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STONE ANALYSIS

& MATCHING REPORT

AP 3762
Nanse Tinnock's, Castle St, Mauchline

Sample 1

Sandstone

SITE	Nanse Tinnock's, Castle St, Mauchline
CLIENT	Wylie Shanks Architects
DATE SAMPLE RECEIVED	02/12/2021
ANALYSIS/EXAMINATION DATES	02/12/2021 – 069/02/2022
ANALYSIS, INTERPRETATION & REPORT BY	Dr Katie Strang and Roz Artis
CLIENT REQUIREMENTS	Petrographic Examination for Stone Source Matching
STRUCTURE DATE	18th century
STRUCTURE TYPE	museum
STONE TYPE	Blonde sandstone
LOCATION/ FUNCTION IN STRUCTURE	Stone from rear elevation
CONDITION OF SAMPLE RECEIVED	The sample received consisted of one core of sandstone Size of largest piece = 44.83mm x 65.98 Total mass of sample received = 118.29 grams

DETERMINATION OF STONE CHARACTERISTICS

Method of Examination & Test

A sample comprising of a fragment of weathered sandstone was received for examination and determination of its properties. The stone was stated to have been collected from Nanse Tinnock's, Castle St, Mauchline with the sample submitted for examination to assist in identifying a suitable source of replacement stone for use in remedial works.

Upon receipt in the laboratory the sample was examined with the aid of a stereo-binocular microscope at magnifications up to x 40. Following the initial examination, one dimensioned sub-sample was prepared and submitted to a range of physical tests to determine the properties of the stone. In addition, a slice was cut through the remaining sample of stone, with the specimen aligned such that the slice extended through the full thickness of the sample.

The slice was prepared for thin sectioning by washing the soiling from the sample, which was then dried to a constant weight prior to the vacuum impregnation of the sub-sample with an epoxy resin, to which a fluorescent blue dye had been added. One side of the resin impregnated slice was polished and mounted onto a glass slide (50mm x 75mm), with the mounted sample ground and polished to give an approximate thickness of 30 microns.

Thin section preparation was undertaken by Mr John Fletcher of the British Geological Survey Thin Sectioning Service.

The thin section was submitted to a microscopic examination, which was undertaken with the aid of a polarised light microscope, fitted with a digital camera, to permit recording of photomicrographs, some of which are included in this report, for reference purposes.

The presence of dyed epoxy resin within the sample enables an assessment of the stone fabric to be made, including an assessment of the visual porosity, void size and distribution along with the evaluation of any crack patterns and physical depositional features apparent in the sample under examination. The sample was examined following standard procedures, and in general accordance with BS EN 12407:2000; Natural Stone Test Methods. This report presents observations from the microscopic examination.

MACROSCOPIC EXAMINATION

In hand specimen the dry fresh stone was found to be 7.5YR 6/3 – 6/4 ‘light brown’ and the weathered surface appeared 5YR 7/2 ‘pink’ when assessed against the Munsell Soil Colour Charts. The stone is predominantly medium to coarse grained and generally uniform throughout, with visible laminated bedding throughout. The stone is hard and cohesive and relatively mineralogically sub-mature to mature, containing a majority of buff to light buff coloured quartz grains, plus smaller proportions of muscovite mica, Fe-oxides and carbonaceous matter; the latter of which provide the stone with its speckled appearance. Grains are moderately well compacted, showing a range of tangential and straight edged contacts, with a high proportion of intergranular frosted silica cement and occasional pore filling clays, which provide the stone with a relatively ‘dirty’ appearance. Grains are texturally sub-mature, comprising a range of angular to rounded grains, with most quartz grains showing partial Fe-oxide staining. The stone experienced a fast water absorption rate when subjected to the water droplet test, indicating an interconnected pore network which permits the fast and efficient absorption and transportation of moisture throughout its thickness. There was no noticeable reaction on application of HCL.

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Plate 1. Image of the sample as received. Note the laminated texture and slight pink hue. Scale is in mm.

MICROSCOPIC THIN SECTION EXAMINATION

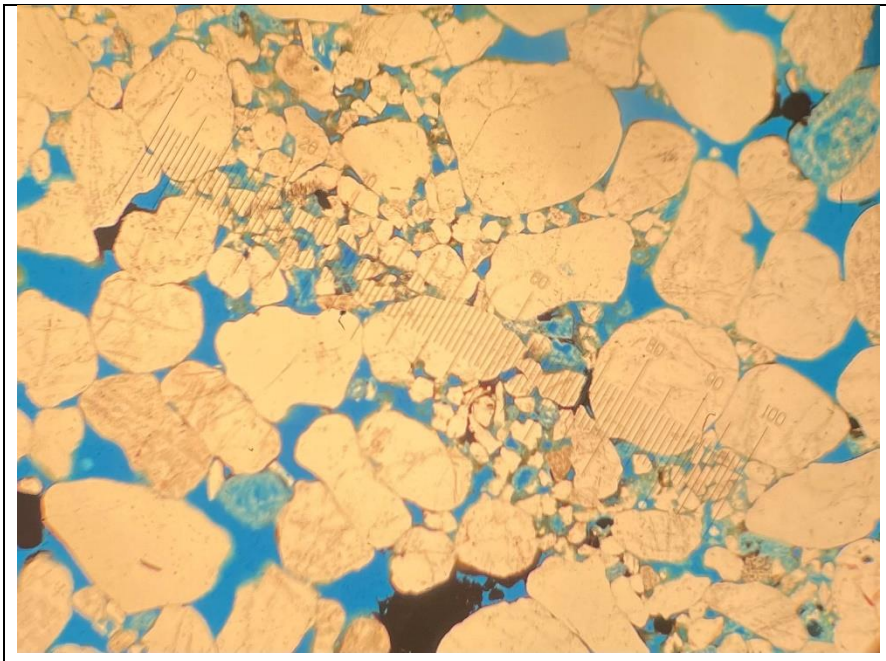
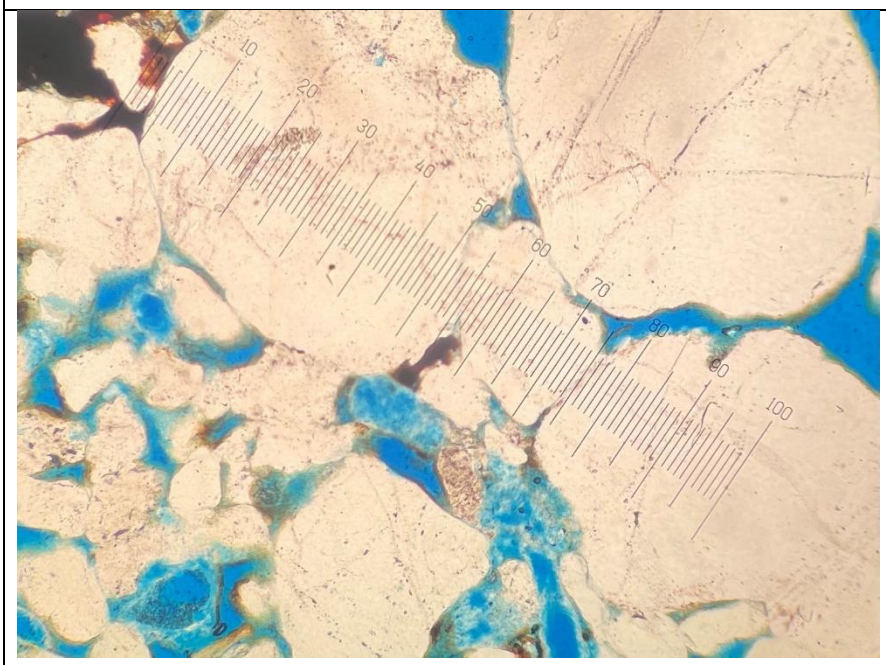
Texture: The stone is medium grained (with occasional areas of coarser grain size). The stone exhibits parallel bedding in hand specimen and this is also visible in thin section. Beds are <2mm thick and consist of layers of coarser grain size. There are abundant Fe oxides, clays and carbonaceous matter throughout the stone which impart the speckled appearance in hand specimen, these secondary minerals often fill up pore space and reduce permeability in those regions. The surrounding stone matrix is composed predominately of medium-grained, moderately compacted, sub-rounded to sub-angular quartz, feldspar and a small proportion of lithic fragments. Feldspar appears mostly unaltered with both K-feldspar and plagioclase, in twinned and un-twinned varieties, present.

Mineralogy: The mineralogy of the stone is dominated by medium to coarse-grained, sub-rounded to sub-angular and spherical quartz and feldspar grains, sub-rounded and slightly more elongated lithic fragments, Fe-oxides and pore-filling clays. Some regions exhibit a greater proportion of Fe-oxides, pore filling clays and smaller, sub-angular to sub-rounded quartz and feldspar grains. Quartz grains are found as both mono and poly-crystalline varieties and some show hematite rims; these provide the stone with its distinctive pinkish hue in some layers. Grains are cemented by silica cement throughout, with a moderate proportion of pore filling clays and quartz overgrowths present, providing secondary cements. Lithic fragments have a mixed composition, including clasts of chert and calcite-rich grains. The stone is relatively ‘clean’ and most grains show low levels of alteration.

Detrital Minerals: Quartz, feldspar, lithic fragments,
Authigenic Minerals: Kaolinite, Fe-oxides, carbonaceous matter

Porosity and permeability: The stone has a moderate visual porosity, estimated between 10-14%. Concentrations of Fe oxides and carbonaceous matter will act to significantly increase the tortuosity of the pore network, which will also impact on moisture movement through the stone. Porosity and permeability is likely reduced perpendicular to bedding/laminations.

Photomicrographs:

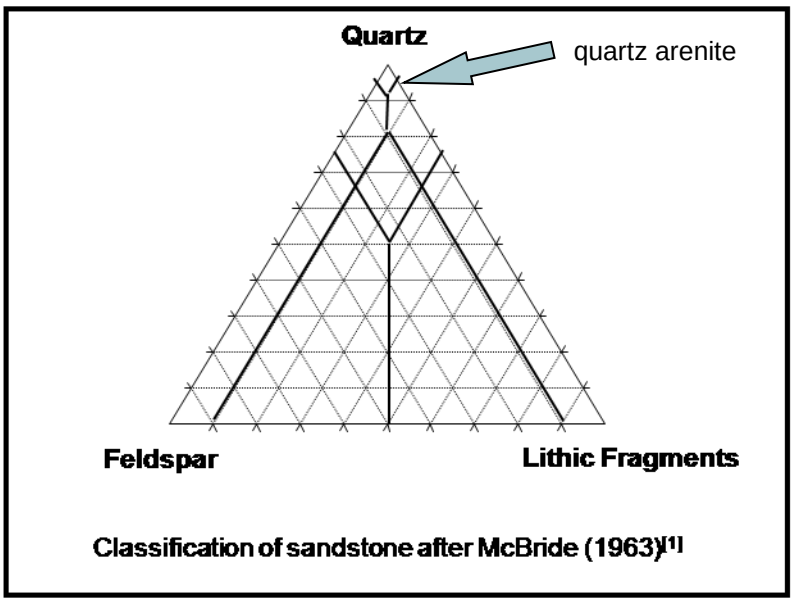
	**Plate 2. Thin section of the sample under plane polarised light. Pore spaces are highlighted in blue, while areas of light blue indicate pore filling clays that have absorbed some of the blue dye. The stone has distinct bedding which is characterised by layers of differing grainsize.** **Field of view is 4.2mm.**
	**Plate 3. Thin section image of the sample under plane polarised light. Pore spaces are highlighted in dark blue, while areas of light blue indicate pore filling clays. Fe staining can be seen surrounding some of the quartz grains, which gives the sample its pinkish hue in some layers.** **Field of view is 1.2mm.**

Point Count Data:

Components	Total (%)	Q/F/L (quartz/feldspar/lithic % proportion)
Detrital Components		
Quartz	90.5	97.3
Feldspar	1.5	1.6
Lithic fragments	1	1.1
Detrital Clay	1	
Muscovite Mica	1	
Authigenic Minerals		
Quartz Overgrowths	1	
Indeterminate Clay	2	
Dolomite/Ankerite cement	0	
Opaque Minerals inc carbonaceous matter	2	
Total	100	100
Porosity	Variable, estimated ~10-13%	

Table 1: Results of modal analysis on the sample received.

Sandstone Classification:



[1] McBride, E. F. (1963), A classification of common sandstones. Journal of Sedimentary Petrology 33, 664-669

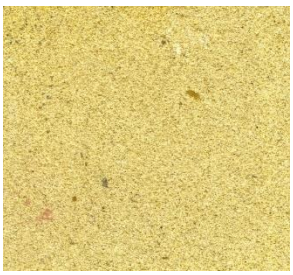
COMMENTS

Sample AP3762 S1 from Nanse Tinnock's, Castle St, Mauchline, is similar to the local blonde sandstone which is of variable quality. The distinct banded texture suggests it was likely obtained from the local quarries such as Dean quarry, or others further afield such as Braehead. It is classified as well graded and mineralogically sub-mature to mature quartz arenite, containing sub-rounded to sub-angular, moderately well compacted quartz grains, feldspar grains, lithic fragments, Fe-oxides and a moderate to low proportion of pore-filling clays. This stone is highly variable and replacement would be dependent on how representative this sample is of the stone overall. The sample analysed displayed fine laminations/parallel bedding, and the only currently available source is the bedded variety of Northumberland Buff. Blaxter and High Nick are similar in terms of grain size and mineralogy however these stones do not usually show any bedding structures. Non-bedded stones may not provide a suitable visual match. Samples should be obtained before selecting a replacement. It should also be noted that this local sandstone can be very variable in weathering and colouration, from blonde, to orange to pinkish.

With regards to choosing a suitable matching stone, it must be remembered that because stone is a natural material, it can vary in colour and appearance both over time and spatially within a quarry. It is therefore important to check the colour and appearance/obtain representative samples of the stone with the quarry operator in advance of works. Furthermore, each stone type will vary in its weathering behaviour over a period of years in accordance to weather conditions, the stone extraction process, and it's functionally within a building. This report is therefore not an endorsement of stone quality, nor does it ensure that the listed matching stones will weather in harmony with the original stone. The matched samples are based on thin section petrographic and physical stone testing analysis, taking into account colour, texture, mineralogy, porosity and permeability.

The contact addresses for these quarries are as follows:

Birchover Sandstone **Colour:** Buff to light greyish buff **Fabric:** Mainly uniform **Grain size:** medium grained. **Permeability:** Moderate to high. **Distinctive features:** commonly exhibits a speckled appearance due to Fe-oxide content. **Comments:** The medium grained variety should be sought.	**Birchover Quarry** **Main Street** **Birchover** **Matlock** **Derbyshire** **DE4 2BN** **Tel.: 01629 650881**

Blaxter Sandstone **Colour:** Buff **Fabric:** Uniform (with alignment of mica grains occasionally indicating bedding). **Grain size:** Fine to medium grained. **Permeability:** Moderate to High but occasionally low. **Distinctive features:** Blaxter sandstone can commonly show distinct Fe-staining; as either individual nodules or as bands within the stone, and also distinct orange-brown clay inclusions.	**Dunhouse Natural Stone** **Dunhouse Quarry Ltd,** **Darlington,** **County Durham,** **DL2 3QU** **Tel: 01833 660 208** 

High Nick Sandstone **Colour:** Buff coloured, with iron spots and iron-oxide banding. **Fabric:** Mainly uniform, with some aligned grains showing a slight orientation. **Grain size:** Medium grained. **Permeability:** Moderate to high. **Distinctive features:** occasional large ironstone nodules/concretions **Comments:** The stone contains distinctive iron-oxide nodules that vary in size from mm's to cm's in diameter. Iron-oxide banding is also common throughout.	**Border Stone Quarries,** **Kirkholmedale** **Lanty's Lonnen** **Haltwhistle** **Northumberland** **NE49 0HQ** **Tel: 01434 322140** 

Sandstone is a natural material and by the nature of its origin, can be extremely variable within and between quarry faces. Ideally, a considered match should be examined in the same manner as the stone to be replaced. Archive sandstone samples of possible quarries may not be equivalent to the currently extracted product.

***As with all quarries the actual properties of the stone available will be dependent on the face, and the bed, being worked at any given time and it is, therefore, always prudent to obtain samples of the current production for comparison with the stone to be matched, prior to ordering supplies for a particular project/applicat*ion.**