Olive, green and buff slate	136	28
Red slate	25	33

Table 8. Composition of slate building stone by the formation on which the building falls

	Meadfoot Group	Dartmouth Group
Pelitic	62	18
Semi-pelitic	51	52
Psammitic	2	8

Table 7 shows that slate described in the notes as olive, green or buff falls mainly on the Meadfoot Group and seldom on the Dartmouth Group; in fact, it is a much better discriminator than the presence of red pigmentation. Table 8 shows that the slate of buildings that fall on the Meadfoot Group is much more likely to be described as pelitic than that which is used in buildings on the Dartmouth Group. Although there are very few examples, the converse applies to psammitic slate.

It might be thought that a combination of these two criteria, colour and composition, would provide an effective tool for discriminating between the two different kinds of slate but there are so few records that have entries for both that this is ineffective. The current approach to get round this difficulty is to cascade these criteria using the following rules:

- (i) Slate described as pelitic is assigned to the Meadfoot regardless of any other recorded characteristic.
- (ii) Slate described as psammitic is assigned to the Dartmouth regardless of any other recorded characteristic
- (iii) Of the balance of occurrences, slate described as olive, green or buff is assigned to the Meadfoot and slate that includes some red is assigned to the Dartmouth.
- (iv) Where there is conflict in the recorded colour, Colour 1 takes precedence.

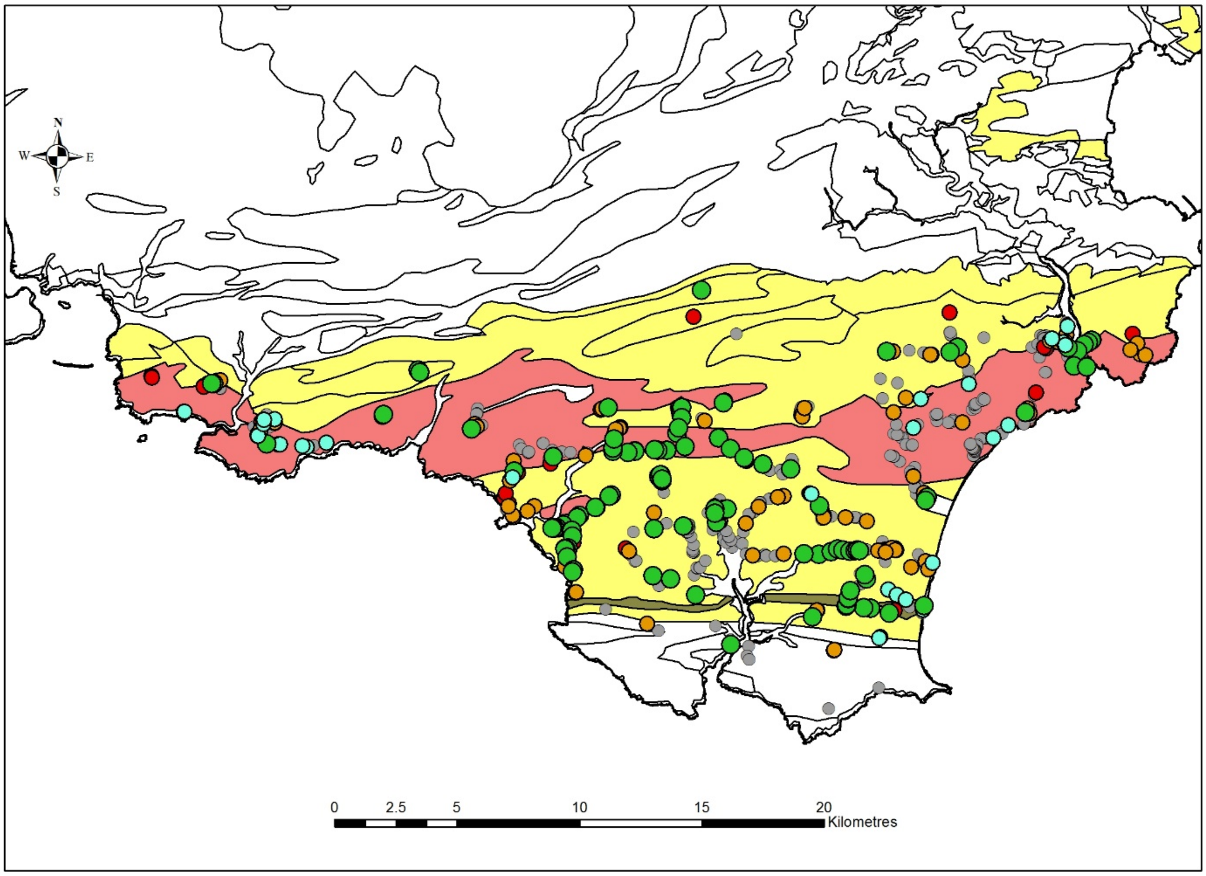

Figure 1. Division of slates used for building. Bedrock geology; red, Dartmouth Group; yellow, Staddon and Bovisand Formations and Meadfoot Group. Circular symbols, stone in buildings; light blue symbols, psammitic slate; green symbols, pelitic slate; orange symbols, olive, green and buff slate; red, red slate; grey, slate without recorded relevant attributes.

Table 9. Slate in buildings: distribution between mapped Meadfoot and Dartmouth Formations

		Geological map	
		Dartmouth	Meadfoot
Slates in buildings	Dartmouth	28	17
	Meadfoot	17	126
	Unassigned	93	124

Figure 1 and Table 9 show how this approach maps out on the ground. There are many buildings where the slate is still unassigned following the analysis. The field observations were reviewed to assign these to one or other of the categories based on how the preceding slate observations were assigned. The basis for this is the tendency, no doubt subjective, to keep the same slate identification from one building to the next on a traverse unless there is a strong case for changing it. With hindsight, a much more accurate allocation of slate to one or other of these groups could have been made if more attention had been given to the composition of the slate (psammitic or pelitic).

186, Hurdwick Stone (Milton Abbot Formation)

Hurdwick Stone is a variety of green chloritic slate with strong cleavage containing inclusions flattened in the foliation up to 10 x 2cm but typically smaller, and exceptionally so large that individual inclusions exceed the size of the building block (Figure 1). The inclusions are typically darker than the matrix but in a minority of cases, the opposite is the case (Figure 2). Exceptionally, the stone is brown rather than green but its basic colour is usually evident and is seldom obscured by surface weathering. It is composed of chlorite and light-coloured minerals which are not very prominent but no doubt include quartz and plagioclase; exceptionally the matrix encloses large subhedral phenocrysts of plagioclase (Figure 3). The texture and composition of the rock point to an origin as tuff in which fragments of igneous rock are enclosed in a matrix of very similar composition.

The rock usually has holes or voids, on millimetre scale, exceptionally up to 10 mm across and in some blocks zoned (Figure 3). Some of these are ellipsoidal and are interpreted as deformed spherical vesicles or amygdales from which the filling has fallen out. In some blocks they are so closely packed that the rock resembles pumice (Figure 4). In other cases, they are angular and probably represent fragments of devitrified glass (Figure 1). They occur in both the matrix and the volcanic clasts. It is evident from this description that Hurdwick Stone is a distinctive variety of the volcanic and hypabyssal rock widespread in the Devonian and Carboniferous rocks of south Devon and includes lavas, tuffs, agglomerates and hyaloclastites in its make-up.

Hurdwick Stone is available in good-sized blocks and appears to be resistant to weathering and degradation. Exceptionally, very large blocks have been used (Figure 5). There is a tendency for the clasts to fall out of the matrix in some blocks, requiring repair with cement or other filler but the stone is of moderately good quality and has been used successfully to construct ashlar walls.

Where the surface is poorly exposed, it is easily confused with other dark slates but in some cases, can be differentiated by its rubbly appearance.

It is the principal building stone of central Tavistock (Figures 6, 7, 8 and 9) and was preferred by the 7th Duke of Bedford for his wide-ranging reconstruction of the town in the Nineteenth Century although some of the secular buildings made of Hurdwick Stone predate this initiative (Figure 10). The quarry from which the stone was won lies some 2km north of the town. Similar stone is used in the towns and villages north of Tavistock extending as far as Clovelly (Figure 13) but is mainly restricted to the dressings of parish churches (Figures 11 and 12). The stone is something of a rarity away from Tavistock. In these cases it probably was not won from Hurdwick Quarry except perhaps in those villages owned by the Russell family (eg Milton Abbot).

Several of the churches that include the stone in their dressings also include Polyphant Stone (Code 190, qv), an equally rare building stone in Devon (the parish churches of Whitechurch in Tavistock, Luffincott, St Giles on the Heath, Germansweek, Bridestowe, Lydford, Coryton and Mary Tavy contain both stones). Eight out of the 21 churches that contain Polyphant Stone in this region also contain Hurdwick Stone and 8 of the 19 churches that contain Hurdwick Stone also contain Polyphant. It perhaps suggests that there was a school of masons in medieval times that was biased towards the use of these materials together for their church-building projects.

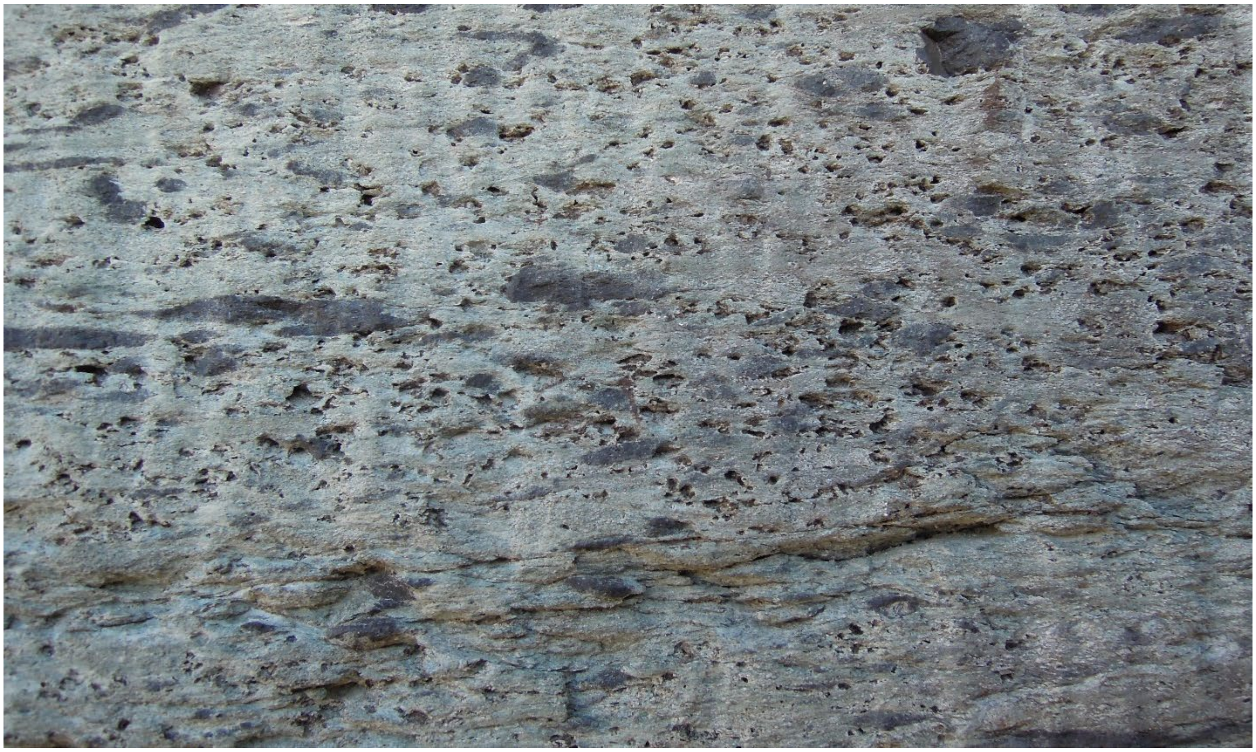

Figure 1. Well cleaved green slate with darker inclusion flattened in the cleavage and containing angular voids representing glass shards. Town Hall, Tavistock. Width of view 30cm.

Figure 2. Lighter fragments of lava set in a darker matrix, both with voids representing vesicles or glass shards. St Rumon's Primary School, Dolvin Road, Tavistock.

Figure 3. Green chloritic tuff with darker inclusions flattened in the foliation and containing several subhedral crystals of white plagioclase and one large flattened inclusion of darker lava with amygdales zoned from the centre to the margin of the clast, perhaps a bomb. Tourist Office, in front of Court Gate, Tavistock.

Figure 4. Hurdwick Stone with abundant ellipsoidal vesicles. East wall of Town Hall, Tavistock.

Figure 5. Ye Olde Priest's House, Lamerton. Very large blocks of green Hurdwick Stone are used for the dressings round the door and are incorporated in the quoins.

Figure 6. Bedford Hotel, Tavistock.

Figure 7. Town Hall, Tavistock, of Hurdwick Stone with granite dressings.


Figure 8. Street scene, junction of Drake Road and Duke Street, Tavistock. The buildings are of Hurdwick Stone with Bath Stone dressings.

Figure 9. Catholic church, Callington Road, Tavistock; of green Hurdwick Stone with Bath Stone dressings.

Figure 10. Ford Street Charity, Ford Street, Tavistock (1762). The lintels of the ground floor windows are of granite.

Figure 11. Jamb of south aisle window, St Petroc's church, Lydford; the voids in the Hurdwick Stone mainly represent devitrified glass that has fallen out of the surface of the block (qv. hyaloclastite, Code 199).

Figure 12. Entrance gateway to the churchyard of St Bridget's church, Bridestowe. The dressings of the arch, which was the chancel arch of the earlier Norman church, are of Hurdwick Stone.

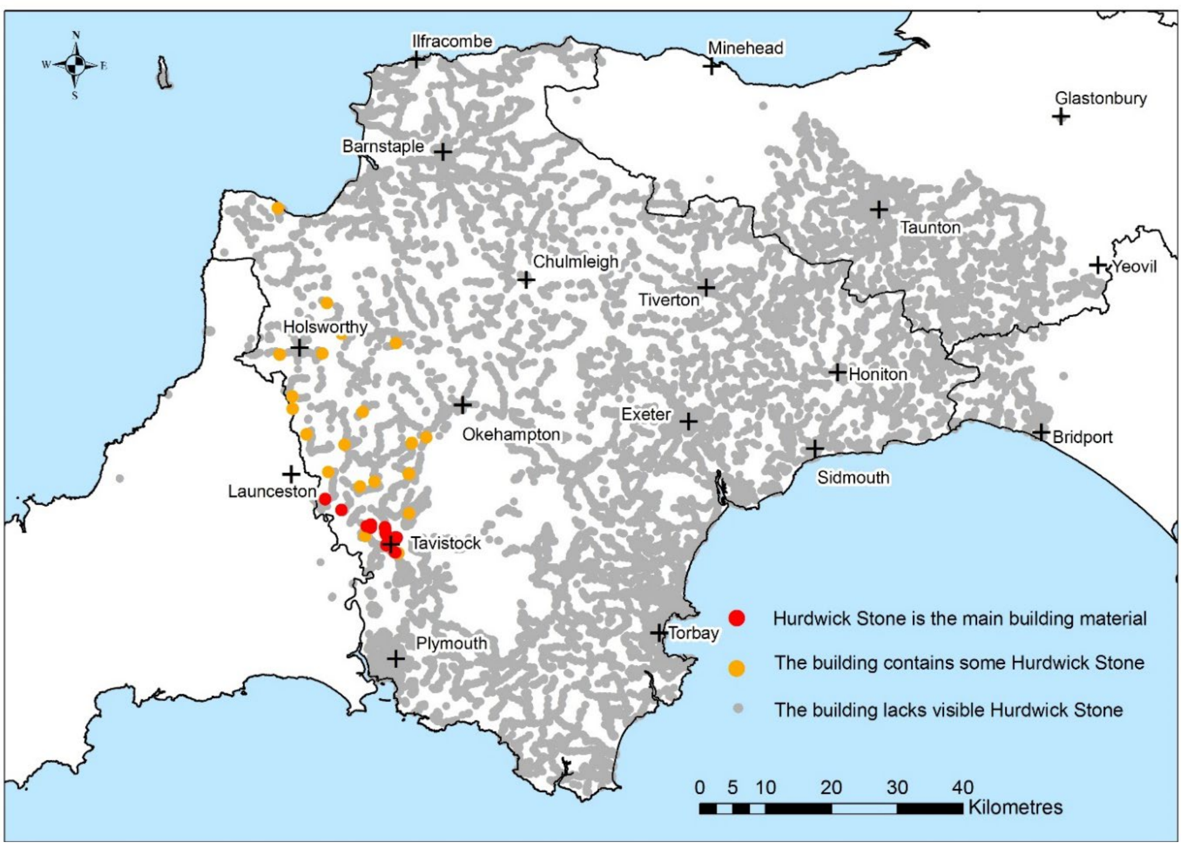

Figure 13. Distribution of Hurdwick Stone in buildings.

187, Bovisand Formation

Slate from the Bovisand Formation is the main building stone of Kingsbridge and it is here that it displays its most characteristic qualities (Figures 1 and 2). The building stone is predominantly pelitic (Figures 3 and 8) with subordinate semi-pelitic and psammitic variants. It has a strong penetrative cleavage in the great majority of buildings observed (Figures 3, 4 and 8), with a minority of building blocks showing spaced cleavage planes up to 3mm apart, separated by less slatey rock. While it is surely not an intrinsic property of the stone, a surprisingly large proportion of the blocks used in buildings show the development of kink bands related to deformation of the bedrock following the formation of the slatey cleavage (Figure 5).

The predominant colour of fresh slate is pale green (Figure 6) but subordinate hues range through grey and dark grey (Figures 7 and 8). However, the predominant colour of the stone seen in buildings is a characteristic buff (Figures 1 and 2) or less commonly is described as olive green, olive brown or dung-coloured. Outside Kingsbridge, this colour may be overlaid with nondescript grey, with or without red- and black-stained joint and fracture surfaces, weathering colours that are common to nearly all the slate building stones of Devon (Figures 4 and 9).

Building blocks of the better-quality stone tend to be somewhat larger than ordinary bricks and proportionately narrower across the cleavage (Figures 1, 6 and 7) but poor-quality stone used for rough walling tends to come in blocks of irregular size and shape, in many cases small and thin (Figures 4 and 8).

This code is given to stone used in the southern part of the outcrop of the Meadfoot Group between Plymouth Sound and Brixham. Stone from this group in buildings further north is given a separate code reflecting the fact that here the slate is commonly accompanied by sandstone; it is given the material code 159 representing all rock-types of the Meadfoot Group.

Difficulties are encountered in differentiating between slates from the Bovisand Formation and those from the Dartmouth Group which crop out next to each other across south Devon. In terms of composition, the latter may be somewhat richer in quartz and poorer in phyllosilicates but there is a very large overlap in composition and consequently in appearance, and this criterion was quickly abandoned as a method of distinguishing between these two groups of slate building stones. During the course of the mapping, in the absence of any other differentiating features, the distinction was made mainly on the basis of the presence in the Dartmouth slates of red pigmentation that is an intrinsic property of the rock and is unrelated to surface weathering. Comparison of the distribution of Bovisand and Dartmouth slate in buildings with the geological map (see Appendix) suggests that this approach has not been very successful; many buildings containing slate supposedly from the Bovisand fall on the outcrop of the Dartmouth Group and *vice versa,* even in the case of lowly buildings like roadside walls where the incentive to carry building stone from distant sources must have been pretty low. The confusion may have one or more of several origins.

i. Wherever possible the stone of buildings was closely examined to see if parts of it were stained red; however, it has to be admitted that not all buildings could be examined closely and in these cases, red pigmentation may have been missed and the stone assigned to the Bovisand Formation in error.
ii. Surface reddening due to weathering is commonplace in all of these slates; it is not always easy to differentiate between this and red pigmentation that is an intrinsic property of the fresh rock, leading to erroneous assignment of some slate from the Bovisand to the Dartmouth.
iii. Dartmouth slate is not all red; most is grey. Where the stone of a building genuinely lacks any red pigment, it has been assigned to the Bovisand Formation but may in truth have been drawn from a part of the Dartmouth lacking red pigmentation.
iv. In any case, mapping of the Bovisand Formation by the BGS shows that it does contain some red slate; where building stone has several of the characteristics of the Bovisand Formation but also some red stone, it is nevertheless assigned to the Bovisand Formation (eg Figure 10). This approach is defensible but is likely to be error prone.

The confusion may be compounded by errors in the geological mapping. For example, the mapped Bovisand Formation outcrop encloses patches of Dartmouth Group for which there is no structural justification. If the mapping of these patches is based on the colour of the slate, then they could as easily belong to the Bovisand Formation.

The approach finally adopted for discriminating between Bovisand and Dartmouth slate is set out in the appendix.

Appendix: Meadfoot and Dartmouth Group Slates

Very considerable difficulty was experienced in distinguishing between these two groups of slates. There seems to be considerable overlap of their properties. The initial solution south of the outcrop of the Staddon Grits was to map any slate that had some red pigment not thought to be due to weathering as Dartmouth and the balance as Meadfoot. The outcome was the mapping of many buildings apparently incorporating Dartmouth slate on the outcrop of the Meadfoot Group and *vice versa*. While this is of course possible, nevertheless considering the low status of some of the buildings involved, for example roadside walls, it seems unlikely that the builders of the past would have taken the trouble to carry the stone for them very far and much more likely in these cases that the stone was local. Moreover, the BGS memoir for the area includes a discussion of whether the presence of red pigment is a reliable indicator of slate from the Dartmouth Group (Ussher, 1912) and concludes that it is not. To compound matters, the pink pigmentation of the Dartmouth Group is not everywhere present; it is perfectly possible for building stone from that group to lack any red or pink slate, making this characteristic unreliable as an indication of stratigraphic origin.

The geological map for most of this area has been revised by the BGS since the days of Ussher but there is no accompanying memoir. This is unfortunate for it would be helpful to have a description of the criteria used to distinguish between these groups of slates for the purpose of geological mapping in the South Hams. The BGS lexicon stresses the quartz-rich nature of Dartmouth Group 'slates' which helps to distinguish them from adjacent formations.

In an attempt to resolve the difficulty, an analysis of the properties of the slate building stone used south of a line from Bovisand Bay in the west to Dartmouth in the east was undertaken in 2016. North of this line, slate of the Meadfoot Group is associated with sandstone in buildings (Staddon Formation) and is fairly easily distinguished from stone from the Dartmouth Group where any sandstone associated with slate contains considerable proportions of phyllosilicates and is mainly identified as psammitic slate in this study.

The criteria used for characterising the slates were developed during the course of the survey, when it became apparent that a more systematic approach was needed to distinguish between the different kinds of slate used in Devon. The initial objective was to distinguish between Middle and Upper Devonian slate used for building south and west of Dartmoor with a particular emphasis on differentiation between the Kate Brook Slate and its correlatives, and slate from the Crackington Formation. This was extended to assist in distinguishing between slate from the Meadfoot Group and that from the Dartmouth Group. The criteria (Tables 1-5) were copied from existing narrative descriptions of building stone seen in the field. This explains why some of them are a bit short on intellectual rigour.

Details were entered into the database through drop-down lists which allowed a choice only from the entries in these lists or a null record.

Table 1. Colour

ID	Colour
1	Grey
2	Dark Grey
3	Black
4	Olive
6	Green
7	Red/purple
8	Silvery
9	Pale
10	Buff

Table 2 Composition

ID	Composition
1	Pelitic
2	Semipelitic
3	Psammitic

Table 3 Association

ID	Association
1	Sandstone
2	Limestone
3	Hornfels
4	Volcanics

Table 4 Cleavage

ID	Cleavage
1	Penetrative/strong
2	Spaced - fracture
3	Not very good

Table 5. Weathering

ID	Weathering
1	Red-black
2	Black
3	Buff/fawn
4	Orange
5	Dull
6	Stone
7	Ochre
8	Grey
9	Rich brown
10	Dark

Two colour tables were created to allow both dominant and subordinate body colours to be systematically recorded. Red pigment used during the field work to identify the slate as being from the Dartmouth Group is recorded in the first colour table; red pigment described in the narrative notes was entered in the second colour table. In most buildings red was subordinate to other colours in the fresh building stone.

The characteristics were mainly entered into the database well after the end of the fieldwork, from the details recorded in the narrative summary for each record. However, in the case of original pigmentation, a decision was made part way through the fieldwork that the presence of red slate was the most reliable indication that it came from the Dartmouth Group and thereafter, an effort was made at each building to check whether the stone used had any red pigmentation of this kind.

Given the nature of the survey, very few of the observations record a complete set of the characteristics in Tables 1-5 but it was thought nevertheless that an investigation of how they might, individually or in combination, improve on the simple assignment of slate to one or other group based on the presence/absence of red slate.

A critical premise of the following analysis is that for ordinary building stone, the more lowly the building, the less likely it is that the stone for it has been brought from a distant source. The ranking of buildings for this purpose is outcrop (which of course is not a building), wall, outbuilding, house, church with the stone of walls/embankments being the most likely to be local after actual outcrops, and that of churches the least likely. There is some evidence that this holds for some kinds of stone (eg Barr, 2016, p. 41 for Dartmoor granite). Table 6 shows the outcome of a rough count of buildings containing red slate by the formation on which they fall.

Table 6. Count of buildings (including outcrops observed) containing red slate in Colour1

Building type	On Meadfoot Group	On Dartmouth Group
Outcrop	2	1
Wall	14	13
House	2	15
Church	4	4
Other	3	0
Total	25	33

Table 6 is unhelpful. Only *houses* built on the Dartmouth Group show preferential use of red slate. Other kinds of building and buildings of all types added together show no very marked bias. The implication is that there is nothing to be gained by an analysis of the data on the basis of the kind of building that incorporates slate. Table 6 also shows that a building containing red slate is almost as likely to fall on the Meadfoot Group as on the Dartmouth Group.

The analysis showed that the weathering characteristics (Table 5) and the nature of the planar fabric (Table 4) are unhelpful in distinguishing between these building stones as were the data entered into the second colour table. Table 7 shows a summary of the results of analysis of the colours of slates entered as Colour1 and Table 8 shows the analysis of the composition of the slates.

Table 7. Partial summary of the colour of slate building stone by the formation on which the building falls

	Meadfoot Group	Dartmouth Group
Olive, green and buff slate	136	28
Red slate	25	33

Table 8. Composition of slate building stone by the formation on which the building falls.

	Meadfoot Group	Dartmouth Group
Pelitic	62	18
Semi-pelitic	51	52
Psammitic	2	8

Table 7 shows that slate described in the notes as olive, green or buff falls mainly on the Meadfoot Group and seldom on the Dartmouth Group; in fact, it is a much better discriminator than the presence of red pigmentation. Table 8 shows that the slate of buildings that fall on the Meadfoot Group is much more likely to be described as pelitic than that which is used in buildings on the Dartmouth Group. Although there are very few examples, the converse applies to psammitic slate.

It might be thought that a combination of these two criteria, colour and composition, would provide an effective tool for discrimination between the two different kinds of slate but there are so few records that have entries for both that this is ineffective. The current approach to get round this difficulty is to cascade these criteria using the following rules:

(i) Slate described as pelitic is assigned to the Meadfoot regardless of any other recorded characteristic.

(ii) Slate described as psammitic is assigned to the Dartmouth regardless of any other recorded characteristic

(iii) Of the balance of occurrences, slate described as olive, green or buff is assigned to the Meadfoot and slate that includes some red is assigned to the Dartmouth.

(iv) Where there is conflict in the recorded colour, Colour 1 takes precedence

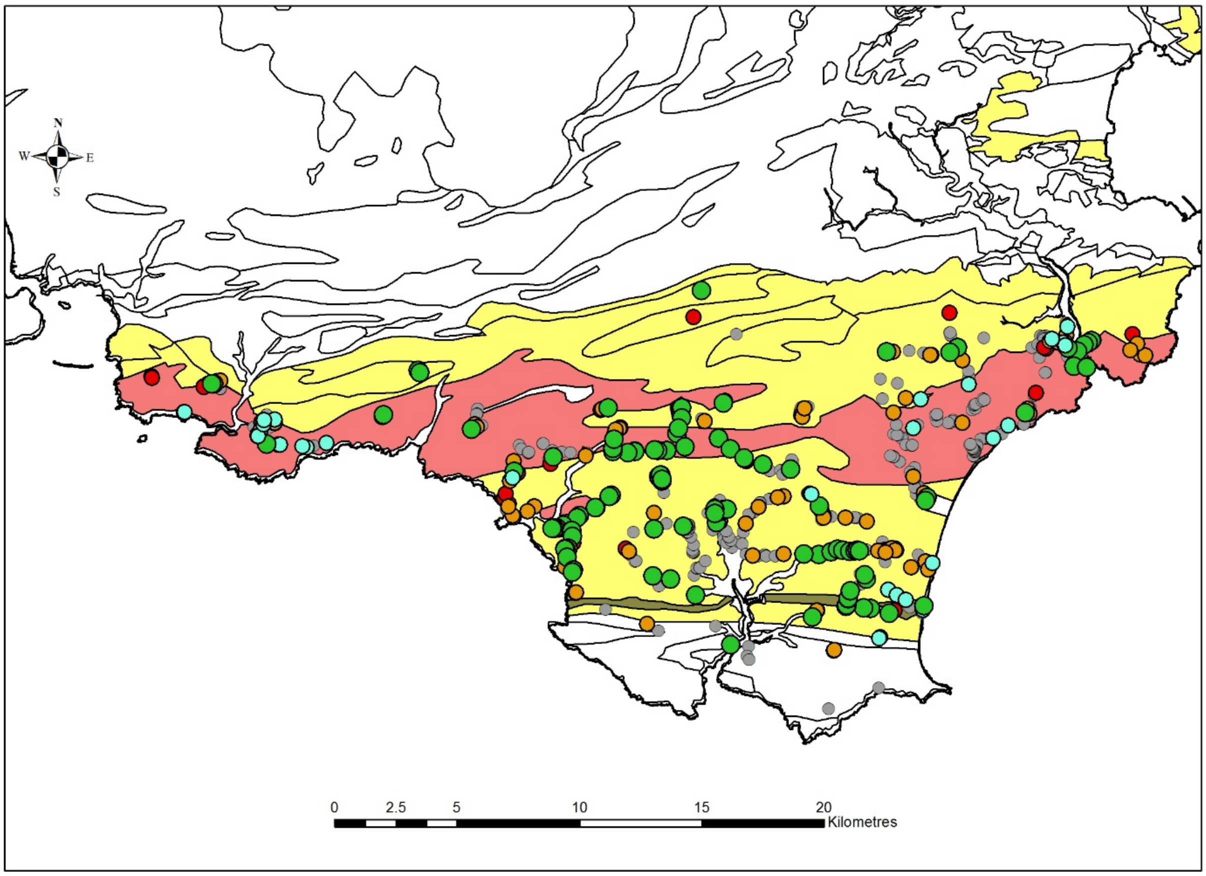

Figure 1. Division of slates used for building. Bedrock geology; red, Dartmouth Group; yellow, Staddon and Bovisand Formations and Meadfoot Group. Circular symbols, stone in buildings; light blue symbols, psammitic slate; green symbols, pelitic slate; orange symbols, olive, green and buff slate; red, red slate; grey, slate without relevant recorded attributes.

Table 9. Slate in buildings: distribution between mapped Meadfoot and Dartmouth Formations

		Geological map	
		Dartmouth	Meadfoot
Slates in buildings	Dartmouth	28	17
	Meadfoot	17	126
	Unassigned	93	124

Figure 1 and Table 9 show how this approach maps out on the ground. There are many buildings where the slate is still unassigned following the analysis. The field observations were reviewed to assign these to one or other of the categories based on how the preceding slate observations were assigned. The basis for this is the tendency, no doubt subjective, to keep the same slate identification from one building to the next on a traverse unless there is a strong case for changing it.

Figure 1. Buff, pelitic slate from the Bovisand Formation. North-west side of Church Street, Kingsbridge.

Figure 2. Buff slate from the Bovisand Formation. Former warehouse, south side of Duncombe Street, Kingsbridge.

Figure 3. Wall of the south porch, church of St Thomas a Becket, Church Street, Kingsbridge.

Figure 4. Poor quality green/buff pelitic slate (left) replaced by better quality slate weathered red and black (right). North-east side of Ebrington Street, Kingsbridge.

Figure 5. Pelitic slate of characteristic buff colour showing kink bands. Outbuilding 70m north of the church on east side of the road, East Allington.

Figure 6. Entrance to the covered market, Fore Street, Kingsbridge. The slate has the greenish pigment typical of the fresh rock. The quoins and dressings are of Portland Stone.

Figure 7. South porch of the church of St Thomas a Becket, Church Road, Kingsbridge. The slate of the front of the porch shows the characteristic buff/greenish hues but the colour of the slate on the side of the porch, its footing and of the tower is masked by grey, a commonplace result of exposure to the weather.

Figure 8. Predominantly grey-weathered pelitic slate. Wall on north side of leat, behind Mill Street, Kingsbridge.

Figure 9. Wall on the north side of the main road, opposite the primary school, West Charleton.

Figure 10. Grey and buff pelitic slate with patchy red pigmentation. Tower of All Saints church, Thurlestone.

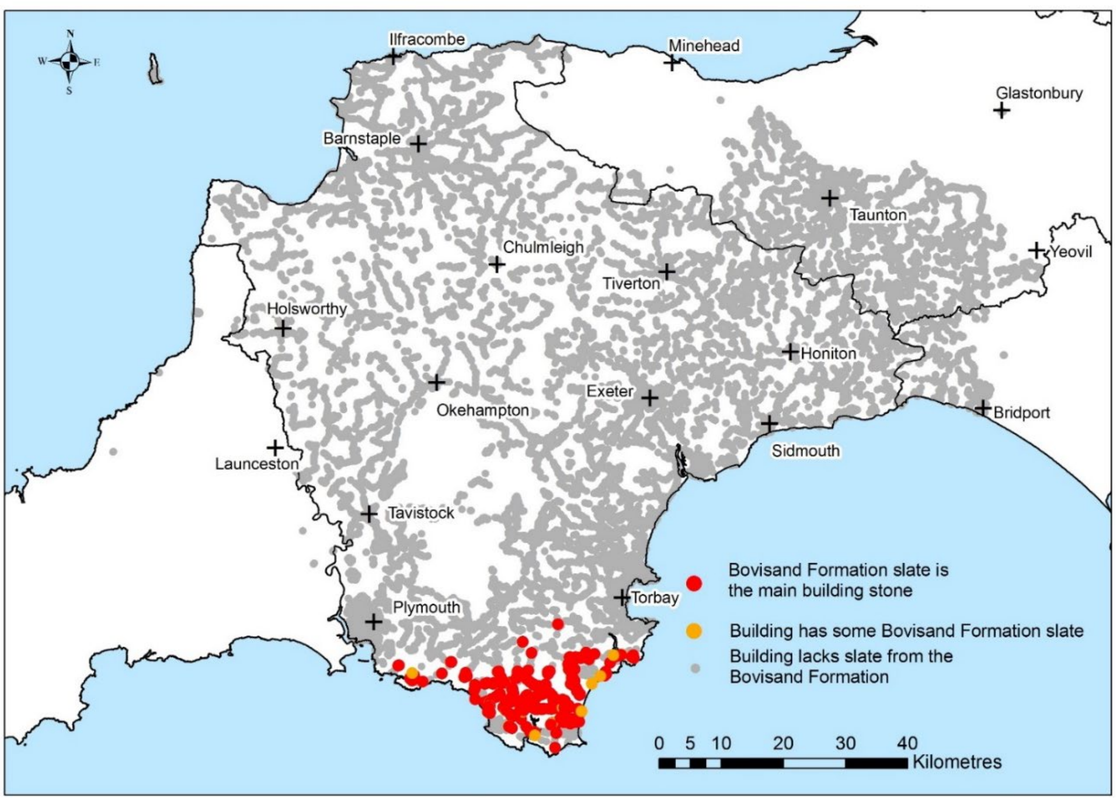

Figure 11. Distribution of Bovisand Formation slate in buildings.

188, Mica Schist

Schist composed mainly of quartz and white mica (muscovite/phengite) is used in buildings on and near the outcrop of the Start Complex from which it is drawn but extends a little further north, with one occurrence recorded in Kingsbridge (Figures 1 and 4). It is associated with chlorite schist also from the Start Complex in many of these buildings. In outcrop, the schist is shot through with irregular aggregates, lenses and veins of quartz.

The schist has a well-marked schistosity which makes it unsuitable as a building stone since the blocks tend to split easily along the cleavage surfaces. This may be the explanation of the fact that much of the stone used for building exhibits folding of the schistosity or is crossed by kink bands which give the building blocks greater all-round strength. It has to be admitted however that this is a very poor building stone, much less suitable for this application that the chlorite schist (Code 189 qv) with which it is interbanded; chlorite schist is used in about one and a half times as many buildings as mica schist.

Figure 1. Pale grey and steely grey mica schist associated with green chlorite schist. Information Centre, Kingsbridge.


Figure 2. Colour laminated grey mica schist interbanded with chlorite schist (green), with quartz bands and lenses. Exposures behind the beach, 170m north of Hallsands car park.

Figure 3. South aisle and porch of All Saints church, Malborough, all of mica schist. The large size of the blocks is unusual for mica schist used for building in Devon.

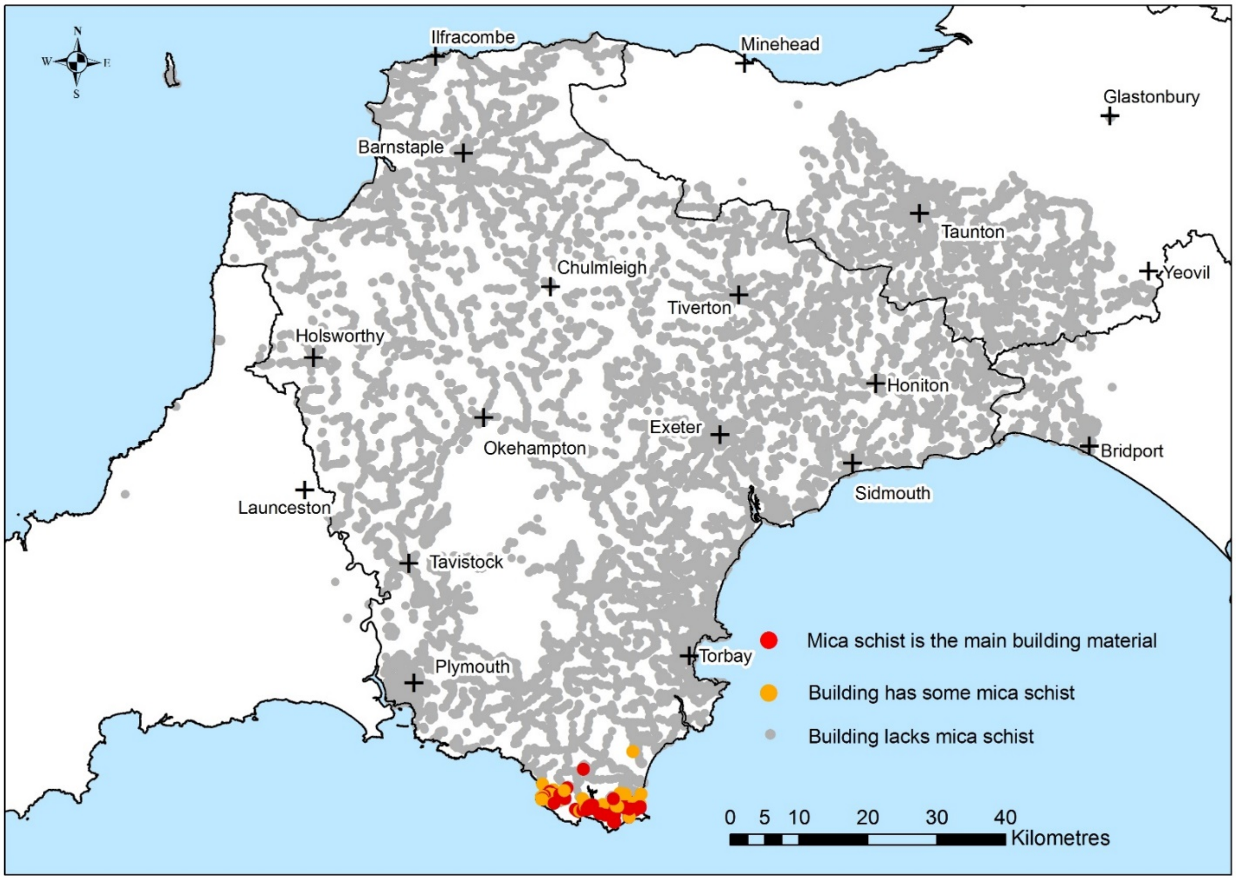

Figure 4. Distribution of mica schist in buildings.

189, Chlorite Schist

Low grade metamorphic rocks of broadly basic composition won from the Start Complex are one of the main building stones used on its outcrop (Figure 6) and are also used more sparingly to the north as far as Kingsbridge. The stone is typically composed of quartz, chlorite, epidote and opaque minerals and many examples also, no doubt, include plagioclase and hornblende (see Floyd *et al.,* 1993). It is easily identified by the green colour of the chlorite (Figures 1, 4 and 5) and pistachio green or brown of the epidote which is exceptionally abundant (Figure 2). The stone typically has colour and compositional banding and lamination on millimetre to centimetre scales, very likely of sedimentary origin, but now much disrupted and contorted by deformation (Figure 3).

Compared to the associated muscovite schists (Code 188, qv), the stone appears poorly recrystallized and of very low metamorphic grade. A significant proportion is not well cleaved especially where chlorite is sparsely distributed. The stone is typically inhomogeneous on the scale of the building block and in outcrop, with contrasts in composition between adjacent bands, laminae and irregularly recrystallized parts. Interbanding with mica schist in outcrop is common (Figure 3).

Chlorite schist used for building is reasonably easily distinguished from other building stone of the extreme south part of Devon. Because of its very low metamorphic grade, it can be confused with the green slate won from the Meadfoot Group (Code 159, qv) to the extent that at some localities, there is doubt as to which group a particular building stone should be referred.

Reference

Floyd, P. A., Holdsworth, R. E. and Steele, S. A., 1993. Geochemistry of the Start Complex greenschists: Rhenohercynian MORB? *Geological Magazine* **130**, 345-352.

Figure 1. Chlorite schist showing typical green pigment caused by abundant chlorite with in many cases hornblende also. Roadside wall, North Sands Bay, Salcombe.

Figure 2. Brown epidote-rich poorly cleaved but strongly lineated schist. Roadside wall below Old Harry Beacon, Cliff Road, Salcombe.

Figure 3. Interlayered strongly banded chlorite schist (green and white) and mica schist (grey and white). Exposures behind the beach, 170m north of Hallsands car park.

Figure 4. Tower of Holy Trinity church, Galmpton. The green colour of the chlorite schist is clearly displayed in the newly cleaned and pointed parts of the tower.

Figure 5. Information Centre, central Kingsbridge. The wall is made of a mixture of chlorite schist (green) and mica schist (steely grey).

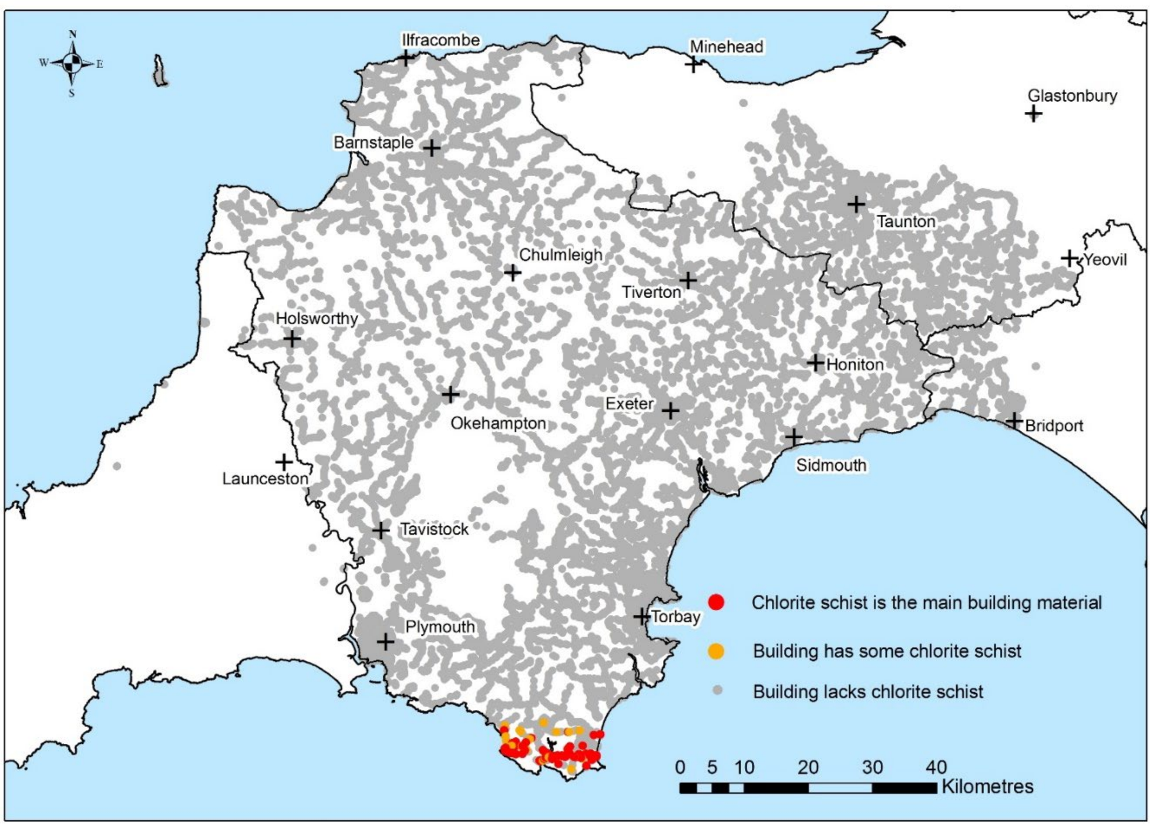

Figure 6. Distribution of chlorite schist in buildings.

190, Vesicular quartz porphyry (Roborough Stone)

This distinctive and striking rock-type is used mainly for the dressings of medieval churches in the South Hams and west Devon. The rock is typically pale fawn or grey and is strongly vesicular, almost pumice-like in texture, composed of a fine-grained granular matrix of quartz and feldspar with few dark minerals, enclosing rounded phenocrysts of quartz up to 5mm in diameter (Figure 1). The rock contains vesicles typically up to 10mm across representing original gas bubbles in the solidifying rock and showing varying amounts of departure from the spherical presumably caused by deformation and flow during solidification.

The rock was clearly prized in medieval times for its appearance, durability and workability. Of the 185 records containing Roborough Stone, 137 relate to churches. Typical occurrences include examples where the jambs, mullions and sills of church windows are made of Dartmoor granite but the tracery is carved in this variety of quartz porphyry. The tally includes multiple occurrences in a single building; 112 separate buildings contain the stone, mainly in west and south Devon (Figure 5), including the abbey church of Buckland Abbey (Figure 4) and many of the outbuildings there, and the parish church of Buckland Monachorum.

Figure 1. Close up of window dressings, south side of the nave, St James' church, Kingston. The vesicles in this example are 5mm across maximum.

Figure 2. St John's church, Woodland, south side of nave. The quartz porphyry is used for the jambs, sills and tracery of the windows. Bath Stone is used for the mullions.

Figure 3. West door of the church of St Mary and All Angels, Plymstock. The dressings round the door are of pale orange quartz porphyry. The relieving arch and walls are of well cleaved grey slate, probably from the Jennycliff Slates.

Figure 4. Buckland Abbey. The dressings of the arch into the original crossing are of Roborough Stone. The archway is now filled in with local Upper Devonian slate.

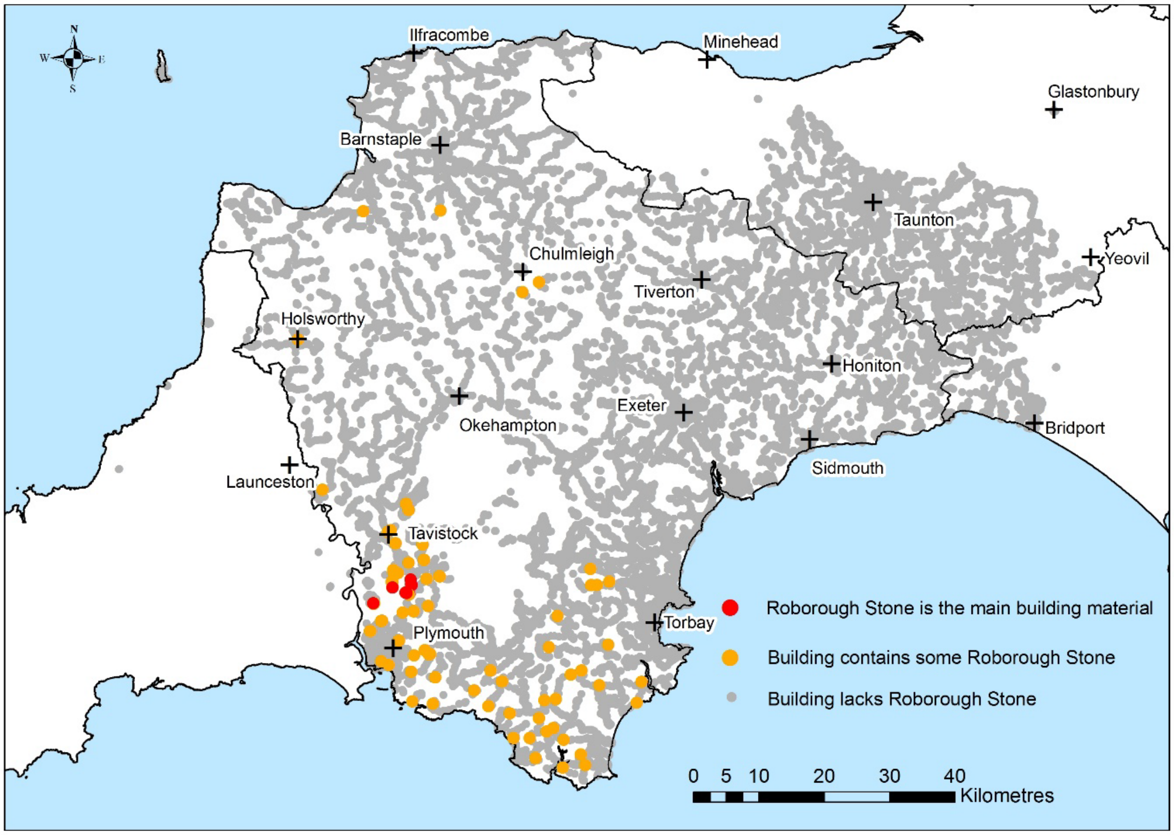

Figure 5. Distribution of Roborough Stone in buildings.

191, Slate of Unknown Origin

This code is given to slate used for building which cannot be confidently fitted into one of the categories of local building stone. It is therefore something of a sack term covering a range of slatey rock types. There are, nevertheless, a number of features which set this range of slates apart from those of local origin:

- used mainly in modern walls, outbuildings and houses;
- the slate has a fresh appearance; visible surfaces appear planar and compact especially where sawn; cleavage is seldom strongly expressed on visible surfaces; blocks seldom display splitting parallel with the cleavage at the edges of blocks;
- building blocks are usually regular, in many cases about the size and shape of a standard brick. Compared to blocks of local slates used for building, they are of good quality.

The inventory notes refer in many cases to slate "of garden-centre type", meaning that the stone can be matched with slate offered for sale in garden centres, in most cases originating from outside Devon and in many, from outside the UK.

While it was possible to recognise slate with common properties used for buildings visited on a single day's traverse, or on several traverses grouped together in time, and while the notes refer to aspects of the appearance of slate building stone which have been seen months and even years before, it has not so far been possible to divide up the stone given this code into separate categories; they have therefore all been given Code 191. Reference to the database notes shows that the assigned code has been changed, in some cases several times, as thinking on the correct classification has changed during the progress of the survey. An outstanding task is to revisit some of the buildings where slate coded 191 occurs and attempt a more complete (and hopefully accurate) categorisation of slate building stone used in modern buildings.

The illustrations that follow give some idea of the range of different kinds of slate used for building where so far, a local source formation has not been identified. Common attributes include orange, red, ochre, yellow and brown pigmentation of weathered cleavage and joint surfaces and partings, grey, greenish, dark grey, bluish and even black body colour, and semi-pelitic to pelitic composition.

Figure 1. Orange-weathered grey slate laid with cleavage parallel to the plane of the wall. North side of Folly Hill, Bigbury-on-Sea. This kind of slate is widespread in Devon for walls and embankments.

Figure 2. Grey slate with a touch of green. Wall at entrance to Long Meadow Farm, Coombe Road, Ringmore.

Figure 3. Embankment at entrance to Wayford, Ridley Hill, Kingswear. A passer-by said the slate was from a quarry in Wales no longer in operation.

Figure 4. Wall at entrance to Chimneys, east side of Vinery Lane, Elburton. Slate of this kind is very widely used for garden and roadside walling throughout Devon. The gatepost on the right is composed of Middle Devonian limestone and slate which looks more like the local Devonian slate than the slate of the main part of the wall and is coded 59. One supposes that similar stone formerly used in the wall has been replaced using stone from an exotic source.


Figure 5. Wall in front of a small development of modern bungalows, of grey, orange-weathered slate; a very widely distributed type. Moorside, Luckhams Lane, Malborough.

Figure 6. Grey, black, red and yellow-weathered semipelitic slate, roadside wall, north side of Folly Road, Bigbury-on-Sea.


Figure 7. Brownish, red and yellow slate, some laid with bedding parallel to the plane of the wall. Gateway near Lundy View, 3.6km southwest of Clovelly.

Figure 8. Black slate, Roland Levinsky Building, University of Plymouth, north side of Cobourg Street, Plymouth.

Figure 9. Black- and red-weathered pelitic slate. Roadside wall, Walkhampton.

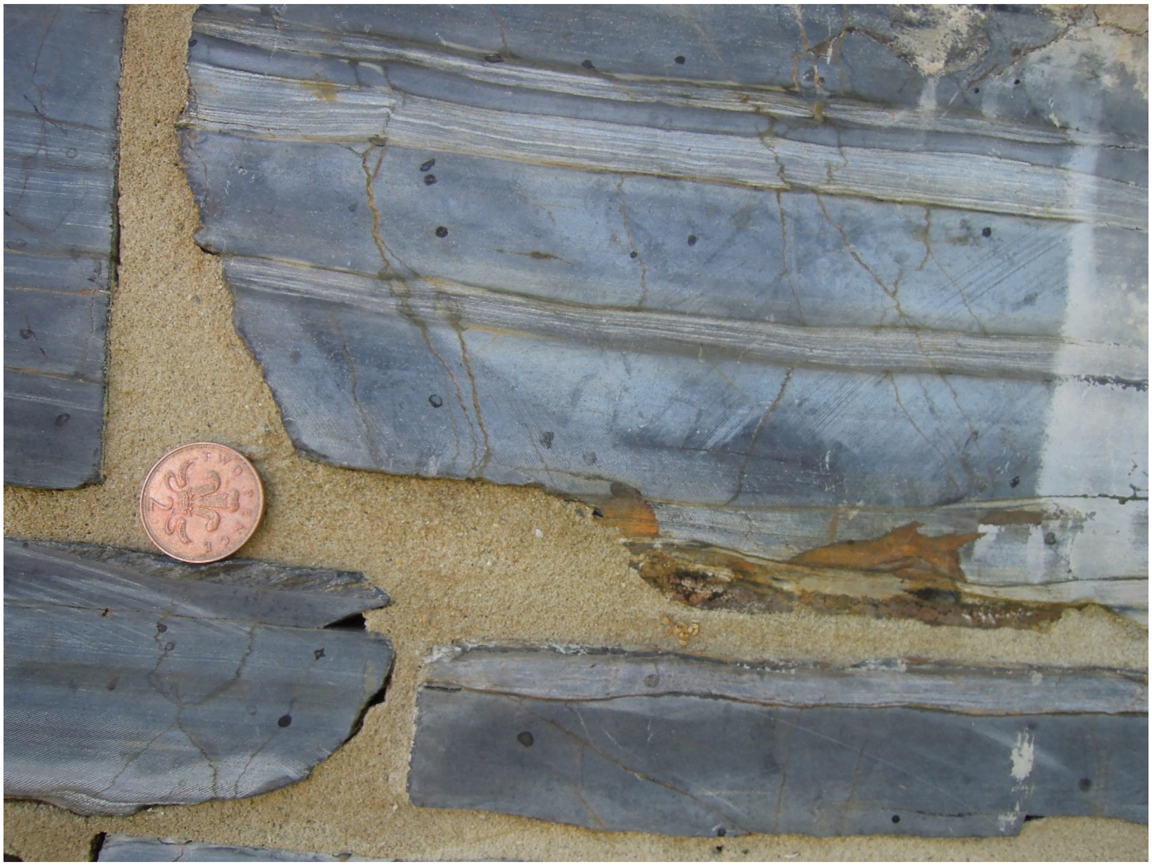

Figure 10. New wall at entrance gateway. Grey pelitic slate, partly laminated. South end of Earnesettle Lane, Plymouth.

Figure 11. Roadside wall, 2km north of Broadwoodwidger. Brown-weathered slate with dusty finish. Some blocks are colour laminated.

193, Pale Buff Slate

Pale buff, yellow, grey and brown well cleaved pelitic slate, greenish where fresh, is assigned the Material Code 193. The slate in most occurrences is silvery or lustrous (Figures 1 & 2) and some occurrences around the Kingsbridge estuary were originally described as phyllites. The slatey penetrative cleavage is strong and regular in most buildings (Figure 2).

The slate of these southern occurrences resembles the Meadfoot Group slate of Kingsbridge and is very likely drawn from that group. However, it is more lustrous, probably on account of more thoroughly recrystallized micas, inviting comparison with the schists of the Start Complex. It is associated with chlorite schist and epidote-rich volcanic rock, themselves of very low grade even although they also are assigned to the Start Complex. One is drawn to speculate that this group of lustrous slates represents part of the Meadfoot Group of higher-than-typical metamorphic grade from quarries close to the contact with the Start Complex.

An entirely separate group of occurrences of pale buff, strongly cleaved pelitic slate is centred around Milton Abbot and the borderlands with Cornwall near Greystone Quarry. They are clearly unrelated stratigraphically to the south Devon occurrences. The slate ranges from pelitic to semipelitic in composition and is associated with hyaloclastites in one building. There are several formations from which the stone could have been won in this area of complex stratigraphy and structure. Candidates include the Brendon and Lynton Formations both of which are predominantly slatey, and the Teign Chert and Milton Abbot Formation both of which include some slate.

Figure 1. Pale pelitic slate, roadside wall, near Woolston Villa, 2km southeast of South Milton.

Figure 2. Close-up of stone in Figure 1 showing strong penetrative cleavage.

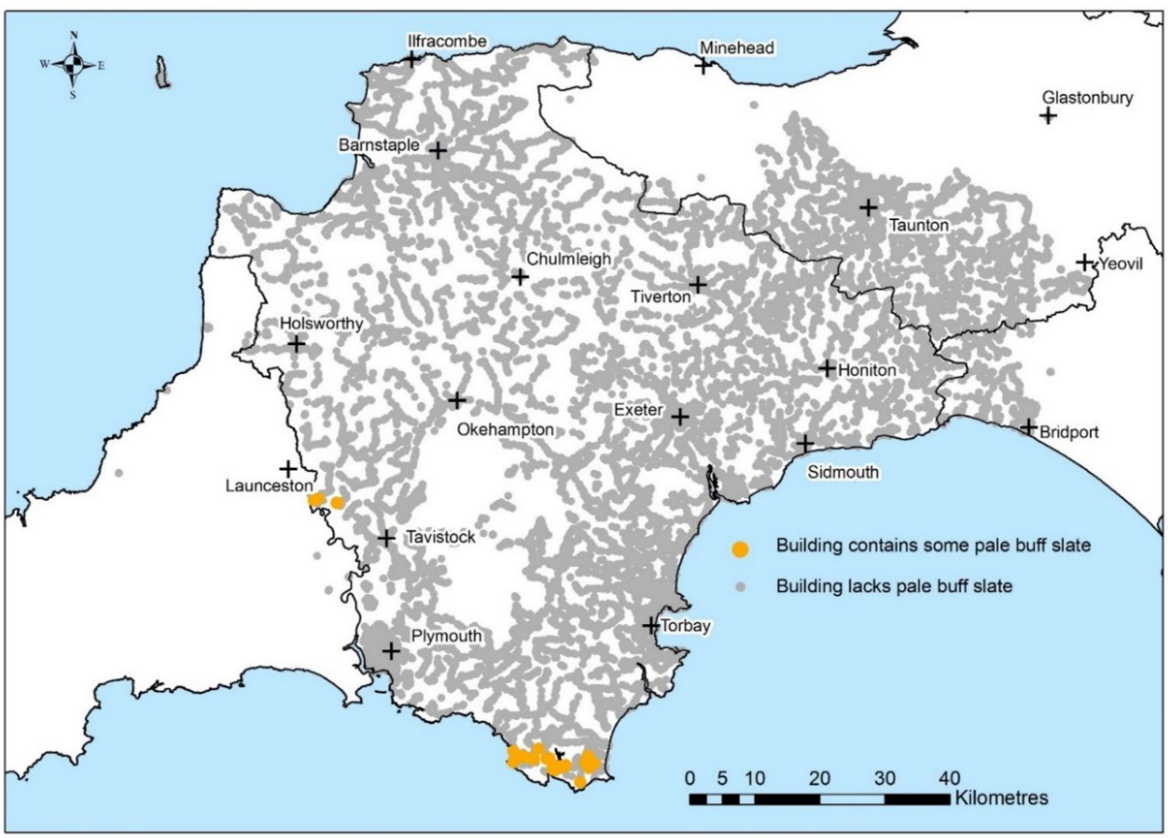

Figure 3. Distribution of pale buff slate in buildings.

197, Polyphant Stone

Polyphant Stone is a dark grey medium-grained igneous rock composed of olivine altered to serpentine, talc, pyroxene, hornblende and opaque minerals, lacking oriented fabric and with a compact and homogeneous texture (Power and Scott, 1995). It is ultrabasic in composition and has been given a number of different technical names including altered picrite and serpentinite. Because of its refractory nature, it was formerly used for crucibles; hence the former name "Pot Stone" (Watson, 1911, p94). It was formerly won from a quarry near the Cornish village of Polyphant west of Launceston. The extraction licence is still extant but there is no current production.

In the external walls of buildings, it may retain a smooth original finish but is susceptible to spalling where the original surfaces of building blocks have fallen off leaving a much rougher finish to the exposed surface (Figure 4). In both its original state and this partly decomposed one, it is in many places possible to identify the outlines of original olivine grains, now represented by somewhat rounded aggregates of brown serpentine minerals evenly dispersed through the rock otherwise composed of dark pyroxene and its alteration products, and lighter coloured talc (Figures 2, 4 and 5). The altered olivines in some cases stand proud of the average surface of the block and are stained red, giving the rock a knobbly appearance. The rock is in places traversed by veins rich in brown-weathered altered olivine (Figure 2).

Polyphant Stone takes a fine polish and has been used to decorative effect in church furniture, objets d'art etc. The arcades of St Mary's church, Bratton Clovelly are made of polished Polyphant Stone giving the interior of the church an especially rich atmosphere.

The best documented occurrences during the survey up to 10-05-2014 are in St Peter's Shaldon and St Lawrence's Bigbury with additional possible use in the church of St Peter and St Paul, Ermington and All Saints, West Alvington, of which, St Peter's shows by some margin the widest use of the stone. Since that time the stone has also been identified in the dressings of the parish churches of Newton Ferrers, Shaugh Prior, Lydford, Bridestowe, Lewdon, Germansweek, St Giles in the Heath, Clayton, Luffincott, Stowford, Coryton, Milton Abbot, Dunterton, Mary Tavy, Peter Tavy, Alverdiscott and Bradworthy. Both St Eustacius' and St Andrew's churches in Tavistock include some Polyphant Stone. In nearly all these churches its external use is restricted to the dressings of some of the windows. Woodacott Methodist chapel contains at least one block in the walling, surely a fortuitous occurrence. The distribution of the stone is almost entirely restricted to medieval churches (Figure 7); the single exception in north Devon is its identification in the cloister windows of Hartland Abbey, now a private house but of course, originally an abbey, and in East Devon, St Peter's, Shaldon, completed in 1911. There is a suspicion that the prevalence of Polyphant Stone dressings in churches restored in the Nineteenth Century by the Sedding architectural practice of Plymouth is more than a coincidence.

On the other hand, looking at the distribution of these churches (Figure 7) one is struck by their concentration in west Devon. Only All Saints, Alverdiscott and St Peter's, Shaldon are more than 17km from the River Tamar or the sea. One is drawn to speculate that water transport was important in the export from Cornwall of this much sought after decorative stone in medieval times.

References

Power, M.R. and Scott, P.W., 1995. Talc-carbonate alteration of some basic and ultrabasic intrusions in Cornwall. *Proceedings of the Ussher Society,* **8,** 392-397.

Watson, J. 1911. *British & Foreign Building Stones*. Cambridge University Press

Figure 1. East end of St Lawrence' church, Bigbury showing grey unfoliated Polyphant Stone used for the buttresses and the dressings of the east window. The walls are made of Dartmouth slate; its characteristic green and red colours are exposed beneath the window where acid run-off has kept the stonework clear of dirt and lichen.

Figure 2. Close-up of the east wall of Bigbury church. The brown patches are of altered olivine. The lichen spots have the same diameter as a 20p piece.

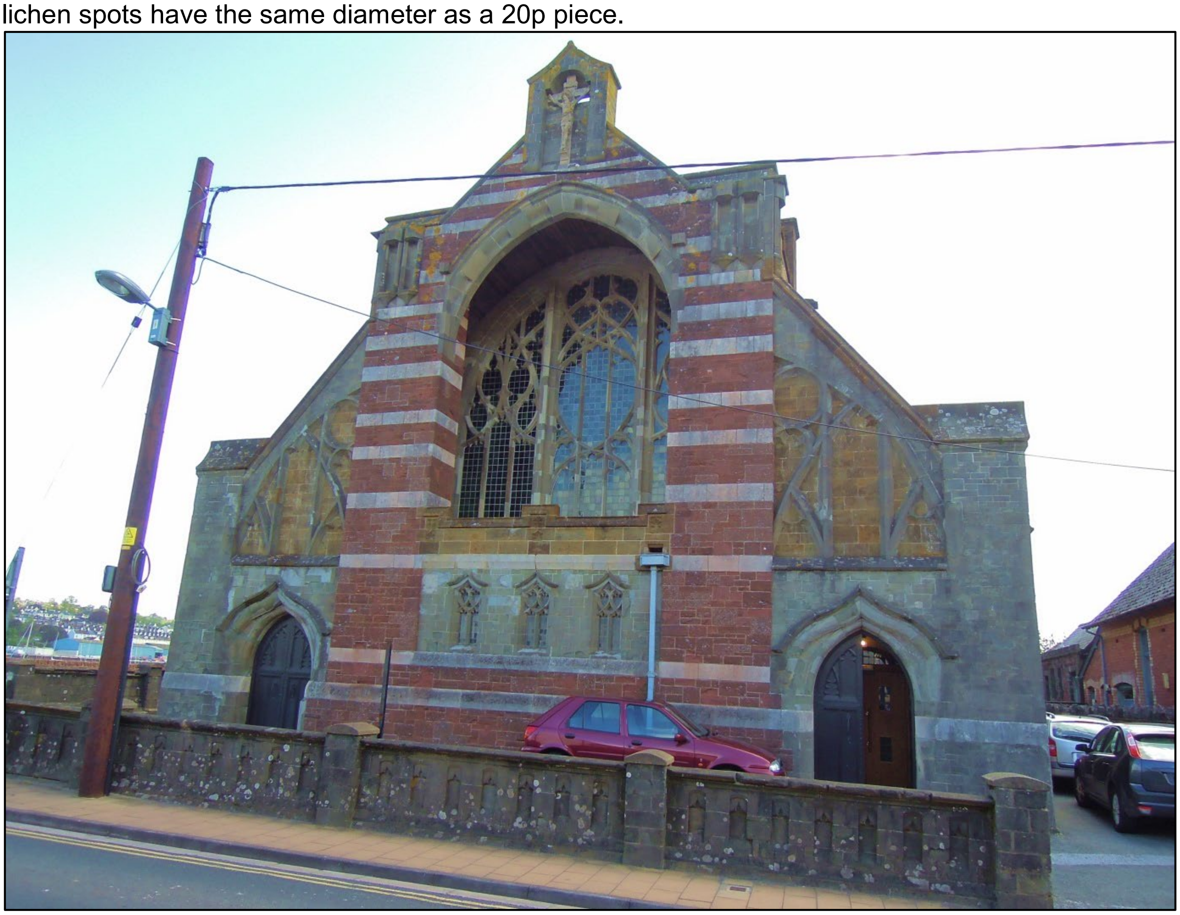

Figure 3. West end of St Peter's, Shaldon composed of Polyphant Stone (grey), Teignmouth Breccia (red), Portland Stone (white) and Ham Hill Stone (brown) with a string course towards the base of mid-Devonian limestone from Plymouth.

Figure 4. Detail of Polyphant Stone blocks, St Peter's Shaldon, showing typical spalling of the surface.

Figure 5. Enlargement of the photo above showing the outlines of original igneous mineral grains now pseudomorphed by alteration products.

Figure 6. East window of Holy Cross church, Newton Ferrers. Dressings are of grey and brown Polyphant Stone and the walls are of the distinctive pale grey limestone used in the town.

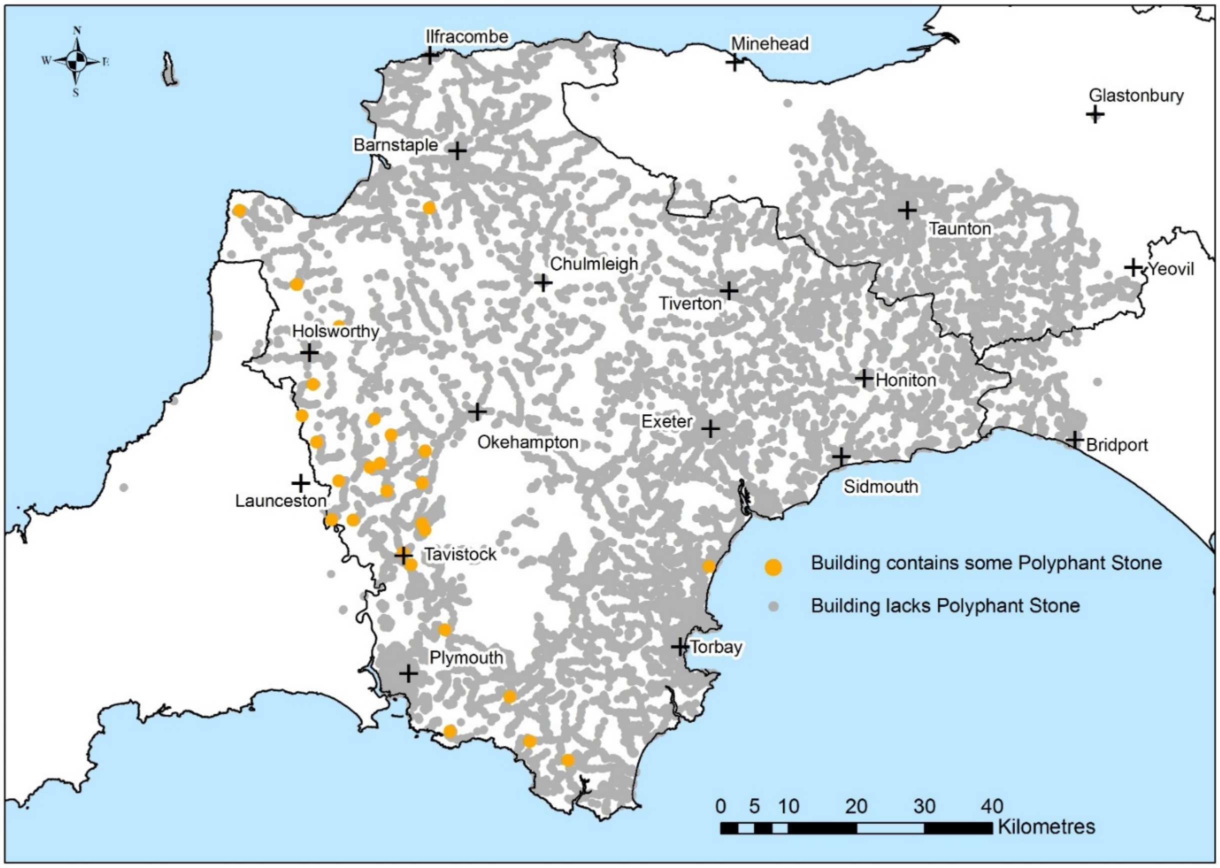

Figure 7. Distribution of Polyphant Stone in buildings.

198, Carbonate rock from Yealmpton

Brown unfoliated carbonate rock is typical of buildings in Yealmpton and the surrounding villages, intermixed with more typical pale- and medium-grey limestone. It seldom shows any oriented fabric and in many cases forms large equant blocks, in some cases with somewhat rounded corners. It has a distribution restricted to Yeampton and the surrounding villages and very likely was quarried locally. Samples tested with dilute hydrochloric acid barely fizz, suggesting that the stone is dolomitic. De la Bêche (1839, p491) thought so too.

Reference

de la Bêche, H.T., 1839. *Report on the Geology of Cornwall, Devon and West Somerset*. Longmans, London.

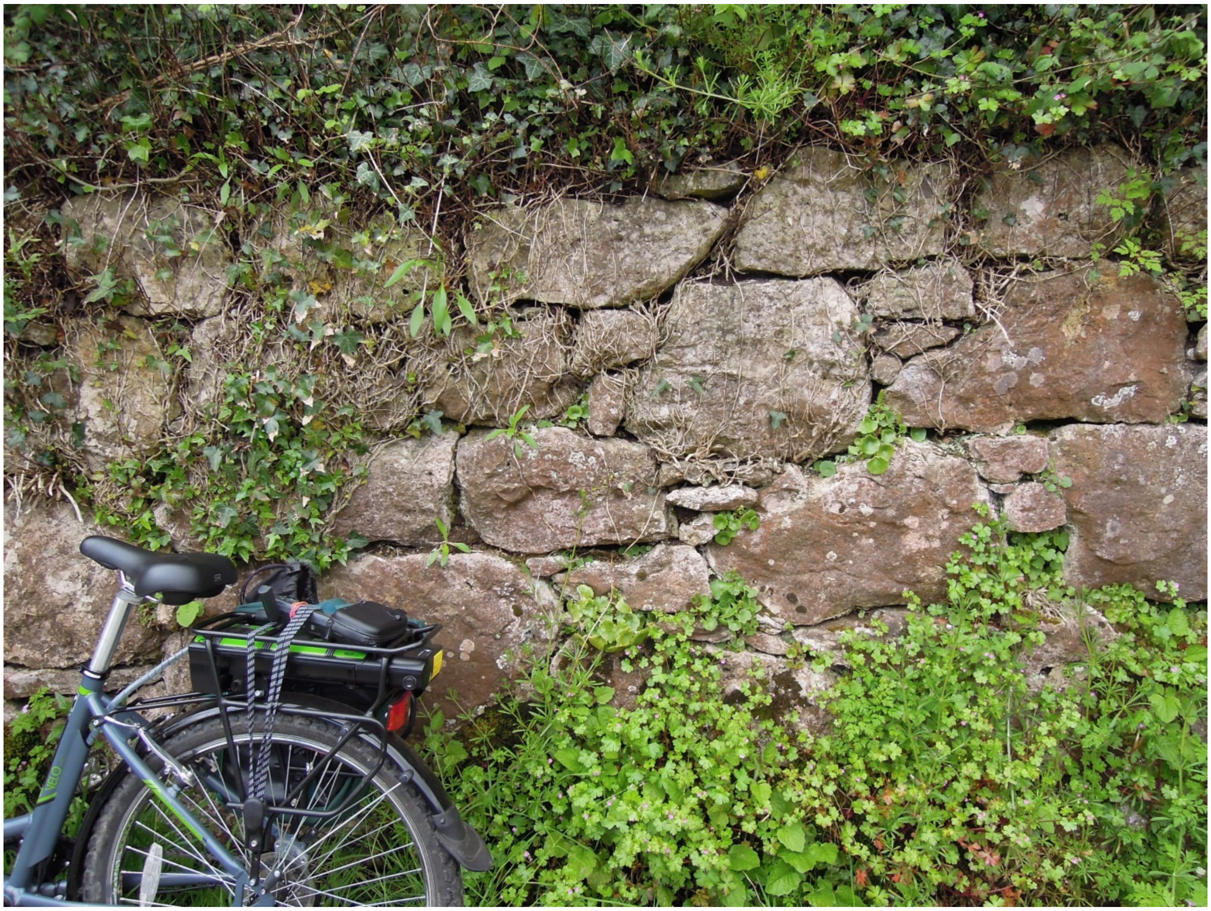

Figure 1. Roadside wall adjacent to Higher Torr Farm. Brown, locally almost ochreous carbonate rock as large unfoliated blocks.

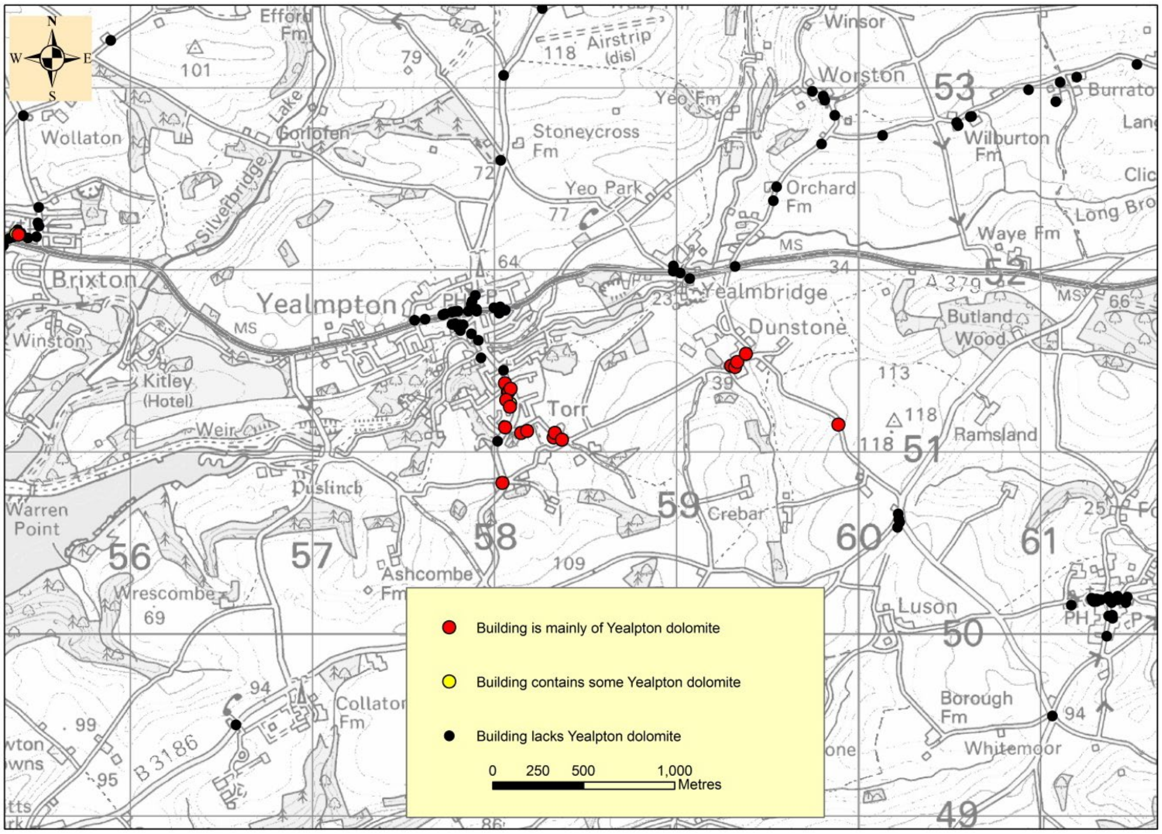

Figure 2. Distribution of Yealpton dolomite in buildings. Topographical mapping © Crown copyright and database rights 2018 OS 93830343.

199, Hyaloclastite

Many of the Devonian volcanic rocks used for building in the southern part of Devon have angular voids, in some examples filled with a fine-grained clay mineral. Unfortunately, these were confused with vesicles/amygdales until quite far through the survey. It is clear that angular voids like those shown in Figure 1 could not have originated as gas holes in solidifying magma and are not vesicles. They are now interpreted as the trace of fragments of volcanic glass, now altered and mainly eroded away, and the enclosing rocks as hyaloclastites, volcanics made up of angular glass fragments enclosed in lava or tuff and formed by the rapid quenching of magma as it flows into water to form the glass and its explosive brecciation. The identification of these rocks as hyaloclastites was deferred until the survey reached Rattray in May 2012. Those seen earlier in the survey and originally coded as undifferentiated volcanic rocks of the Devonian succession (Code 161) were reassigned to the hyaloclastite class (Code 199) based on the existing narrative field descriptions.

Rock-types identified as hyaloclastite are grey, brown or dark green poorly cleaved slates that enclose these angular voids typically 1-5mm across, the identifying characteristic. The groundmass is typically slatey but rather poorly cleaved compared to nearby slates of sedimentary origin, and the building stones tend to be equant rather than flattened in the cleavage (Figure 2). The voids can easily be mistaken for vesicles especially if they themselves have been flattened in the cleavage planes (Figure 3). They may be filled with clay minerals and/or show a banded distribution (Figure 4). The groundmass is generally fine grained and its constituent minerals have not generally been identified but are assumed to include quartz, feldspars, chlorite, clay minerals and iron oxides. Devitrified glass may be so abundant that the rock resembles pumice although, as noted, the voids are interpreted not as gas holes but as places where the devitrified glass has fallen out of the groundmass. In some examples, the complex texture may include both glass fragments and vesicles, superimposed on an overall agglomeratic texture (Figure 5).

Similar poorly cleaved slate, typically dark grey or black in colour and forming large blocks but generally lacking the obvious voids formed by devitrified glass is used for building notably for the forts built in Victorian times for the defence of Plymouth against the French (Figure 6) and for a few other structures, for example the wall at the entrance roundabout at Derriford Hospital. The rock is particularly tough and hard wearing, perhaps making it the stone of choice for the forts. At Woodland Fort, it contains sparsely distributed voids identical to those seen in the hyaloclasitite (Figure 7), providing the link between the two groups of rocks.

Hyaloclastites are distinguished from other building stone by their characteristic texture although, as noted above, there is some confusion between these rocks and other volcanics with vesicular texture especially those identified earlier in the survey. The main concentrations are in Plymouth and around Milton Abbot but there is a fairly wide distribution in the South Hams and West Devon (Figure 8). Hyaloclastites are abundant in the volcanic rocks won from Hurdwick Quarry (Code 186) widely used for building in Tavistock. Here they tend to be green and are obviously agglomeratic. They are assigned the code for Hurdwick Stone.

Figure 1. Brown hyaloclastite, roadside wall, Dormy Ave., Mannamead, Plymouth.

Figure 2. Montrose, Rattery. Wall of the garage composed of grey volcanic rock with dispersed voids. All gradation exist from rock like this to slate where the voids are reduced to spots streaked out in the cleavage, in many cases filled with ochreous alteration products.

Figure 3. Hyaloclastite with glass shards, now voids, flattened in the cleavage. Garden wall, Trethake, Efford Road (north side), Plymouth.

Figure 4. Devitrified glass fragments altered to brown clay minerals showing banded distribution in hyaloclastite, wall at Consort Village Care Centre Trade Entrance, Torr Lane, Plymouth.

Figure 5. Hyaloclastite-agglomerate with complex texture including vesicles *and* glass shards, roadside wall, Church Hill, Plymouth.

Figure 6, entrance to Crownhill Fort, Plymouth. The walls are made of poorly cleaved dark grey slate, believed to be of volcanic origin, the dressings round the doorway of biotite granite probably from Dartmoor and the other dressings and the quoins of grey mid-Devonian limestone.

Figure 7. Dark grey poorly cleaved slate with widely dispersed voids believed to represent weathered-out glass shards, outer wall, Woodland Fort, Crownhill Road, Plymouth.

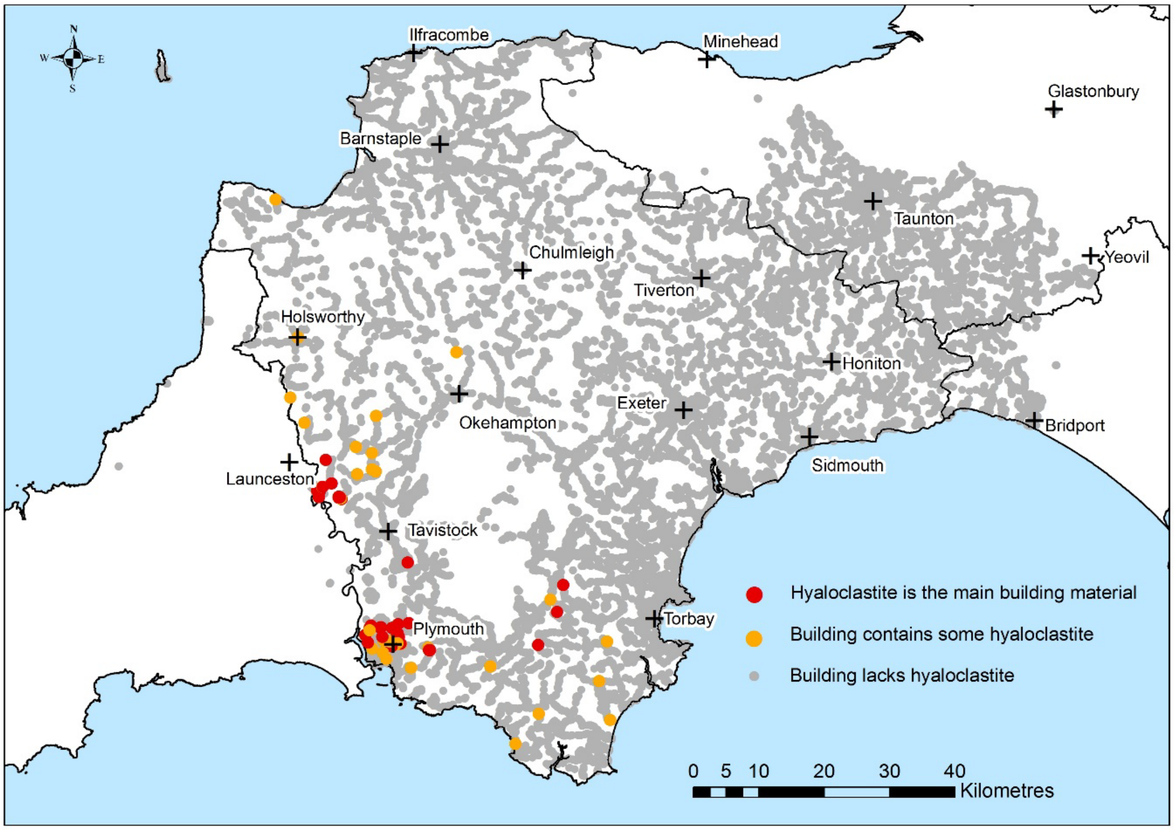

Figure 8. Distribution of hyaloclastite in buildings.

200, Wearde Sandstone member of the Saltash Formation

This is a medium- to fine-grained yellow sandstone composed of close-packed subangular quartz grains with some mica in a calcareous cement. Some blocks appear homogeneous and show onion-skin weathering and leisegang rings, some have approximately oblong outlines with faint bedding lamination parallel to the long dimensions defined by bedding plane partings (Figure 1); these may be richer in mica. The sandstone is accompanied by ochreous-weathered slate (Figure 2) with good to irregular cleavage such that some block outlines are irregular and approximately equant, not elongated in the plane of the cleavage. The ochreous slate has lenses of limestone in some blocks.

The stone is restricted to a few buildings in Plymouth. Sandstone is not well represented in the local succession, the main horizon being the Wearde Sandstone from which this stone is believed to be derived. It is used for the wall to Central Park at the Venn Lane entrance on the A386 and for the dressings of the northern of the two chapels in Ford Park cemetery.

Figure 1. Yellow sandstone with fine colour lamination from the Wearde Sandstone member and grey Middle Devonian Limestone, north side of Clovelly Road, Plymouth.

Figure 2. Orange-weathered impure cleaved sandstone and slate and grey Middle Devonian limestone, north side of Clovelly Road, Plymouth.

202, Slate from the Pilton Mudstone Formation

Slate from the Pilton Mudstone Formation is grey and mainly semi-pelitic with a penetrative cleavage or, in those varieties richer in quartz, with a cleavage that sweeps around quartz-rich lenticular or lozenge-shaped parts that are less well cleaved and have a more granular texture. This applies particularly to slate containing narrow siltstone laminae, now broken up, which are quite common. Hues range from light through medium to dark grey and greenish grey slate also occurs.

It is apparent from the above description that the slate generally lacks distinctive characteristics and if it were necessary to depend on lithology alone, it would be difficult to distinguish this building stone from, for example, the Morte Slate. However, there is a strong association in buildings of the slate with sandstone from the same formation (Code 203, qv, Figure 2) and this sandstone has more distinctive attributes allowing more confident referral to the Pilton Mudstone Formation. It must be admitted that a more than ideal dependence on the location of the buildings in which the slate occurs in relation to the geological map has been used in deciding on the choice between Pilton and Morte slate (Figure 3). Partial justification comes from the fact that both slates are poor quality building stones and are unlikely to have been used far from their outcrop.

Figure 1. Grey slate from the Pilton Mudstone associated with more plentiful brown laminated sandstone from the Baggy Sandstone. Sandleigh Tea Room and Garden, Moor Lane, Croyde.

Figure 2. Dark grey slate, top left and bottom of photo, enclosing a band of laminated sandstone, foreshore, south side of Croyde Bay.

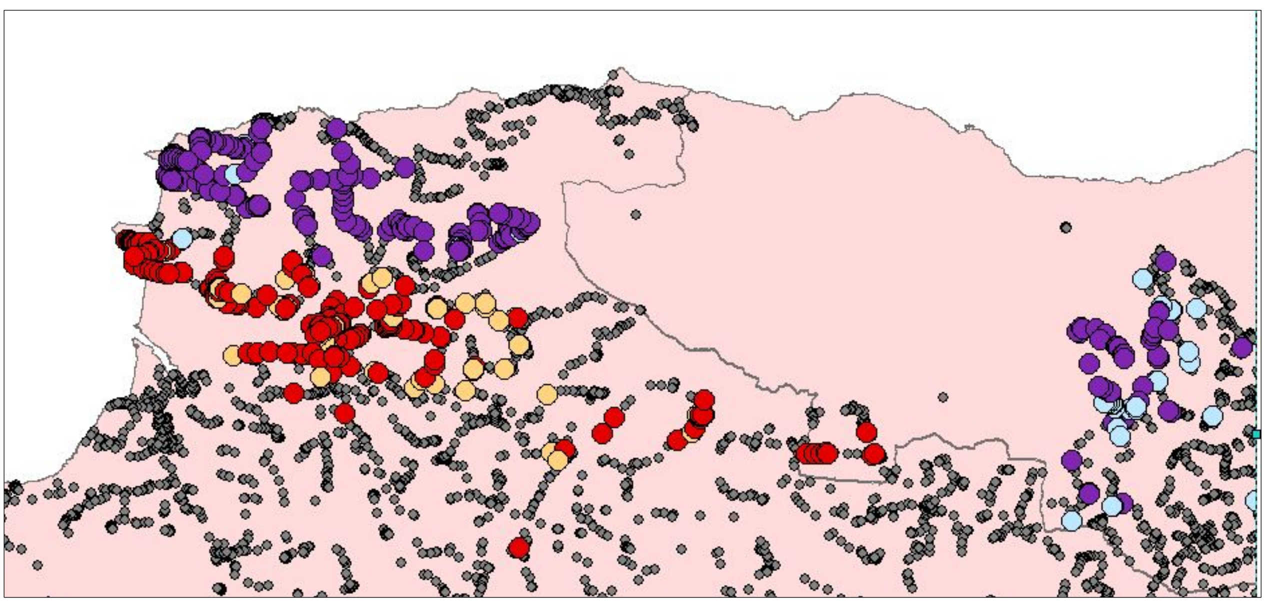

Figure 3. Northwest Devon showing clear geographical separation of buildings containing Morte Slate (purple and pale blue symbols) from those containing slate from the Pilton Mudstone (red and yellow symbols). Buildings containing neither are marked by small grey symbols. Width of view, 80km.

203, Sandstone from the Pilton Mudstone Formation

The Pilton Mudstone Formation contains sandstone beds; thick ones are extensively quarried in the valley of the River Bray just south of Brayford and further examples are very well displayed on the foreshore on the south side of Croyde Bay.

The sandstone is medium-grained varying from pale (Figure 1) to dark grey (Figure 2) with pale varieties preponderating. The clasts are almost exclusively of subangular quartz but small proportions of feldspar have been noted in a few examples. The stone typically has narrow sub-parallel laminae richer in dark minerals (Figures 3 and 4) and many examples are also micaceous (Figure 6) in which case they may be foliated (Figure 5). A significant proportion of buildings with Pilton sandstone also contain slate from the same formation (Figure 3).

The matrix is hard to discern under the hand lens but the rock typically has purer grey pigmentation than sandstone from the Bude Formation perhaps because of a lack of coloured fines in the quartz grain boundaries. The combination of "pure" grey colour with few surface weathered crusts (brown, yellow, red, orange) typical of sandstones from adjacent formations, colour lamination and surfaces coated in mica serves to identify this sandstone with an unusual degree of certainty, but as always, there are many buildings where not all of these properties or even any of them, are well displayed and in these cases the identification is more problematic.

Building blocks are typically of medium size, somewhat larger than a brick and include both equidimensional blocks and those appressed across the bedding (Figure 2). The bedding is defined by narrow darker laminae no more than a millimetre across separated by thicknesses of grey sandstone 5mm to 5cm across. In most blocks it is remarkably regular but in outcrop the stone can be seen to be cross bedded (Figure 10) and in a few examples the bedding appears to be distorted by slumping. The scale of the cross beds is large so than within a single building block, the bedding appears to be laminar.

Ripples (Figure 7) and load casts (Figure 9) have both been observed in this building stone. Mention has already been made of a lack of coloured crusts on weathered examples but in a few cases blocks show some damage through weathering where the outer parts are crumbling along concentric fractures (concentric weathering).

Sandstone from the Pilton Mudstone Formation may be distinguished from sandstone from the Bude Formation by its "pure" grey pigment and general lack of khaki tones on fresh surfaces and lack of brown, yellow, red and orange tones on weathered surfaces. It is distinguished from sandstone from the Bideford Formation which also has a "clean" grey appearance, through the widespread occurrence of mica and lack of brightly coloured weathered surfaces and from the "Cornborough" Sandstone by distinctive bedding lamination and widespread occurrence of mica.

The sandstone is the main building stone of Barnstaple and the surrounding villages (Figure 11).

Figure 1. Tower of St Nicholas' church, Brushford, mainly composed of pale grey blocks of sandstone from the Pilton Mudstone Formation. The colour of the fresh rocks is here as in most places, obscured by surface weathering.

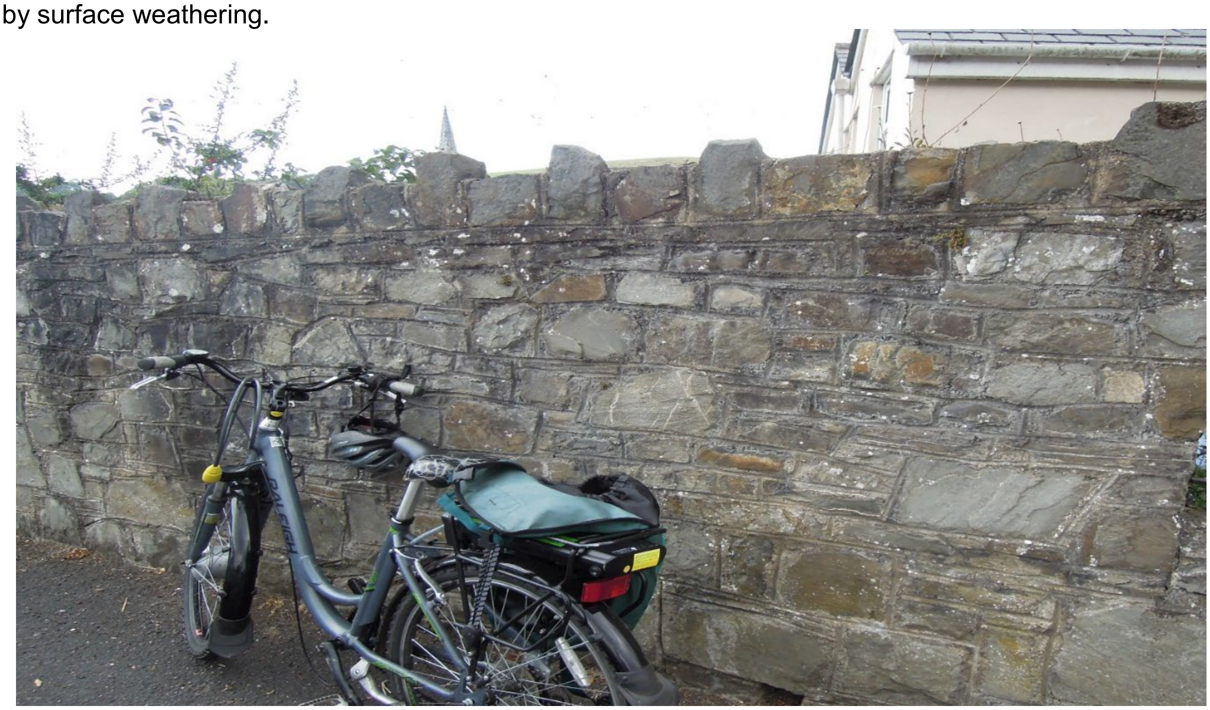

Figure 2; wall on the north side of the main road in Swimbridge at junction with Dennington Hill. Typical dark grey sandstone from the Pilton Mudstone Formation. Weathered blocks are hard to differentiate from the Bude Formation sandstone.

Figure 3. Finely laminated grey sandstone with stronger bedding towards base. Grey slate selvage at the bottom of the picture is typical of the association of slate with sandstone in building stone from the Pilton Mudstone. Roadside wall, Bear Street (south side), Barnstaple.

Figure 4. Typical grey sandstone from the Pilton Mudstone showing "clean" aspects without surface discolouration and characteristic narrow planar laminae richer in dark minerals. Wall outside United Services Bowling Club, Pottington Road, Barnstaple.


Figure 5; Methodist church, Landkey. The quoin of the buttress is made of grey foliated sandstone from the Pilton Mudstone weathered brown in some blocks. The rest of the wall is of laminated grey-, cream-, yellow- and black-weathered sandstone with knots of chert from the Codden Hill Chert.

Figure 6. Bedding surface of dark grey sandstone rich in mica. Width of view, 20cm. Wall in front of the primary school, Swimbridge.

Figure 7. Ripple marks on the surface of a sandstone block laid with bedding parallel to the plane of the wall. Wall in front of the primary school, Swimbridge.

Figure 8. Typical planar bedding lamination in sandstone from the Pilton Mudstone. Wall in front of the primary school, Swimbridge.

Figure 9. Load casts on sandstone blocks laid with bedding parallel to the plane of the wall. Wall in front of the primary school, Swimbridge.

Figure 10. Cross bedding in sandstone band enclosed by slate, foreshore on south side of Croyde Bay opposite Down End. The cross bedding is on a large scale and this explains why it is seldom identified in building blocks. The scale also explains why the bedding defined by narrow dark laminae appears planar rather than curved in building blocks.

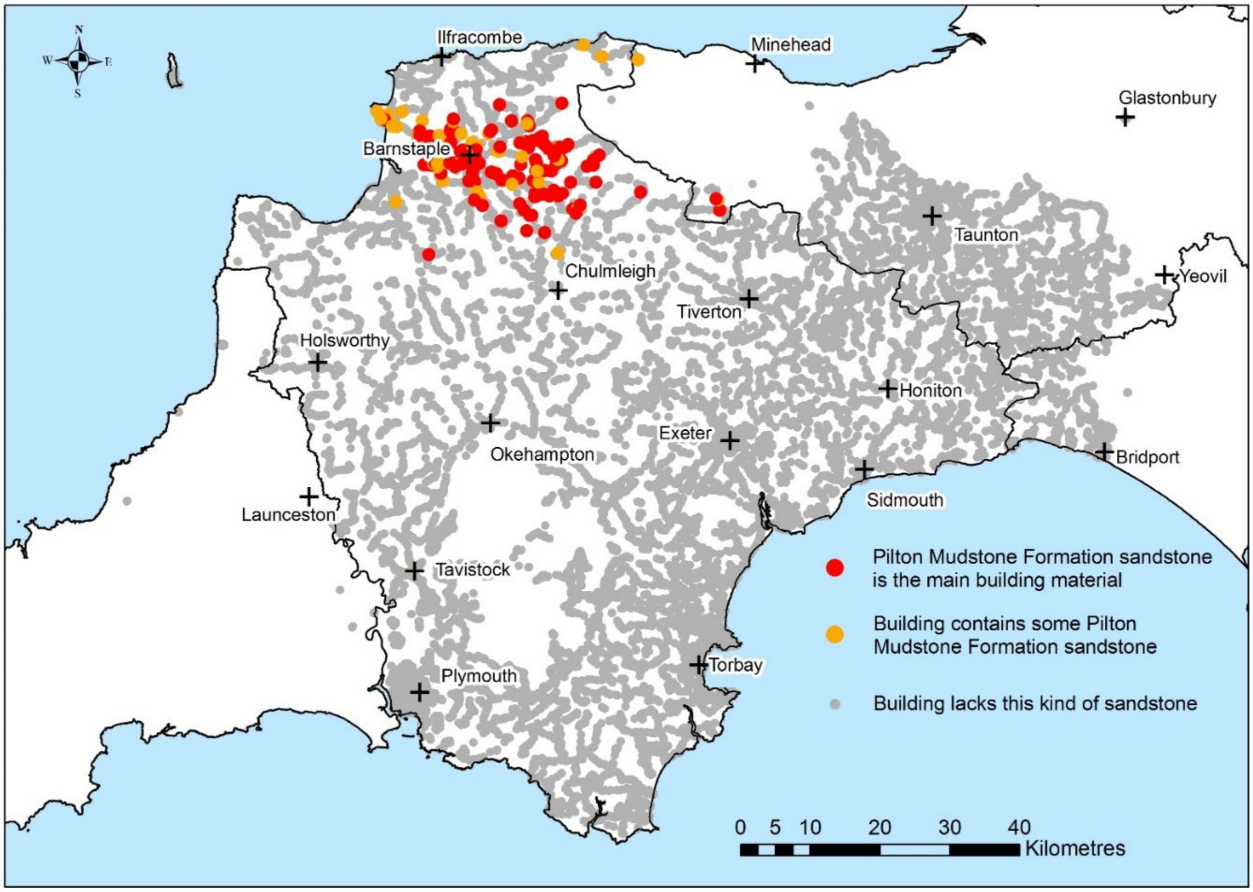

Figure 11. Distribution of Pilton Mudstone Formation sandstone in buildings.

204, Beach Rock

Six buildings examined during the survey, all of them churches, contain coarse-grained shelly calcarenite most likely won from the raised beach at the north end of Saunton Sands and called by the EH/BGS Strategic Stone Study 'Saunton Stone'. It is a brown medium-grained friable sandstone with an open texture and faint colour and grain size bedding lamination parallel to the long axes of the building blocks in the best examples, (Figures 1 and 2). The clasts are a mixture of quartz and calcite including comminuted shell fragments in varying proportions. Some blocks contain well rounded pebbles. Most examples have less regular bedding or appear unbedded (Figures 3 and 4). Apart from St Anne's chapel and St Brannock's church in Braunton, they occur as just a few blocks in buildings (Figure 4). They are easily the worst quality building stone seen in the survey. An example was forwarded to the Sedgewick Museum, Cambridge for inclusion in the building stone collection curated there (Watson, 1911, p216).

Three metres of beach rock are exposed at the base of the cliff below the Saunton Sands Hotel and aspects of this exposure suggests that it was once a quarry and perhaps the source of much of this kind of stone used in buildings (Figure 6).

Reference

Watson, J., 1911. *British & Foreign Building Stones*. Cambridge University Press

Figure 1. St Anne's chapel, Saunton, made entirely of Saunton Stone.

Figure 2. Detail of the stonework, St Anne’s chapel, Saunton


Figure3. Church of St Mary the Virgin, Pilton. A block of beach rock incorporated in the south side of the church.

Figure 4. Tower of the church of St Mary the Virgin, Pilton. The quoin is made of beach rock. The walls are made of sandstone from the Pilton Mudstone Formation.

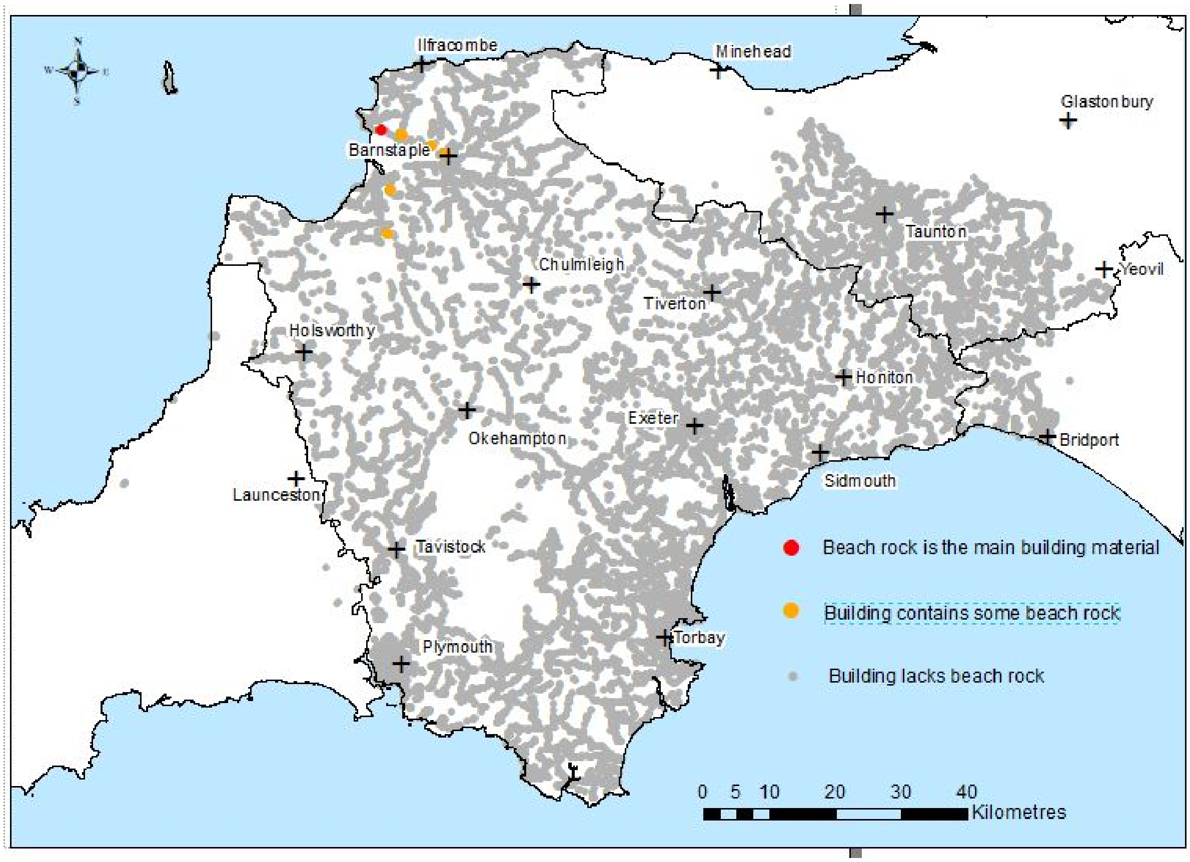

Figure 5. Distribution of beach rock in buildings.


Figure 6. Beach sand rock exposed at the base of the cliff below the Saunton Sands Hotel.

206 and 217, Quality Grey Sandstone from the Bude and Bideford Formations

These codes refer to grey medium-grained sandstone typically homogeneous and lacking planar fabric. Code 206 was originally applied to sandstone of this kind used in Abbotsham and believed to be won from the Cornborough Sandstone, the topmost unit of the Bideford Formation, which crops out in the sea cliffs to the west near Greencliff Farm. It was subsequently extended to cover similar sandstone with a wider distribution in the country between Instow, Great Torrington, Hartland and the sea (Figure 10). Code 217 was applied to similar good quality sandstone used in Bideford. Only four of these occurrences were identified. Two of these had distinctive and unusual lozenge-shaped voids up to 4cm long lying in the bedding, perhaps the sites of claystone inclusions. The other two occurrences are indistinguishable from sandstone coded 206; because of the small number of occurrences and the lack of distinguishing features in two of the occurrences, the decision was made to amalgamate the sandstones with these codes for the purposes of description.

Their main characteristics are as follows:

- Medium grained; the sandstone is typically clean-washed with few fines between the clastic grains which are typically exclusively of quartz, as subangular to angular easily resolved grains; in some occurrences, the grain boundaries are the preferred sites for the growth of red algae and a few variants are micaceous.
- Pale grey body colour (Figures 1 and 2); there are exceptions where the colour is quite dark (Figure 3) and pale grey sandstone blocks in many buildings have a dark grey weathered skin; orange- and red-weathered varieties are the exception rather than the rule.
- large blocks of homogeneous, good quality stone (Figures 1, 4 and 5); building blocks tend to be equidimensional and are up to 50cm on a side (Figure 6); bedding is present in many blocks, but its expression is typically restricted to spaced narrow laminae of darker rock (Figure 7). Because of its good quality, the stone tends to be quite widely used for the quoins or dressings of prestige buildings (Figures 1, 4, 5).

The building stone is distinguished from the brown friable stone of Westward Ho! (Code 207) by stronger cement, poorly defined bedding, larger blocks and predominantly pale grey (not brown) pigmentation (Figure 9). It is distinguished from the typical sandstone of Bideford (Code 215) by larger blocks and lack of impurities i.e. much better quality and from the Bude Formation sandstone by larger blocks and lack of khaki pigmentation (Figure 8). In many cases the mode of occurrence, for example as the quoins of buildings mainly of another inferior kind of sandstone, suggests that this kind of sandstone is just a better quality variant of Bude, Bideford or Westward Ho! sandstone specially chosen from the run of quarry product for use in the quoins and dressings. While most of the buildings in which it occurs fall within the outcrop of the Bideford Formation reinforcing the view that the stone comes from that formation in many cases, some are quite distant and it is far from clear, as originally thought, that all occurrences are of stone from the Cornborough Sandstone and other Bideford Formation sandstones. It is probable that some of the stone is from the Bude Formation. Indeed, transitional rocks types do occur here and there. If this is the case, it is remarkable that it does not have a wider distribution on and close to the Bude Formation outcrop which covers a large proportion of central and western Devon.

Figure 1. Large blocks of pale grey sandstone used for the dressings of the west door of St George's church, Monkleigh. The walls and relieving arch are made of Bude Formation sandstone.

Figure 2. Red and orange-weathered sandstone from the Bideford Formation with grey high-quality sandstone used for the dressings. Queen Anne's Apartments, High Street Bideford.

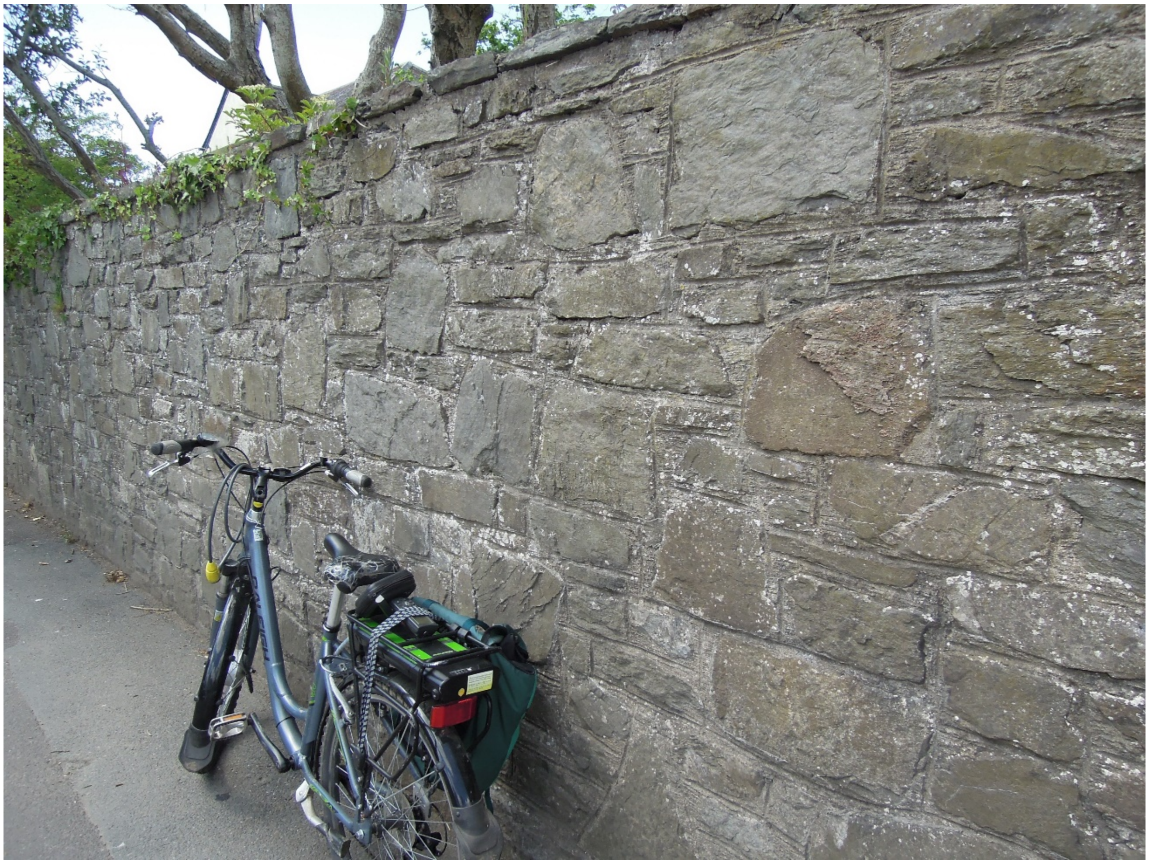

Figure 3. Dark-weathered sandstone. Wall on the north side of Calf Street, Great Torrington.

Figure 4. Dressings of filled-in doorway, Pannier Market, Bideford. The wall is otherwise made of the sandstone typical of Bideford.

Figure 5. Large blocks of pale grey sandstone used for the dressings of the south porch door, All Saints church, Clovelly.

Figure 6. South chapel and south aisle of St Andrew's church, Alwington. Ashlar walling and quoins are made of approximately square blocks of good quality grey sandstone.

Figure 7. Pale grey laminated sandstone block, upper right. Tower of St Peter's, Westleigh, south of Instow.

Figure 8. South transept of St Michael's church, Great Torrington. There is a gradation of colours from the pale grey, almost white typical of this group of sandstones and the more strongly pigmented Bude Formation sandstones.

Figure 9. Limekiln above the beach northwest of Greencliff Farm, Abbotsham. The stonework shows a mixture of pale grey sandstone coded 206 and brown bedded friable sandstone from Westward Ho! coded 207 including intermediate rock types.

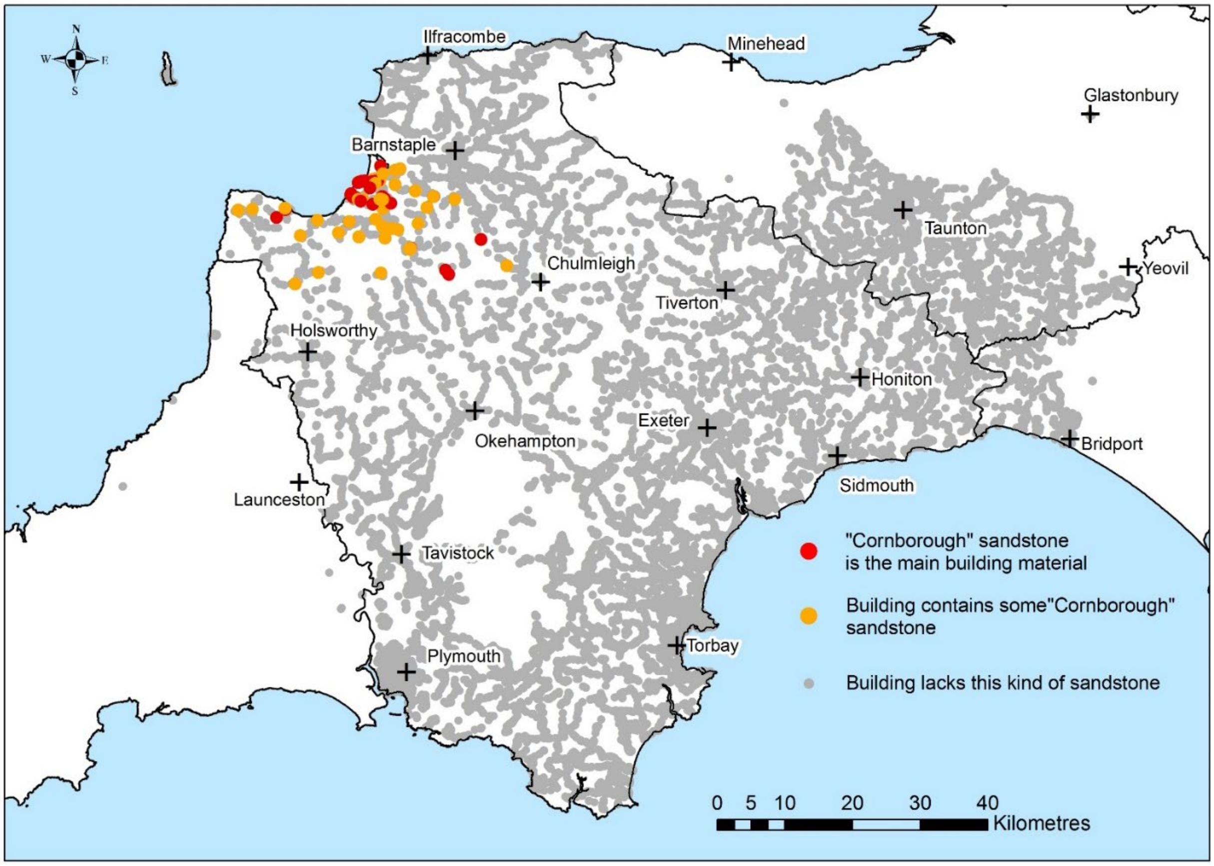

Figure 10. Distribution of sandstone coded 206 and 217 ("Cornborough" sandstone) in buildings.

207, buff laminated Sandstone of Westward Ho!

The stone is medium-grained, porous, friable and poorly cemented and typically has bedding lamination defined by colour and grain size. Building blocks are shorter across the bedding than in the other dimensions and are medium sized (Figures 1-3). Exceptionally, the rock contains mica. It is fawn, khaki or rich brown in colour and a relatively small proportion of blocks have orange-weathered surfaces like the sandstone from the Bideford Formation (Code 215). Perhaps its friable nature prevents the build-up of dirt and weathering products on the surfaces of the stone.

It has a restricted distribution in the Westward Ho! area (Figure 5) but the source quarry has not been identified. Gradations from this kind of sandstone and that more typical of the Bideford Formation are present in many locations, for example in the roadside wall at Obs. 30336 on the west side of Heywood Road between Bideford and Northam (GR 244943, 128087). The open texture, friable nature resulting in the maintenance of fresh rock surfaces in many walls, and characteristic colour distinguish this building stone type from other sandstones. Widespread gradations to building stone coded 215 indicate that it is also from the Bideford Formation (eg Figure 4).

Figure 1. Slab-shaped blocks of brown friable sandstone showing bedding lamination (Code 207) and rounded cobbles of pale grey sandstone (Code 206) picked off the beach, roadside wall, Golf Links Road, Westward Ho!


Figure 2. East end of St Margaret’s church, Westward Ho!

Figure 3. North aisle of St Margaret's church, Westward Ho!

Figure 4, outbuilding adjacent to the road at the junction of the B3236 with Bay View Road, Westward Ho!. The building stone has attributes covering the range from those typical of sandstone from the Bideford Formation (Code 215) to those typical of this brown friable sandstone.

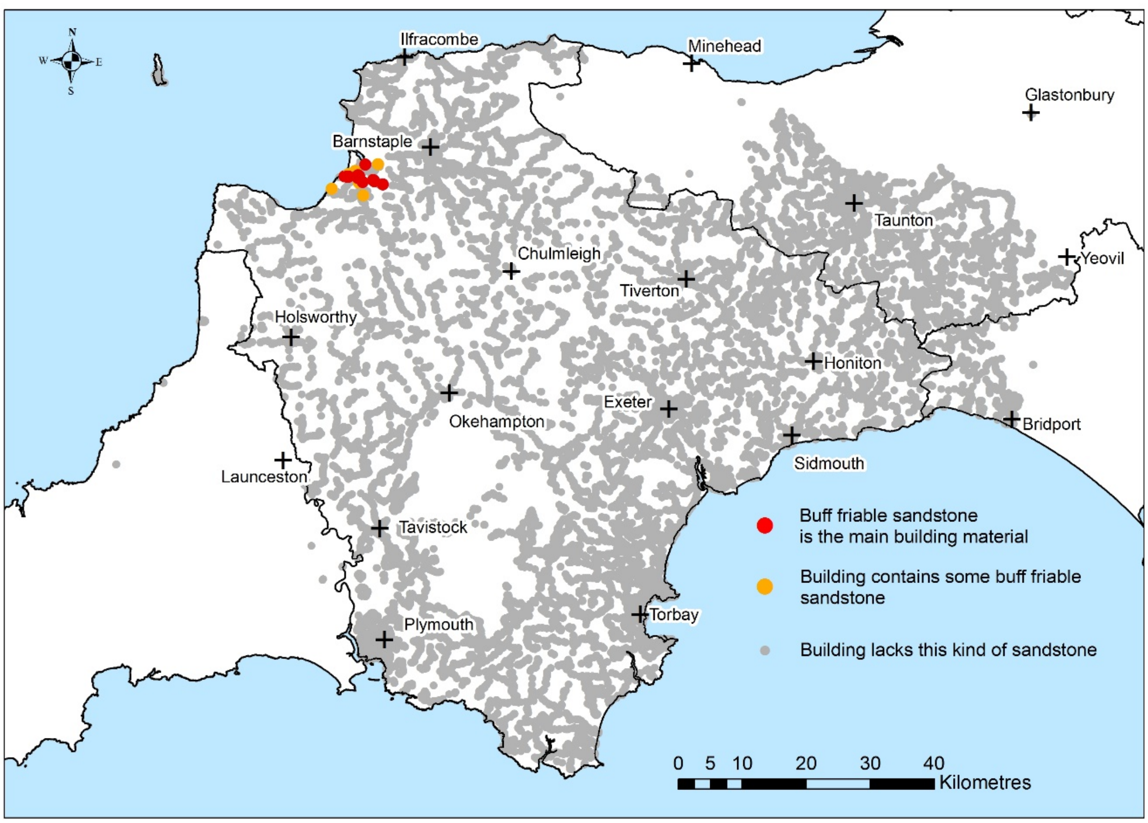

Figure 5. Distribution of buff friable sandstone in buildings.

208, Pentewan-type elvan

Elvan similar to the kind won from Pentewan in Cornwall (Bristow, 2014; English Heritage and British Geological Survey, 2015) is mainly restricted to the village of Lifton and its environs close to the road to Launceston in west Devon and to Bere Ferrers on the west bank of the River Tavy near its junction with the River Tamar (Figure 4). It is a buff fine-grained quartzo-feldspathic rock lacking obvious dark minerals, in many cases encrusted with pink algae and is markedly homogeneous (Figure 5), a property no doubt making it suitable for shaping into building blocks. Its use in Lifton for all of houses, outbuildings and walls as well as the parish church (Figures 1, 2 and 3) is perhaps encouraged by the lack of decent local stone which is mainly black slate of indifferent quality. It may have been brought from Cornwall by boat or barge for the buildings in Bere Ferrers.

The stone resembles float of yellow microgranite seen close to the Roborough Stone quarries on Roborough Down; these rock types are associated in some buildings (Figure 8).

References

Bristow, C. M., 2014. The geology of the building and decorative stones of Cornwall. *In* Cassar, J., Winter, M. G., Marker, B.R., Walton, N.R.G., Entwisle, D. C., Bromhead, E.N. and Smith, J.W.N. (Eds.). *Stone in Historic Buildings: Characterization and Performance.* Geological Society, London, Special Publications, **391**, 93–120.

English Heritage and British Geological Survey, 2015. *The Strategic Stone Study Database* www.bgs.ac.uk/mineralsUK/buildingStones/StrategicStoneStudy/EH_project.html

Figure 1. Arundel Arms, Lifton.

Figure 2. Outbuilding opposite St Mary's church, Lifton, of black slate with elvan quoins and lintels.

Figure 3. Terrace of C19 houses, Duntz Hill, Lifton. The front elevations are of elvan ashlar, the side wall of black slate rubble. The gateposts are granite monoliths.

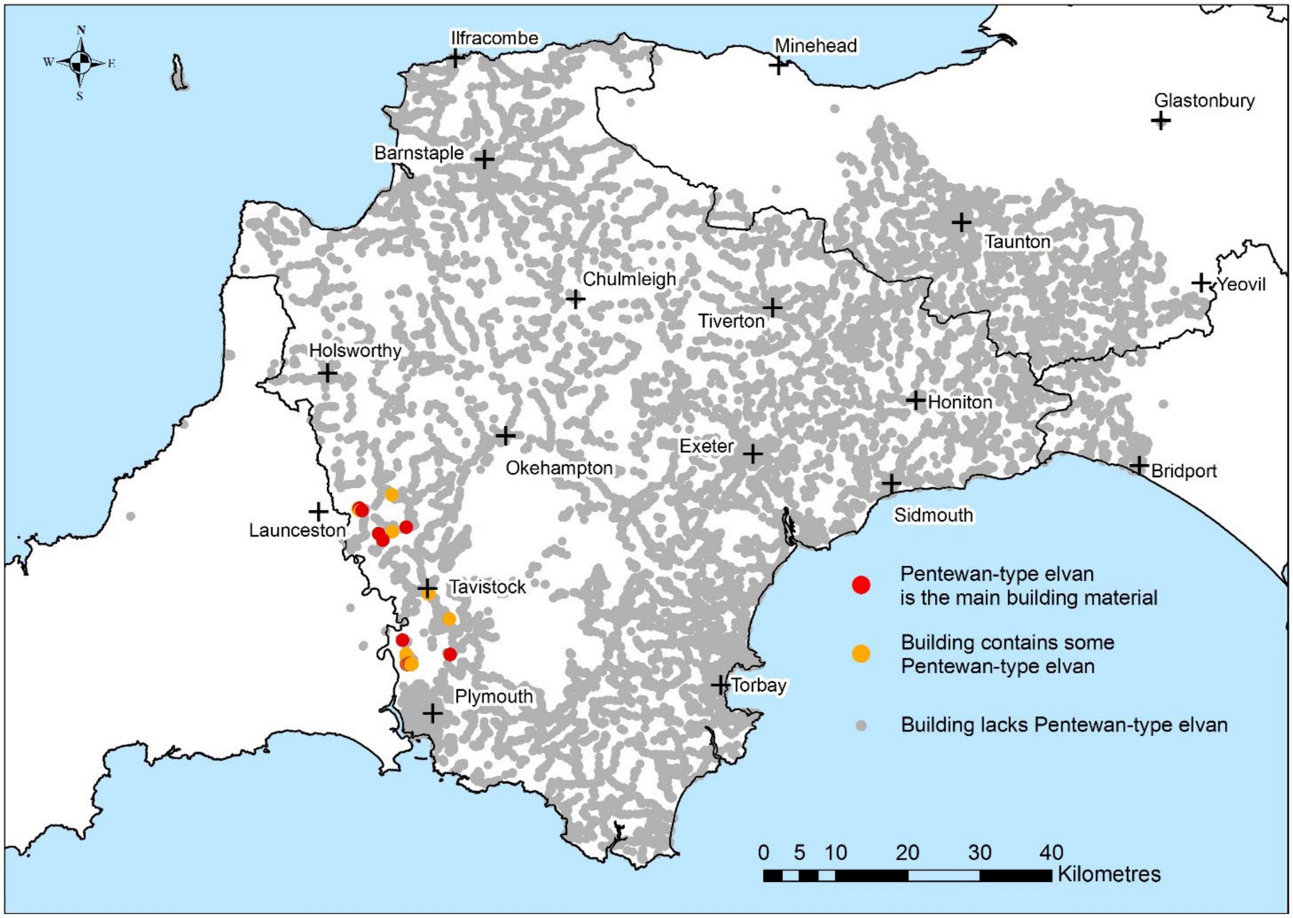

Figure 4. Distribution of Pentewan-type elvan in buildings.

Figure 5. Dressings of the south porch door, St John's church, Stowford.

Figure 6. Booking hall and stationmaster's house, Bere Ferrers. The walls are mainly of slate from the Tavy Formation with larger pale yellow blocks of elvan.

Figure 7. St Andrew's church hall, Bere Ferrers. The dressings round windows and door are of even-grained biotite granite.

Figure 8. River embankment, Bere Ferrers. Yellow elvan associated with Roborough Stone (qv) blocks on lower left. The main building stone is slate from the Devonian.

210, Slate from Mill Hill Quarries

This code represents good quality slate building stone used mainly in Tavistock and Lamerton. Its distinguishing features are:

- pelitic composition; composed largely of clay minerals or micas with very little quartz or other granular minerals
- strong penetrative cleavage (Figures 1, 2, 3 and 4)
- large blocks compared to most slate building stone used in Devon (Figures 1 and 4)
- preponderance of dark grey, blue-grey and black stone (Figures 2 and 3).

Some occurrences were described in the field as mudstone, reflecting the fact that although universally cleaved, the cleavage planes are not everywhere obvious and the stone looks more like mudstone than slate unless closely observed. The dark grey colour is by no means universal and some occurrences are described as pale grey. Weathered colours on cleavage surfaces and joints exceptionally include yellow, olive, red, ochreous and brown; a few buildings include colour laminated slate. However, the good quality of the stone, reflected in its occurrences in buildings as large blocks compared to other kinds of slate seems to be a widespread characteristic, as is its pelitic composition and well developed penetrative cleavage.

The dark colour of much of the slate used for building in central Tavistock was noticed during early visits to the town. This was reinforced by the nature of the slate used for building in Lamerton and in those parts of Tavistock close to the Mill Hill quarries. However, reference to the Mill Hill Quarry website shows that the slate is far from universally dark in hue. Moreover, there is a continuum of characteristics between slate given the code 210 and the general run of Middle and Upper Devonian slate which is used very widely for building in west and south Devon (Code 59). The latter tends to include varieties with a green-grey pigmentation and semipelitic composition but shows a wide variation in both composition and colour; one would be hard put to make the distinction in many cases, and a more than ideal dependence has been resorted to in making the distinction, on the location of the buildings in which the slates occur. This is evident in the assignment of codes 59 and 210 to the slates of Tavistock. Code 210 predominates in the town centre while Code 59 tends to be restricted to the south-east of the town. This might reflect a genuine difference in source but one cannot help suspecting that it has something to do with the day the fieldwork was carried out. Code 210 tends to have been chosen on 05-11-2014 and 05-09-2015 while Code 59 was preferred on 24-08-2016, perhaps for slates with identical or at least overlapping characteristics. A balance has to be struck between lumping stone with a range of characteristics into a single classification, and making small variations in the properties of stone from a single source the justification for the creation of a number of separate categories. It may be that there has been a reluctance to change the classification of a particular building stone part way through a single day's traverse if it looks similar enough to stone that has already been seen that day.


Figure 1. Roadside wall at entrance to Mill Hill Quarries


Figure 2. Café Liaison, opposite tower of St Eustacius' church, Tavistock.

Figure 3. Bridge parapet, east side of Lamerton village centre. The coping includes a block of granite on The right-hand-side by gate. The paving of the footway beside the road is of the same slate.

Figure 4. Outbuilding 400m southwest of Lamerton Green crossroads. The stone rubble footing includes Devonian metavolcanics as well as Mill Hill slate. The quoins and dressings include some granite.

211, Limestone from the Ilfracombe Slates Formation

The Ilfracombe Slates Formation has limestone beds at several different horizons and limestone used as building stone thought to be from this formation is coded 211. The stone shows a wide range of characteristics but is typically grey, pale grey or almost white, dark grey or bluish, usually forms small flat blocks and is impure with many silicate inclusions. The limestone may be interlayered with soft silvery and green slate (Figure 2). The stone is mainly of poor quality and tends to look dusty-buff in walls. Some stone with this code could alternatively be called a calcareous slate. Fragmentary fossils are characteristic of which crinoid ossicles and corals have been noted at several localities.

These lithological characteristics are so variable as to be a poor guide to the source formation of the stone. Rather more reliance than ideal has had to be placed on the location of buildings containing limestone on or near the outcrop of the Ilfracombe Slates Formation. Good quality dark grey limestone used for semi-detached villas on the east side of St Brannock's Road south of its junction with St Brannock's Park Road in Ilfracombe has been given this code but seems of much better quality and lacks silicate impurities (Figure 3). It may be Carboniferous limestone imported from south Wales.

Some of the houses and walls, and also the church, at Cothelstone Manor contain impure limestone associated with slate from the Ilfracombe Slates Formation (Figure 4). Only two of these occurrences has been coded 211 and are shown in Figure 1; the rest have been coded as Ilfracombe slate (Code 132).

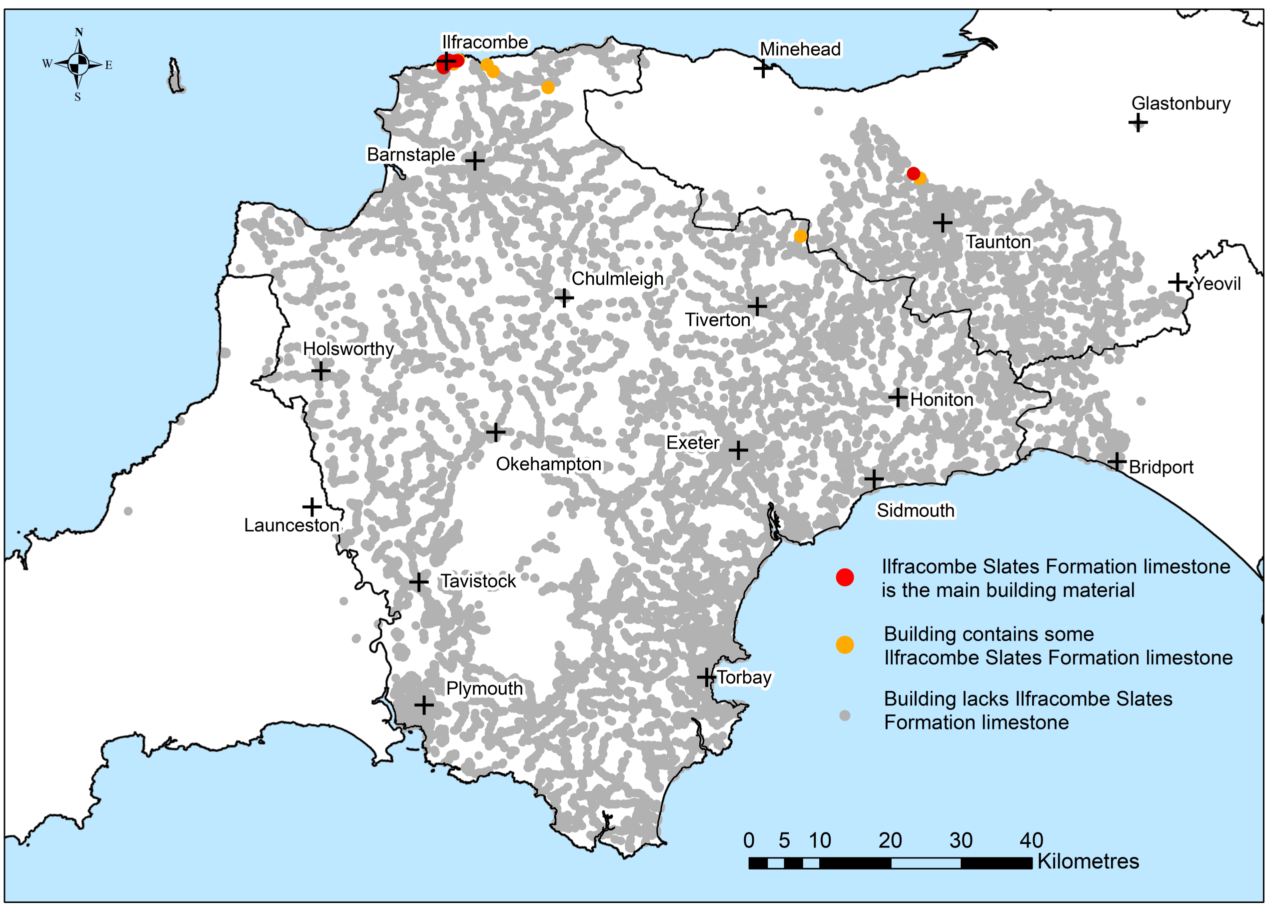

Figure 1. Distribution of limestone from the Ilfracombe Slates Formation in buildings.

Figure 2. Two beds of pale grey limestone weathered buff, intensely folded, with axial planes defined by the cleavage in the enclosing slate, Hele Bay near Ilfracombe.

Figure 3. 28 and 29 St Brannock's Road, Ilfracombe. Dressings and quoins are made of brick.


Figure 4. Tower of St. Thomas' church, Cothelstone, of grey limestone from the Ilfracombe Slates Formation with one piece of red sandstone from the Otter Sandstone Formation, lower right.

212, Black Siltstone and Chert

This code refers to a small number of occurrences of black or dark grey fine-grained building stone in the area Ilfracombe-Kentisbury-Dean-Parracombe (Figure 1). The typical rock-type is a black siltstone or chert forming very thin slabs up to 25cm in long dimension (Figure 2). More equidimensional blocks have a surface texture of sub-parallel sharp ridges lying in the long axes of the blocks and likely following the bedding (Figure 3). Stone with somewhat similar surface texture has been referred to the Hangman Grits (see Figure 6, p.400).

All the occurrences lie on or near the Ilfracombe Slates Formation. The stone is of poor quality and it is unlikely to have been carried far for the purpose of using it for building so it is likely to have come from the Ilfracombe Slates Formation. However, it does not correspond with any of the rock types typical of that formation described in the literature (Edmonds *et al*., 1979).

Reference

Edmonds, E.A., Whittaker, A. and Williams, B.J., 1985. Geology of the country around Ilfracombe and Barnstaple. *Memoir of the British Geological Survey, Sheets 277 and 293, New Series.* HMSO, London.

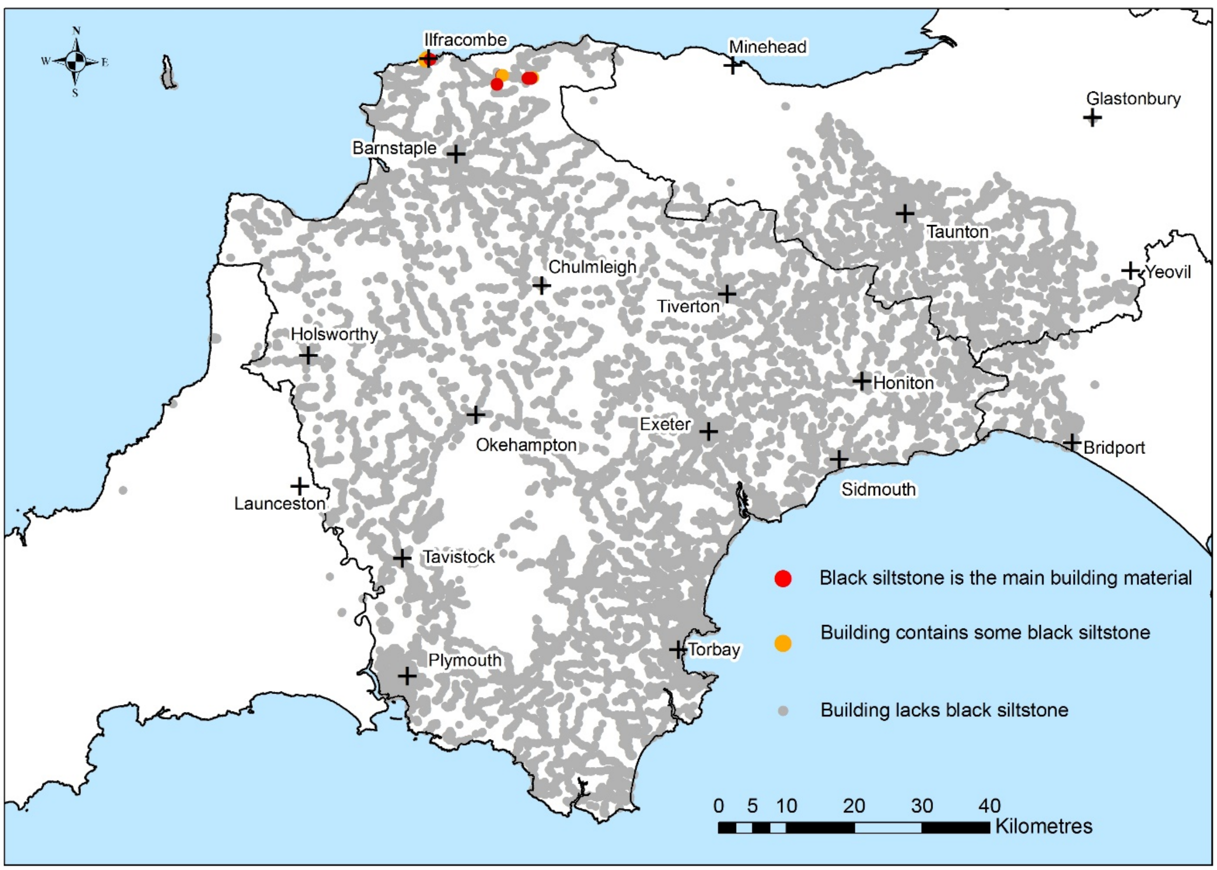

Figure 1. Distribution of black siltstone in buildings.


Figure 2. Thin slabs of black chert, embankment on south side of Portland Street, Ilfracombe.

Figure 3. Tower of St Petroc's church, Parracombe. The central block has characteristic surface ornamentation.

213, Combe Martin Stone

Following the usage of the Strategic Stone Study of the BGS and English Heritage (2015), pale grey and red sandstone from the Ilfracombe Slates Formation, mainly found in Combe Martin, is given this name. It is a medium- to coarse-grained sandstone mainly of quartz with angular and subangular grains and is moderately well cemented. It forms medium-sized blocks somewhat shorter across the bedding than in the bedding planes and with smooth surfaces. Red pigmentation is the characteristic that distinguishes it from other sandstones of northwest Devon (Figure 1). The pigmentation varies from red through pink and brown and is not strong in many cases (Figures 2, 5). Most building blocks are either all of a pale grey colour or all red/pink/brown (Figure 3); only a few examples of mottling in a mixture of grey and pink in a single building block have been observed (Figure 4).

Combe Martin Stone is distinguished from other sandstones from the Morte Slate and the Ilfracombe Slates formations (Code 96, qv) by the distinctive pigmentation. Where sandstone blocks lacking this colour are associated with pink sandstone in a single building, the stone has in most cases also been referred to the Combe Martin Stone. It has to be admitted that this naming convention will cause some confusion between sandstone coded 96 and that coded 213. However, the patchy nature of the pink pigment means that it is inevitable that some blocks of Combe Martin Stone from the run of quarry will lack the distinctive colouring.

Reference

English Heritage and British Geological Survey, 2015. *The Strategic Stone Study Database*. [Online] Available at http//www.bgs.ac.uk/mineralsUK/buildingStones/StrategicStoneStudy/EH_project.html

Figure 1. Community Centre, Church Street, Combe Martin.

Figure 2. South porch of St Peter's, Combe Martin. Although the blocks show a range of colours as well as pink, all are coded as Combe Martin Stone.

Figure 3. South side of Holy Trinity church, Ilfracombe. Large blocks of red sandstone are set in rubble of poor quality sandstone and slate from the Ilfracombe Slates Formation. In this case a distinction is drawn between the red sandstone coded 213 and the pale grey coded 94. Dressings are of Bath Stone.

Figure 4. Grey and pale red sandstone showing faint colour variation within a single building block. West end of Holy Trinity Church, Ilfracombe.

Figure 5. Village Hall, High Street, Combe Martin.

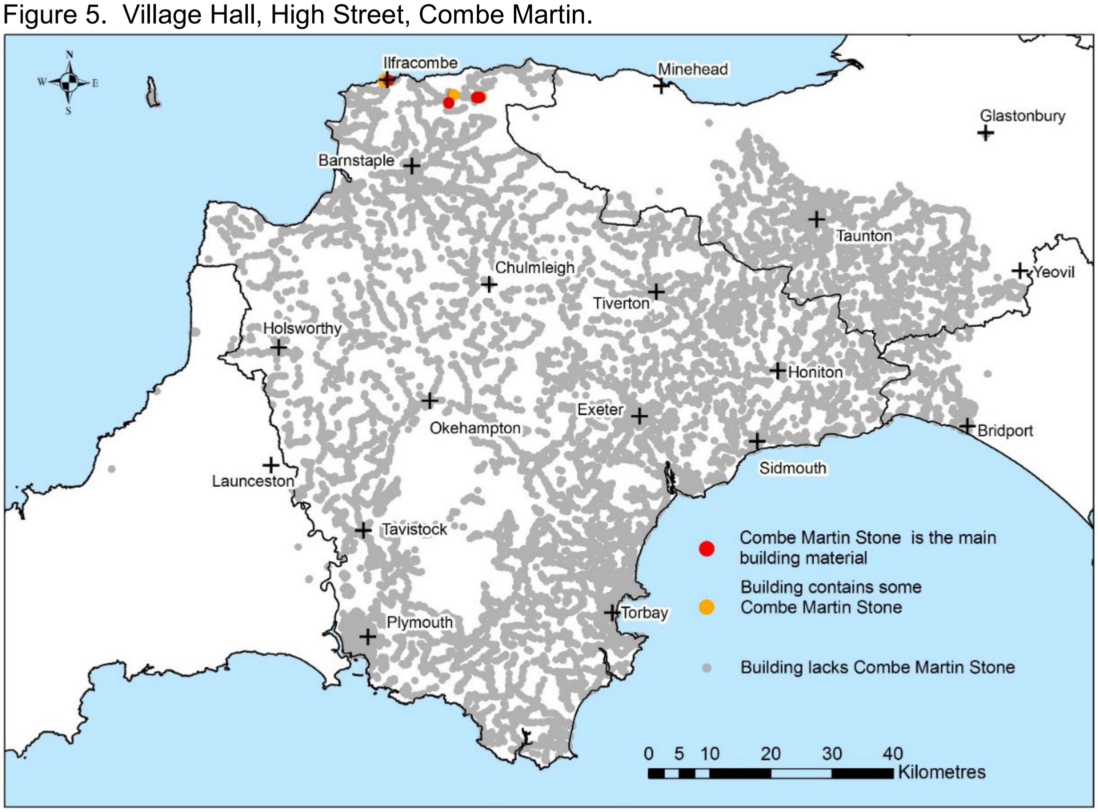

Figure 6. Distribution of Combe Martin Stone in buildings.

214, Yellow Calcarenite without Ooliths (Caen Stone?)

Yellow limestone, closely resembling Bath Stone at first glance (Figures 1 and 2) but differing in important respects, is widely though sparsely distributed across the area of study (Figure 5). It is a fine- to medium-grained calcarenite composed of grains of calcite, in a few cases recognisably shell fragments, but usually too small to allow identification, and in one or two cases enclosing obvious larger shell fragments. The stone is homogeneous, lacking any obvious bedding structures (Figures 3 and 4). It is as durable as Bath Stone although in some cases, the surface of the dressed stone is flaking off.

The stone is used exclusively for the dressings and in a few cases the quoins of churches and prestige houses, and for a fountain in Clovelly. It is very easily confused with Bath Stone when seen from a distance and it may be that in those cases where it has not been examined with a hand lens, it has been mistakenly identified as Bath Stone. In texture it resembles Beer Stone but it is yellow not white. It can be confused with Baggy Sandstone in the northwest of Devon, but it is a limestone not a sandstone. The notes on individual occurrences include discussion of possible origins. It is possible that the stone is a variant of Bath Stone lacking ooliths and it is true the ooliths in Bath Stone are hard to see in some examples. Attempts were made to match it with descriptions of other English building stone. Mansfield White, a Permian calcarenite from the Cadeby Formation of Nottinghamshire (part of the Magnesian Limestone) was considered for a while as a possible source but now seems more than a little far-fetched.

The listed building citation for St Andrew's church at Monkton Wylde in Dorset close to the Devon border states that the quoins and dressings are of Caen Stone. The church was revisited in 2017 and the stone in question matches perfectly the above description. It certainly seems that some if not all of these problematic building stone examples are from Caen.

Figure 1. St Peter's church, Combe Martin. The dressings round the door and the string course at chest height are of yellow calcarenite without ooliths.


Figure 2. St Peter's church, Berrynarbor.


Figure 3. Close-up of the dressings of the west door, Langtree church. Width of view, about 15mm.

Figure 4. South aisle of the church of St James the Less, Merton. The quoins of the buttresses are finished in pale yellow calcarenite without ooliths, weathered a deeper yellow/orange.

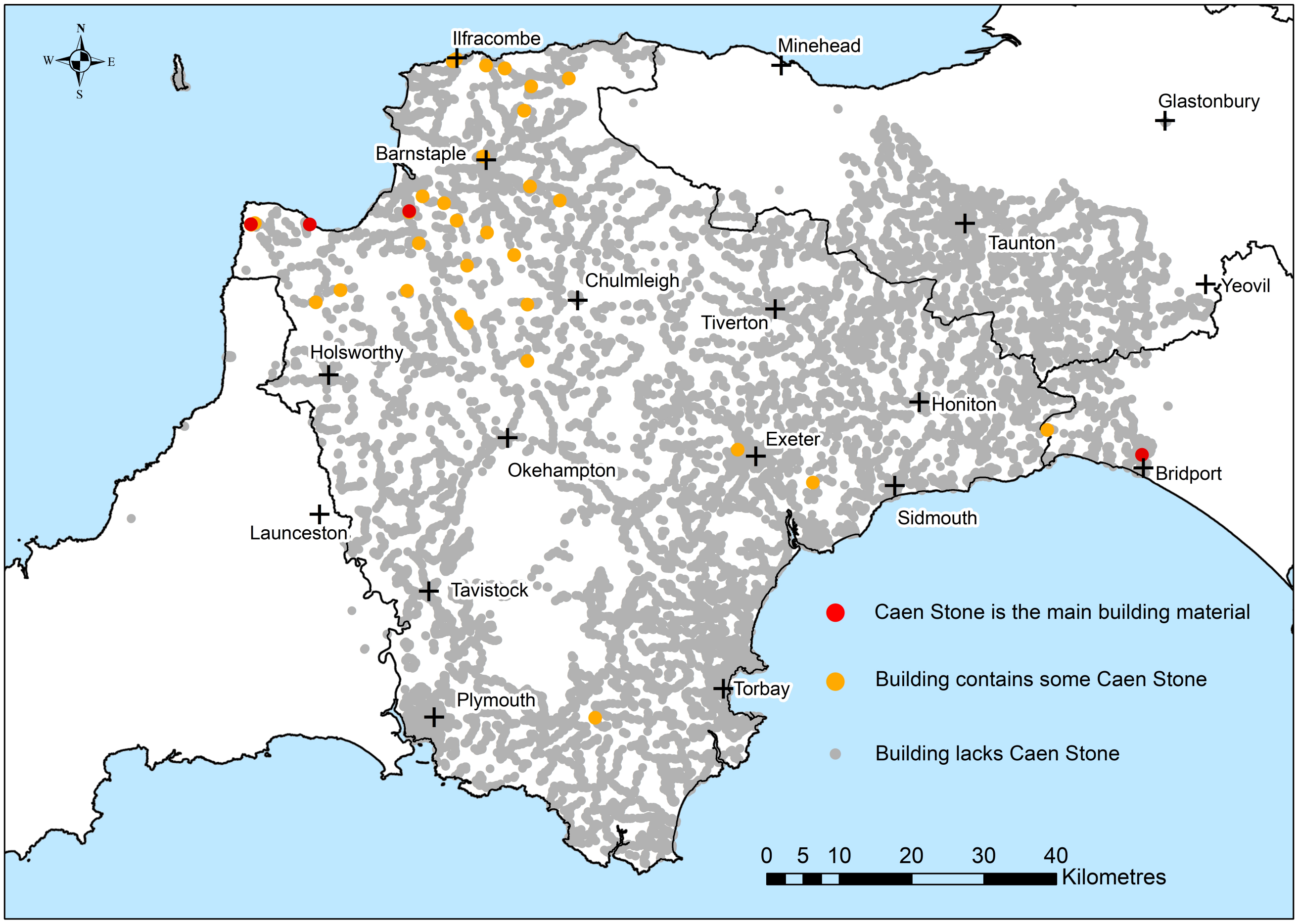

Figure 5. Distribution of Caen Stone in buildings.

215, Sandstone from the Bideford Formation

This sandstone is of indifferent quality and lacks characteristic distinguishing features. The stone is medium-grained, typically weathered orange, red and brown and occurs as small blocks (smaller than a standard brick) or slabs measuring much less across the bedding than in the other dimensions. There is a tendency for the fresh body colour of the sandstone, which has to be searched out in the typical building, to be a “clean” grey (Figure 1), medium-grey but including light grey and exceptionally darker grey (Figure 3). By “clean” is meant a grey of variable tone but generally light and lacking any significant tendency towards green, khaki or brown pigmentation of the fresh rock. Compared to the Bude Formation sandstones, there is little muddy matrix material between the clastic sand grains although the surface may be obscured by the growth of red algae in the grain boundaries. To see the fresh colour of the rock, it is necessary to discount surfaces that show pigmentation caused by weathering and fresh surfaces of this kind are absent in the great majority of walls.

On these fresh surfaces, the sandstone can be seen to have an open texture with sparse cement, of angular or subangular quartz grains; other minerals as clastic grains are not obvious. Bedding is defined in most cases by the long dimensions of the building blocks, but may be reinforced by parallel fractures or variations in colour no doubt following original sedimentary layering. However, angular equant blocks are also present (Figure 4). Cross-bedding has not been observed in building blocks but is present in the outcrops on the shore southwest of Westward Ho! The sandstone is rarely laid with bedding parallel to the plane of the wall but in these cases sole structures are displayed in some building blocks. Many blocks are grey-hearted with cores of fresher sandstone surrounded by more weathered material (Figure 5). In some cases complex patterns of colour variation are displayed including the development of bands of variable colour (leisegang rings). The general impression is of stone of inferior quality that is hard to shape and susceptible to damage with flaking surfaces and bits falling out. Because of this, the quoins and dressings of walls made of this sandstone tend to be made of something of better quality. In many cases this is sandstone also from the Bideford Formation that has been given a separate code (206).

Sandstone coded 215 is distinguished from sandstone from the Pilton Mudstone Formation by a general lack of mica but shares with the latter its fresh “clean” grey body colour. It is distinguished from the “Cornborough” Sandstone by the small size, slabby shape and poor quality of the building blocks, from the Crackington Formation by paler body colour, coarser grain size and lack of sharp edges and from the Bude Formation by lack of khaki-aspect pigment, much commoner presence of bedding and slabby shape of the blocks. Having said this, there is very great scope for confusion between these different kinds of building sandstone partly because of overlap of their properties but mainly because these properties are poorly displayed in many buildings.

This is the main building stone of Bideford (Figure 6). A substantial number of buildings containing this stone fall on the Crackington Formation especially in the Appledore-Instow area. A large quarry in Appledore at GR 246488, 129806 contains sandstone matching this description but is marked on the geological map as being developed within the Crackington Formation.

Figure 1. East wall of St Mary's, Bideford. Orange-weathered pale grey sandstone as somewhat flattened blocks. The corner stones of the buttresses are of similar but better quality sandstone assigned to the "Cornborough" Sandstone (Code 206, qv).

Figure 2. Typical aspects of the Bideford Sandstone showing orange weathering, grey fresh body colour and irregular but predominantly flattened shape of the building blocks. Outbuilding, west side of Nutaberry Hill, Bideford.

Figure 3. Terrace of Victorian houses of exceptionally dark grey sandstone with brick quoins and dressings. Chudleigh Terrace, Torrington Lane, East-the-Water, Bideford.


Figure 4. Atypical angular equant blocks of sandstone from the Bideford Formation. Wall by Providence Road car park, Bideford.

Figure 5. Development of orange staining in good quality Bideford sandstone providing a link between this stone and that coded 206.   South-east corner of Pannier Market, Bideford.

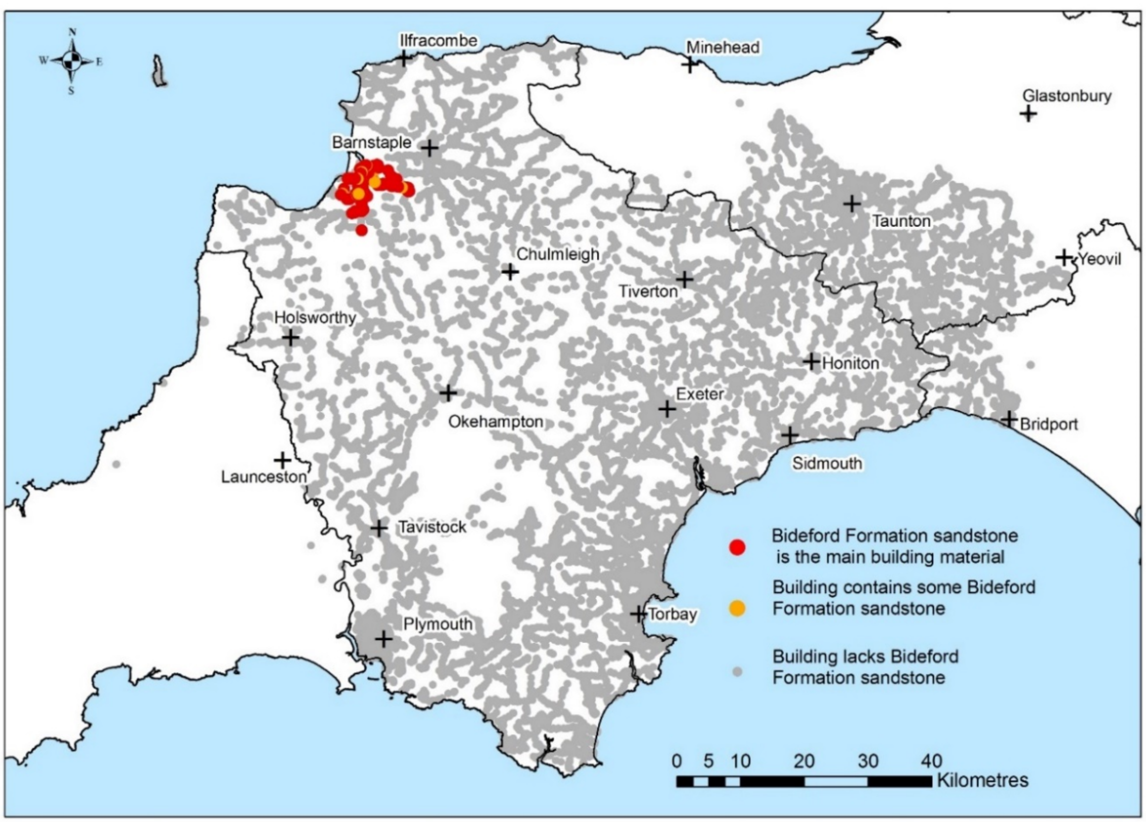

Figure 6. Distribution of Bideford Formation sandstone in buildings.

216, Orange-weathered Sandstone

In early 2014, it became apparent that a distinctive type of sandstone, predominantly dark grey and fine grained but weathered orange, was a widespread building material mainly in walls built in the recent past. From 2014, stone of this kind was given the code 216. A review of previous observations concentrating on those where orange-weathered fine-grained sandstone is described was undertaken, using the Street View function of Google Earth to revisit the localities concerned. A few additional buildings were identified where it is thought this kind of stone was used. Some occurrences in parts of the survey conducted before February 2014 may have been missed. This may partly explain the observed distribution of the stone in Devon where it appears to be absent from the south and east of the county, those parts covered in the early part of the survey (see Figure 6).

The stone is grey where fresh and is usually fine grained (Figures 1, 2 and 3). The most characteristic feature is the tendency for building blocks to be weathered orange (Figures 2 and 3). In most cases they are equidimensional, about the size of a building brick and have rounded corners (Figure 2). Nearly all examples of the stone lack an internal planar fabric (Figure 4). Load casts are observed where the stone is laid with the bedding parallel with the plane of the wall. One further characteristic commonly observed, the stone is quite widely used for bus shelters and public toilets; it seems to have been the stone of choice for several local authorities at the time these structures were being built.

The source quarry or quarries is not currently known. Assuming the observed distribution (Figure 6) is real and is not an artefact of the way the survey has been conducted, then it points to a source (or several sources) in the north and west of Devon. The lithology is most closely matched by sandstone from the Crackington Formation (Code 152) so Venn Quarry near Swimbridge is a possible source. Very similar sandstone, although less darkly pigmented and more micaceous is used in Bude (Figure 5) and is presumably from the Bude Formation, introducing the possibility that the stone seen in Devon might include Bude Formation sandstone. For example, from Beam Quarry, or further afield.

Figure 1, Fine-grained medium-grey sandstone lacking internal oriented fabric and weathered brown or orange. Wall by 87 Honestone Street, Bideford.

Figure 2. Grey fine-grained sandstone weathered orange and with rounded corners. Embankment northeast of Goodleigh village centre.


Figure 3. Modern bungalow and retaining embankment, both of orange-weathered sandstone with brick dressings. North side of the main road, Bridgerule, 200m west of bridge over the River Tamar.

Figure 4. Wall east side of South Molton Street, Chulmleigh. Dark grey fine-grained sandstone weathered brown and orange.

Figure 5. Bude library.

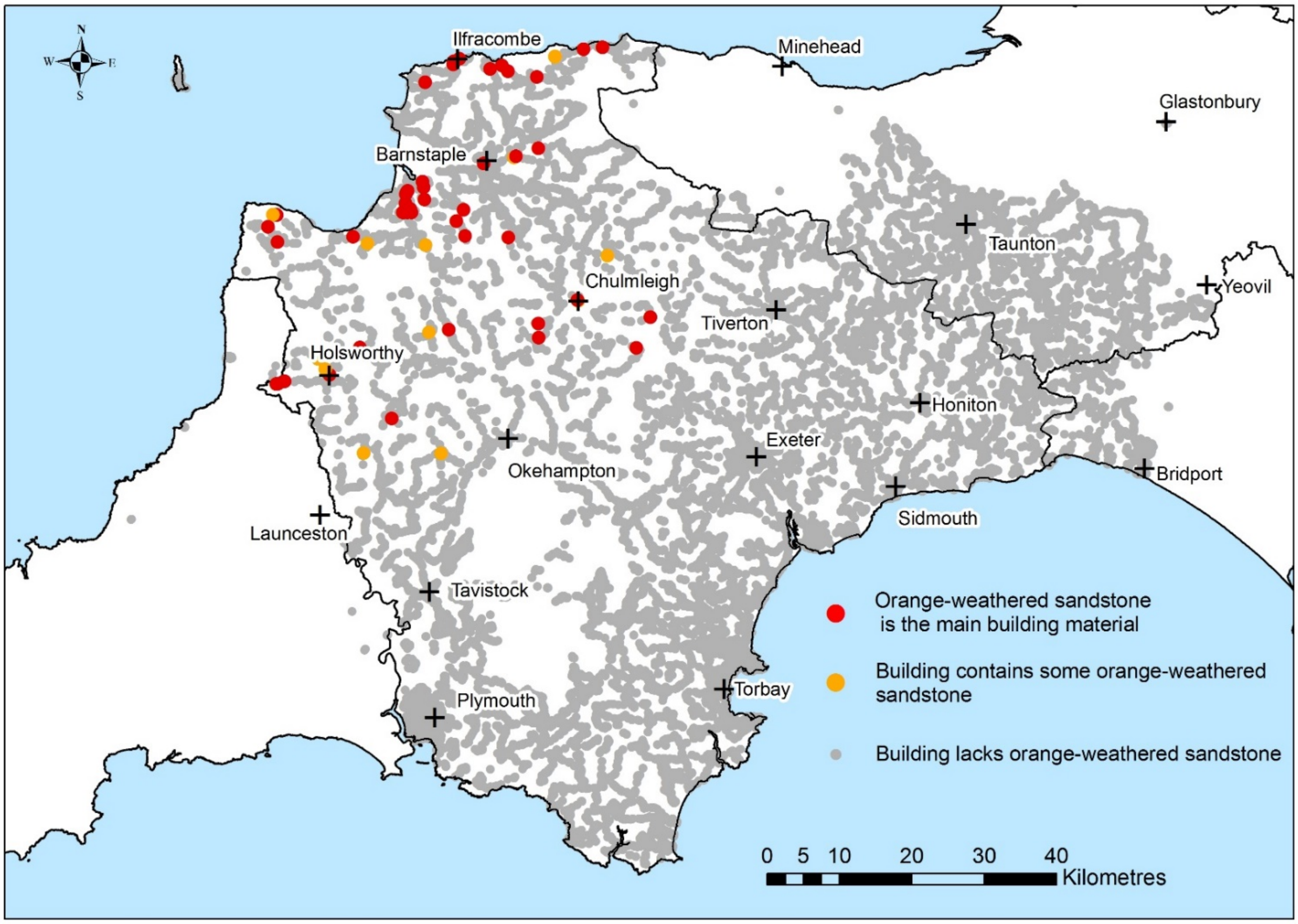

Figure 6. Distribution of orange-weathered sandstone in buildings.

218, Pale Grey Slate

This code is applied to the stone of a small group of buildings at and west of Holsworthy and extending into Cornwall (Figure 3). It represents a pale grey psammitic slate with strong regular cleavage (Figures 1 and 2). It is uniform in composition and appears fresh and unweathered in all occurrences. In one of the building which was under construction at the time of the survey (south of Alverdiscott) it is associated with the orange-weathered sandstone (Code 216) which is widely used in west Devon for new walls and houses.
Its source is currently unknown.

Figure 1. Roadside wall north-west of Bridgerule.

Figure 2. Roadside wall, east side of Victoria Hill, just north of junction with Sanders' Lane, Holsworthy.

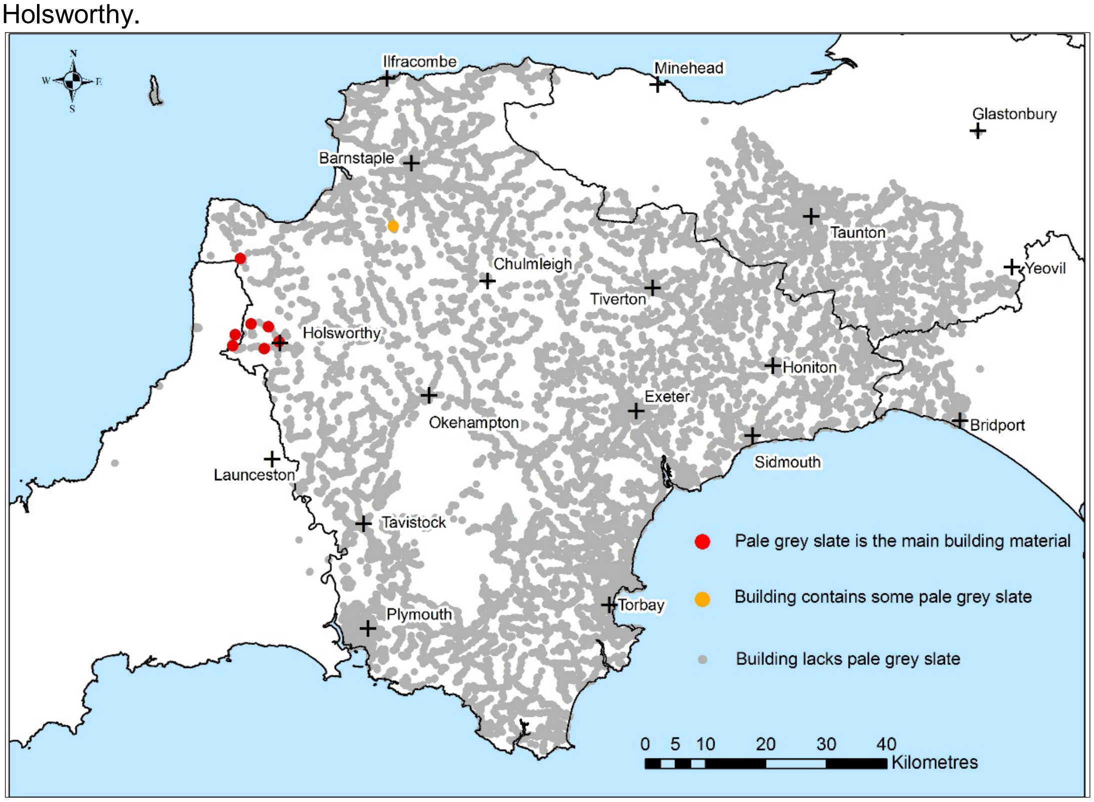

Figure 3. Distribution of pale grey slate in buildings.

222, Lynton Formation

Building stone from the Lynton Formation comprises micaceous siltstone and sandstone and psammitic slate; the stone is typically a mixture of sandy and clayey sediment, poorly cleaved and bedded. The bedding where seen tends to consist of anastomosing thin layers richer in clay and mica. In some blocks, wisps of slate with banding on a millimetre scale are intercalated with more homogeneous sandstone. This structure is characteristic of the stone but is not so widely developed as to be helpful in identification. However, there are variations on this theme and some stone is well enough cleaved throughout the thickness of blocks to qualify as slate while in other cases a planar fabric is poorly developed and the stone is an impure sandstone. The surfaces of the poorly cleaved blocks tend to have a hackly finish (Figure 1) and this is characteristic of the building stone.

Grey is the predominant colour of weathered stone but in favoured settings the fresher rock may be green-grey or have a touch of khaki in the pigmentation, weathered yellow, buff or brown. The hues are typically dark; in many buildings the stone is described in the field notes as dull brown. A significant but subordinate proportion of the stone is mottled in red (Figure 2). A subset, originally given its own building stone code is dark grey or black and tends to be semipelitic in composition and relatively well cleaved (Figure 3).

Stone from the Lynton Formation is distinguished by the presence of a cleavage even if a poorly developed one and a characteristic range of typical pigmentation. The identification of the stone is made easier by the fact that the surrounding areas are underlain by the Hangman Grits from which it is relatively easily distinguished by composition and the presence of a cleavage. The stone is used for building in the Lynton area and its distribution in buildings appears to be quite tightly controlled within its outcrop area (Figure 4).

Figure 1. Tower of St Mary's, Lynton. Dark grey and buff impure sandstone or psammitic slate with characteristic hackly fracture. Length of large blocks, 40cm. Bedding is visible on the smoother surfaces of some blocks.

Figure 2. Upper storeys of Aladdin's Cave, Lynmouth Street, Lynmouth. Grey and buff impure sandstone ashlar with red sandstone used mainly for the dressings. The widespread use of hanging tiles is characteristic or Lynton and Lynmouth.

Figure 3. Dark grey and some red slate, road cutting at car park near Watersmeet.

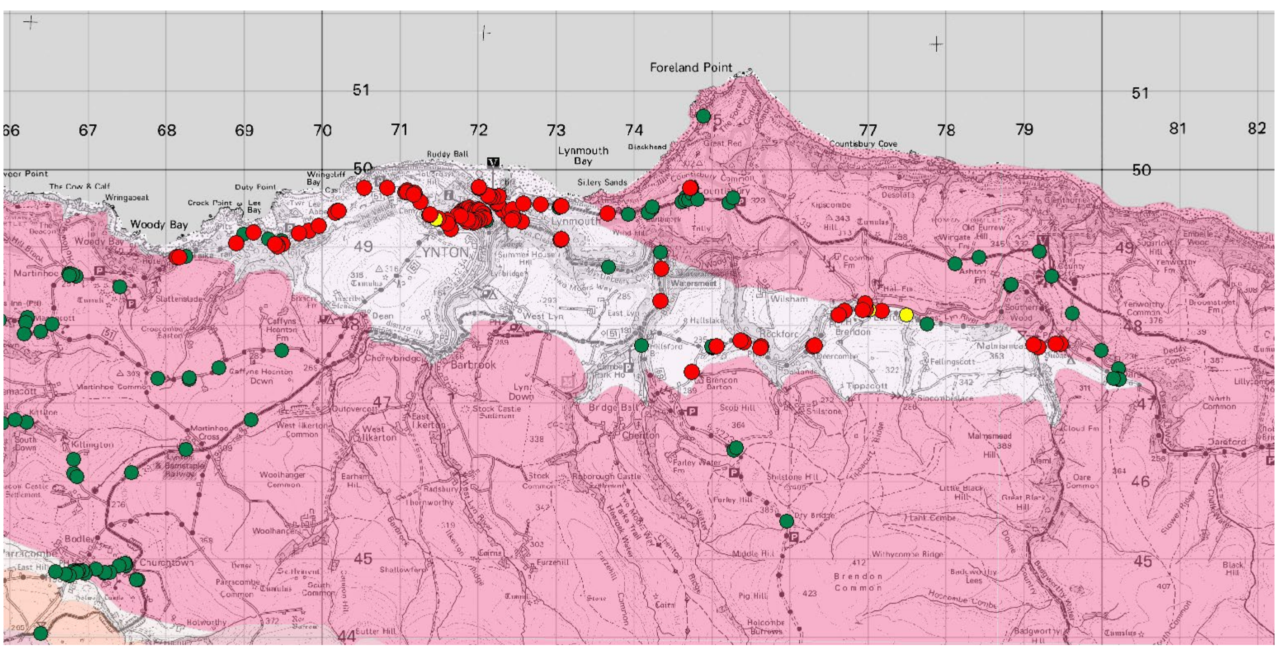

Figure 4, Distribution of building stone in relation to outcrop. Red circles, Lynton slates are the main building stone; yellow, buildings with some Lynton slate; green, buildings lacking Lynton slate. Outcrop areas: purple, Hangman Grits, white, Lynton Formation. Geological mapping reproduced with the permission of the British Geological Survey ©UKRI. All rights reserved. Base map, Ordnance Survey 1:50,000 scale. Crown copyright and database rights 2018, OS 93830343.