# STONE MATCHING



ÀRAINNEACHD EACHDRAIDHEIL ALBA





#### Metamorphic rocks



- ----- Fault
- ------ Thrust
- HBF Highland Boundary Fault
- SUF Southern Upland Fault













#### SCOTTISH BUILDING STONE CHARACTERISATION OF BUILDING STONE

 This is a function of its formation, with the defined properties influencing its behaviour and performance within a building.

Strong, silica-rich sandstones are usually suitable for ashlar work. Fine grained sandstone best suited for fine detailing work. Strong, low porosity, highly compacted stone best suited for paving stones and for dealing with high amounts of moisture.

Scaling-type decay more common in bedded/layered stone.

Calcareous sandstone/limestone will commonly show black crust and alveolar-type decay.

#### WHY MATCH STONE? STONE MATCHING

 To give replacement stone the very best chance of success, that will not be detrimental to the remaining historic fabric of the building.

Like-for-like stone replacement is almost entirely not possible, owing to the closure of historic quarries.

Relatively poor national resources for natural stone products (currently) – importation of stone from England and abroad.





#### **BGS data**

Blackhill Colliery, Pits 8, 9 Cadder Pits No 8 Cadder Pits No 8 Cadder Pits No 9 Cadder Pits No 10 Ritchie Pits Cadder Bits No 1 Ritchie Pits Kenmure Pit No 15 Cadder Bits No 15 Ritchie Pits Kenmure Pit No 15 Ritchie Pits Kenmure Pits Kenmure Pit No 15 Ritchie Pits Kenmure Pits Kenmur **BGS** Data Gadloch-South Crosshill Westerhill Wester dista scube Garscube Brick & Pipe Works Temple rks Dawsholm nilesland Stockingfield Trinleybrae Trinleybrae Garscube Netherton Auchenleck Well Garscube Brick & Pipe Works Anniesland South Balgray South Balgray South Balgray South Balgray 🕒 Westmuir Westmuir Garnkirk Fire Clay Works Mosesfield Stepps Stepps Balomock Possil Park Janefield Balgray Park Possil Park Park Possil Park Craigendmuir Milton Limestone Pit Germiston Mains Milton Ashcraig Ashcraig Cruikshank's Stewart's Millstone Rockvilla Germiston Germiston Heilinead Hogganfield) Bethamhill Ruchazie Beeches Beeches Meadowside Quay Dowannill Bogle's Woodside Town Gilmorenill Clayston Magazine Rosebank Garngad Avston Magazine Rosebank Garngad Craigend Craige Gilmorehill Kelvingrove Craigend Provanside Ewing's Golfhill Firpark Kennyhill Gatteraig Mincroft Cracklinghouse Conhill Colhill Alexandra Park Gartcraig House Mid Drumoyne Ironstone Pit. Carntyne Ladywell Ladywell Drumovne Ironstone Pit Melville Park Ironstone Bit High Carntyne Craigton Craigton Craigton Craigton Westmuir Budhill Budhill Budhill Egypt Corkerhill Bull Wood 🔍 🐸 Hawkhead Asylum RUTHERGLEN Haugh Lime Works Cathcart Road West Quarries West Quarries Pilrksnuv Eastfield, Eastfield Alum Cowglen Cowglen Leggin's Pit Cowglen Newton Wellshotwellshot Nitshill Coats Cathcart Limestone Mine Court Hill Nitshill Nitshill Slates Burnfield Burnfield Hallsid **Witshill** Kirkburn Kirkburn Flag Well Parkhouse HolmhulsOLkirkburn English Chiadwalls Orchard Dovecothall Cathkin Lodge Fernhill Holmhills Holmhills

### BUILDING STONE RESOURCES STONE MATCHING

There is a need for a substantial, sustainable and nationally collective UK database and archive of indigenous stone types and sources.

Many of the remaining indigenous stones are incompatible with historic stone types, while the compatibility of other replacement stones over substantial time-scales is *unknown*.

#### WHY MATCH STONE? STONE MATCHING

Not necessarily based on just colour or appearance.

Mineralogy, stone texture, and petrophysical properties are the key assets to be matched.

Many difficulties arise: what stone to analyse? Function of stone? Past performance?



Range of different stone types used within a building or structure...which ones do I analyse?



Is the stone uniform? Or from one or numerous sources? – remember, large variations can exist between different beds within the same quarry.

#### WHY MATCH STONE? DIFFICULTIES

What is the function of the stone in the building?
 What quarries can supply stone to meet the required sizes and shapes?

What was the past performance of the stone?
 Did it suffer from specific decay processes? Is it vulnerable to salt crystallisation? freeze-thaw weathering?

#### WHY MATCH STONE? DIFFICULTIES

 The stronger and most resilient stone is usually never the most appropriate stone to be used!

Stone Type	Compressive Strength (MPa)
Giffnock (Type B2 / B2a)	40 – 50
Stanton Moor	50 – 80
Witton Fell	57 - 68
Scotch Buff	35 - 58
Dunhouse Buff	36 - 84

#### WHY MATCH STONE? DIFFICULTIES

A stone match must provide similar physical properties, permeability, porosity, pore connection, mineralogy, grain size and grain shape to the analysed stone.

If anything, the replacement matching stone should be slightly more porous than the original historic stone in order to ensure that the historic fabric is retained.

In this sense, the replacement stone is *sacrificial* to the historic stone – but generally as a last resort – we want to match everything as close as possible!



From:

The performance of replacement sandstone in the New Town of Edinburgh Historic Scotland Research Report, 2004.

Wrong grain-size – detailing is different and not compatible.

Cheyne Street (1982)







Sampling of the stone

Cored samples from non-weathered, representative areas of stone to be replaced are ideal.

Measuring ~40-50mm diameter x ~60mm length.

Smaller samples are still suitable for thin section preparation, however samples measuring a minimum of ~45mm x 45mm x 45mm are essential for physical testing.

• Selection of a sample location:

Ideally cored from blocks that will be replaced, in order to minimise aesthetic impact of coring/sampling.

Visually identify (and from experience) how many variants are present within the building or elevation to be repaired.

As a general rule; remember that the good quality sandstones were usually used in dressing and in feature stones, with poorer quality stone (and sometimes a mixture from different sources) used as plain walling, rubble walling or on end/rear elevations.

#### STONE MATCHING STAGE 1 - SAMPLING

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• Find out whether a previous 'professional' petrographic stone match has been undertaken on the stone type in the building.

Undertake a literature search to ascertain whether original records remain that might identify the original stone source(s) used in the building.

Find out information on the age of the building, as this will help to determine how close the source quarry might be from the building.



OBO



Petrographic thin section analysis:

Thin section preparation is an art-form in itself and is usually undertaken in specialist laboratories.

Regularly undertaken for sandstone and limestone samples.

Less important and sometimes not necessary for granite, slate, whinstone samples.

Edinburgh University LMHI Longmore Have Edinburgh

GeoSciences

Edinburgh University



store for Daviclash

a transferrance

**GeoSciences** 

**Edinburgh University** 

DC2 Ruttlestone Doune Custle Edinburgh University



#### STONE MATCHING PETROGRAPHIC ANALYSIS

To determine the mineralogy and stone texture.

To determine the pore network connectivity.

To determine the cause of deterioration and impact of past repairs.

To assess suitability of stone for purpose.

To compare with suggested replacement stone.

### STONE MATCHING PETROGRAPHIC ANALYSIS

Composition: detrital and authigenic mineralogy

Grain size.

Grain shape.

Pore network properties: pore shapes, sizes and connectivity.

Indication to depositional environment and stone provenance.

#### STONE MATCHING PHYSICAL TESTING

Physical tests will all help to reveal information on the permeability of the stone: this is the measure of the ability of stone to transmit a fluid. This depends largely on the size and connectivity of pore spaces.



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Joint

Pore spaces

Jointed sandstone porous and permeable

Pore spaces

Unjointed clay porous and impermeable



Fractures

Jointed nonporous rock porous and permeable

#### STONE MATCHING SLATE, WHIN & GRANITE

Generally a visual analysis / hand specimen analysis is all that is required.

Colour and texture match is of main concern here as these are impermeable stone types.

Slate in particular requires someone with good experience to identify the original source.

Standards exist for slate analysis – controversial however!



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#### STONE MATCHING RECAP



Surface colour will be influenced by weathering processes and the movement of dissolved minerals to the stone surface.

Fresh replacement stone might have a different colour to original historic stone, even if a like-forlike match is provided.



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## STONE MATCHING





#### STONE MATCHING USEFUL CONTACTS

- Pricing: £400 £800 per sample/report.
  Time: ~5 weeks +
  - Important to schedule stone matching analysis well in advance of any works / stone ordering.
- Need to factor in (i) how busy the lab might be, (ii) additional tests, (iii) difficulty in finding a suitable matching stone, (iv) stone availability and lead time for ordering.
  - **Useful contacts:**
- The Scottish Lime Centre Trust
- British Geological Survey (BGS)
- CMC Stone
- Stone Doctor
- Joan Walsh (slate)

#### STONE MATCHING CASE STUDIES

Ingram Street, Glasgow

Ingram Street

**Scotch Buff** 

#### STONE MATCHING CASE STUDIES

Ingram Street, Glasgow

Ingram Street

**Dunhouse Buff** 

#### STONE MATCHING CASE STUDIES

Ingram Street, Glasgow

Ingram Street

Drumhead





proposed replacement







**Stanton Moor** 





**Dunhouse Buff**