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STONE ANALYSIS
& MATCHING REPORT

AP 3759
Poosie Nansies, Loudoun St,
Mauchline

Sample 1

Sandstone

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SITE	Poosie Nansies, Loudoun 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	Public house
STONE TYPE	Red 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 the Poosie Nansies, Loudoun 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 sample showed some slight discolouration on the exposed stone face, measuring 2.5YR 5/3 ‘reddish brown’ with the fresh faces appearing 2.5YR 4/4 ‘reddish brown’ to 2.5YR 6/6 ‘light red’ when assessed against the Munsell Soil Colour Charts. The sandstone is generally fine to medium grained, appearing texturally sub-mature to mature and mineralogically mature to sub-mature. The stone is composed of similar sized, sub-angular to sub-rounded and rounded haematite-stained quartz grains, occasional Fe-oxides and carbonaceous flakes (both creating the slightly speckled appearance) and lighter coloured grains (possibly feldspar or lighter coloured quartz) bound by occasional and well distributed intergranular quartz overgrowth silica cement. Haematite staining of quartz grains provides the stone with its distinctive red colour in hand specimen. It experienced a moderate to strong reaction when subjected to 10% hydrochloric acid (HCL), likely from a carbonate cement and carbonate lithic fragments. The received sample displays a predominantly uniform texture with little evidence of layers/laminations, however it may display bedding on a larger scale not visible in hand specimen. The stone experienced a moderate water absorption rate when subjected to the water droplet test, signifying a discontinuous internal pore network.

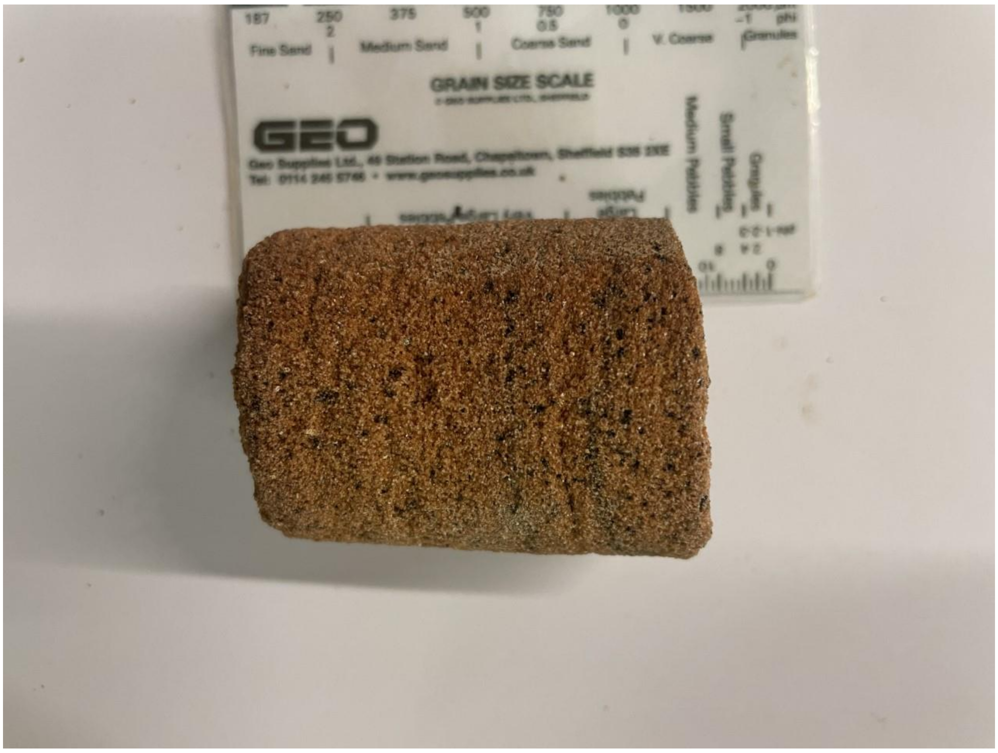


Plate 1. Image of the sample as received. Note the black speckling caused by Fe-oxides. Scale is in mm.

MICROSCOPIC THIN SECTION EXAMINATION

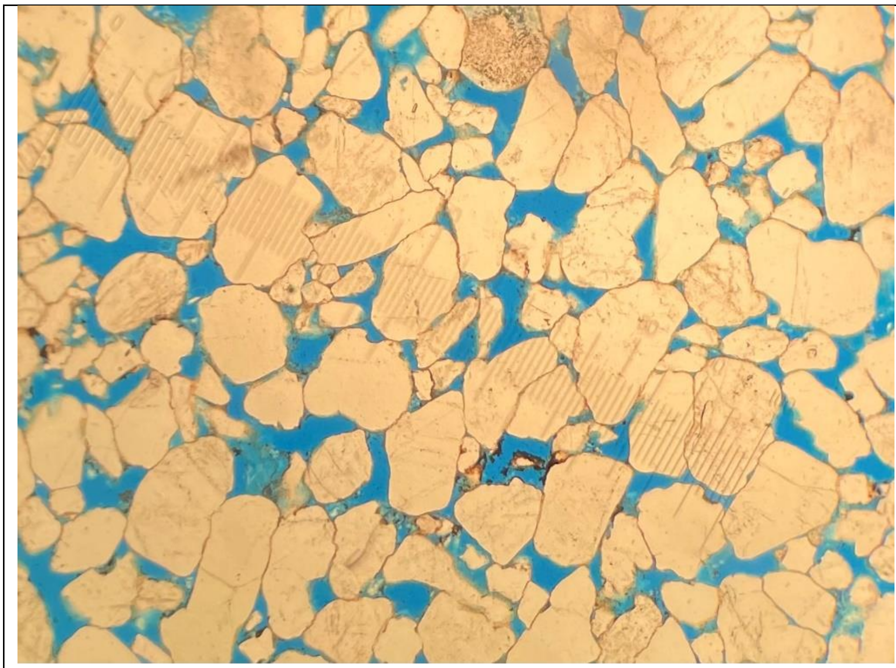
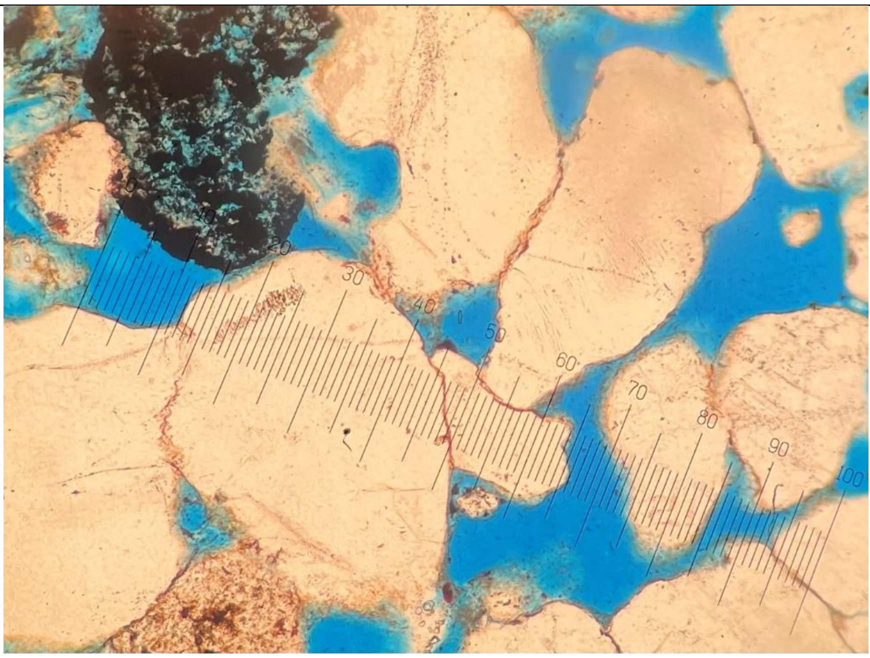
Texture: Bedding planes are not evident within the thin section however, it could be that within this sample the beds are thicker therefore not seen at this scale. There are some areas of concentrated Fe oxides and carbonaceous matter which impart the speckled appearance to the stone in hand specimen. The permeability and porosity are decreased in these areas, owing to the increase in grain compaction, pore-filling clays and the decrease in grain and pore size. The surrounding stone matrix is composed of medium-grained, moderately compacted, sub-rounded to rounded quartz, feldspar and lithic fragments.

Mineralogy: The mineralogy of the stone is dominated by fine to medium-grained, sub-rounded to rounded 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 show well-developed hematite rims; these provide the stone with its distinctive red colour. Grains are cemented by silica and carbonate 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.

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

Porosity and permeability: The stone has a moderate visual porosity, estimated between 10-13%. 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. Small pores are evident between the smaller grains due to poor grain sorting, while larger pores are found between the larger grains in the main stone matrix, but are commonly filled with small, angular quartz grains and kaolinite clay.

Photomicrographs:

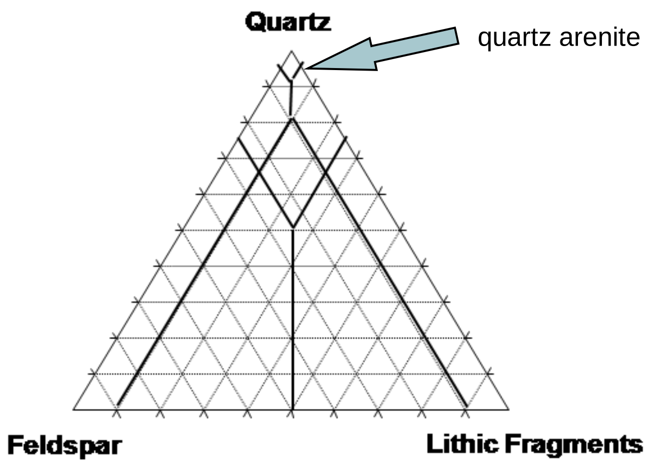
	**Plate 2. Thin section of the sample under plane polarised light. Pore spaces are highlighted in blue, while areas of light blue indicate pore filling clays that have absorbed some of the blue dye. Pores are moderately to well connected, with some of the larger pores filled with small, sub-angular to sub-rounded quartz, feldspar and lithic fragments.** **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. There are some concentration of Fe oxides and organic carbonaceous matter within the thin section. Fe staining can be seen surrounding some of the quartz grains, which gives the sample its red colour.** **Field of view is 1.2mm.**

Point Count Data:

Components	Total (%)	Q/F/L (quartz/feldspar/lithic % proportion)
Detrital Components		
Quartz	89	95.2
Feldspar	2	2.1
Lithic fragments	2.5	2.7
Detrital Clay	0	
Muscovite Mica	1	
Authigenic Minerals		
Quartz Overgrowths	0	
Indeterminate Clay	2	
Dolomite/Ankerite cement	1.5	
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:



Classification of sandstone after McBride (1963)[1]

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

COMMENTS

Sample AP3759 S1 from Poosie Nansies, Loudoun St, Mauchline, was likely sourced from the Permian type deposits found in the Mauchline basin. The Mauchline sandstone is quite distinctive in that it has a bimodal grainsize distribution, but with a variable texture ranging from strongly bedded to uniform. There are currently no quarries working stone from the Mauchline basin. The sample was too small to identify any large-scale sedimentary structures to ascertain an exact source. It is classified as well graded and mineralogically mature quartz arenite, containing sub-rounded to rounded, moderately compacted quartz grains, feldspar grains, lithic fragments, Fe-oxides and a moderate to low proportion of pore-filling kaolinite clay. The closest matching currently available sandstones are Corncockle, Knowehead, and Locharbriggs quarried in Dumfriesshire. These quarries can produce stone which is lighter and more range in colour compared to the analysed sample, therefore samples must be obtained first. All these replacement stones can be sensitive to sodium chloride salt crystallisation damage due to the high percentage of micro-pores within the stone, and their spatial distribution within bedding planes. This means they may not be suitable for buildings that are at risk of salt crystallisation damage: ie close to heavily salted roads in winter.

In regard 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:

Corncockle sandstone **Colour:** Reddish – orange **Fabric:** Well bedded, laminated sandstone. Beds measure ~1-2mm in thickness. **Grain-size:** Fine to medium grained sandstone, with distinct differences in grain size evident between beds. **Permeability:** High permeability parallel to bedding and low permeability perpendicular to bedding. **Distinctive features:** None. **Comments:** Corncockle may not be suitable for buildings that are at risk of salt crystallisation damage: ie close to heavily salted roads in winter.	**Dunedin Stone** **Dunedin Stone Office** **3 Lower London Road** **Edinburgh** **EH7 5TL** **Scotland** **UK** **There are reserves of this stone, and the quarry is opened as required to replenish stock levels.**

Knowehead sandstone **Colour:** Reddish – orange **Fabric:** Well bedded, laminated sandstone. Beds measure ~1-2mm in thickness. **Grain-size:** Fine to medium grained sandstone, with bi modal grain distribution. **Permeability:** High permeability parallel to bedding and low permeability perpendicular to bedding. **Distinctive features:** None. **Comments:** May not be suitable for buildings that are at risk of salt crystallisation damage: ie close to heavily salted roads in winter.	**Stirling Stone Group** **Wallace House** **Whitehouse Road** **Stirling, FK7 7TA** **Tel: 01786 450560**

Locharbriggs sandstone **Colour:** Reddish – pink - orange **Fabric:** Well bedded sandstone, with evidence of cross-beds in areas. **Grain-size:** Fine to medium grained sandstone. **Permeability:** High permeability parallel to bedding and low permeability perpendicular to bedding. **Distinctive features:** None. **Comments:** May not be suitable for buildings that are at risk of salt crystallisation damage: ie close to heavily salted roads in winter.	**Hutton Stone Co Ltd.** **West Fishwick** **Berwick-upon-Tweed** **Scottish Borders.** **TD15 1XQ** **Tel: +(44) 01289 386056** 

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/application.