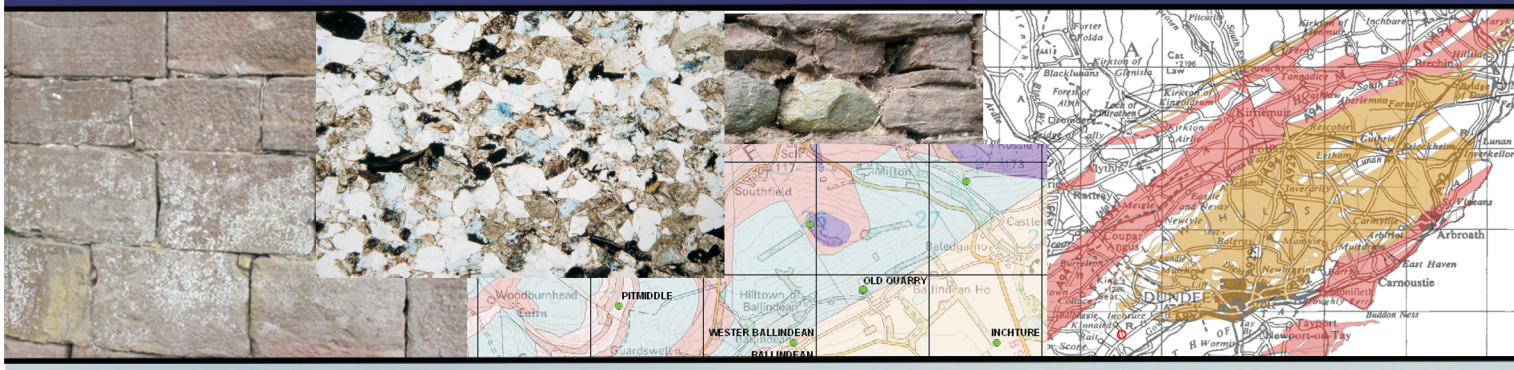
The Source of Building Stone for Westown Kirk, Perthshire:

a geological and architectural investigation



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

BRITISH GEOLOGICAL SURVEY

ENQUIRIES SERVICE

BUILDING STONE ASSESSMENT GEOREPORT GR_200779/1

The source of building stone for Westown Kirk, Perthshire: a geological and architectural investigation

Ewan K. Hyslop, Emily A. Tracey & Luis J. Albornoz-Parra

Front cover

Main Image: Westown Kirk, Westown, Perthshire -a pre-Reformation church and Scheduled Ancient Monument. (left to right): Detail of formal squared rubble masonry; Thin section microscope of the stone; Geological map of the district; Mixed random rubble masonry; Outcrop map of the Dundee Flagstone Formation and Scone Sandstone Formation.

Bibliographical reference

EWAN K. HYSLOP, EMILY A. TRACEY & LUIS J. ALBORNOZ-PARRA. 2010. The source of building stone for Westown Kirk, Perthshire: a geological and architectural investigation. British Geological Suirvey Georeport GR_200779/1

Keyworth, Nottingham British Geological Survey 2010

1. INTRODUCTION AND BACKGROUND

BGS was asked by Andrew Driver on behalf of Perth and Kinross Heritage Trust to assist with an investigation into the origin of the stone masonry in Westown Kirk (Figs. 1 & 2). Certain characteristics of the building and architectural detailing suggest that the masonry may have been reused from another building and transported from elsewhere. The purpose of this report is to document some of the unusual features of the masonry, and to characterise the stone type in order to attempt to identify its provenance. It is understood that no documentary evidence exists relating to the source of the stone used in the church.

This report provides a description of the masonry following a site visit by Ewan Hyslop and Emily Tracey on 29 May 2009. Following the site visit, part of a broken masonry block was provided in order to provide a small sample for detailed characterisation of the stone. The detailed geology of the area is described in order to establish if the stone in the building is likely to be locally sourced or imported from further afield. All the photographs in this report were taken in May 2010.

Fig. 1: Westown Kirk [NO 2493 2746], a 16th century, pre-reformation church in ruinous state.

Fig. 2: Location of site. Map Scale approx.: 1:50,000. Site location indicated in red.

2. HISTORICAL AND ARCHITECTURAL SIGNIFICANCE OF WESTOWN KIRK

Westown Kirk is a scheduled ancient monument and C(s) listed building. It is considered to be of national importance because it is a well-preserved example of a pre-Reformation church which demonstrates how buildings could be adapted to serve changing ritual practice. In addition it is thought to provide evidence and has the potential to provide further evidence to contribute to knowledge of Medieval ecclesiastical architecture, material culture, parish organisation and settlement evolution during the period of its construction and use.

The building has also been referred to as Wast-Town Church and Old Inchmartine Parish Kirk. According to the listed building description, regular services were held here until the end of the 18th century. The Kirk was once with a nave and chancel, but the latter was removed to make 'a suitable preaching station' after the Reformation. Evidence for this survives in the east gable end pointed chancel arch infilled with random rubble walling (Fig. 3). Rectangular in plan, the nave measures 15m x 6.85m with walls varied in thickness (wider east gable than west) measured over a meter in places.

Fig. 3: Eastern gable wall with pointed chancel-arch. The infilled wall probably represents the post-reformation alterations making the building a 'suitable preaching station'.

3. SITE VISIT: VISUAL INSPECTION OF MASONRY AT WESTOWN KIRK

3.1 Masonry: general observations

The church is constructed of purple-grey sandstone. Most of the exterior faces consist of large blocks of squared coursed rubble with simple moulded detailing. The coursing is irregular in places and poorly constructed especially given the fine quality of the masonry blocks. The interior walls and east gable are random rubble of a similar sandstone type, together with occasional rounded whinstone boulders and pinnings of slate. The exterior squared rubble shows signs of having a chiselled outer face (now weathered).

3.2 Architectural detailing: windows and doorways

The windows in the structure reflect different architectural styles. In the south wall there are two square-headed windows; the easternmost window having a roll-moulded frame and the westernmost window with simple straight-edged frame and sill of a different stone type, most likely a re-used copestone. Both south facing windows have glazing grooves. A lancet window appears in the north wall with cusped head and glazing grooves.

Two entrances lead into the Kirk, one in the north elevation and one in the south (Fig. 4). The south entrance is round headed with roll-moulded surround; the north is simpler with square head and chamfered arris on either side reflecting the narrowing walls of the door frame. These opposing entrances illustrate the inconsistency of the architectural features within the structure of the building.

Fig. 4: The two entrances to the building; round headed, roll-moulded archway of south entrance and square headed north entrance.

3.3 East Gable

The east gable of the church contains a large central pointed arch of dressed stone within a random rubble gable wall of dark purple-red sandstone with occasional whinstone boulders. Most of the sandstone rubble shows parallel bedding and has small block/bed heights typically less than 200mm (Fig. 5). The dressed stone is a similar sandstone, although with larger block/bed heights. The arch has been infilled with a similar random sandstone rubble, generally of a larger block size than the adjacent rubble.

The large squared rubble blocks of the adjoining north and south walls continue beyond the face-line of the east gable, giving the impression that either the building formerly continued to the east beyond the current gable wall, or that the building was 'unfinished' with blocks left protruding to facilitate future extension of the north and south walls.

On the east gable the junction of the random rubble and the large block square rubble highlights subtle differences between the two stone types, with the latter having a more grey colour. Along with the difference in bed heights described above, it is therefore considered possible that the sandstone for the random rubble and more formal squared rubble came from different quarry origins.

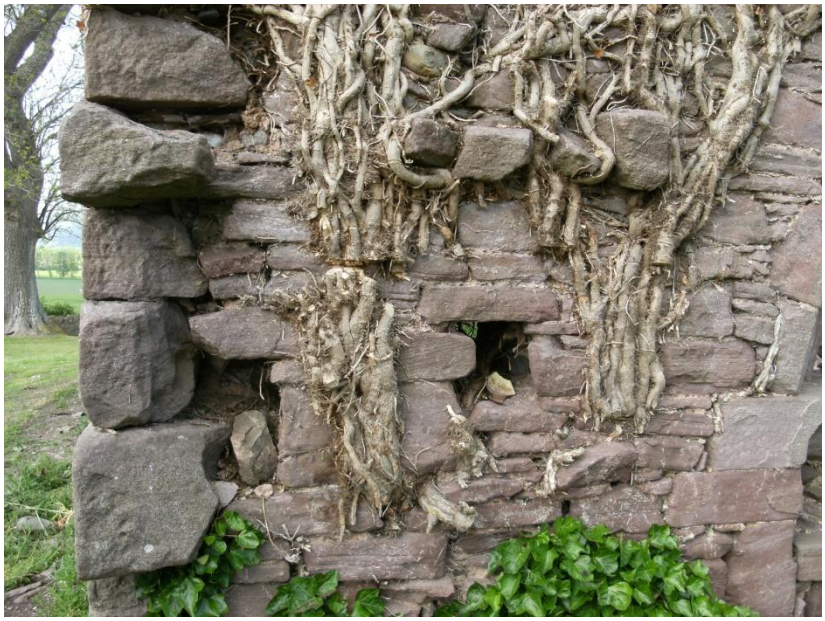


Fig. 5: The east gable of the church contains a large central pointed arch of dressed stone within a Junction between random rubble and external squared rubble on east gable, showing differences between block sizes and bed heights.

3.4 South Elevation

The masonry on the south elevation shows a number of unusual features. The masonry courses in the eastern part of the wall (from the east gable to just before the second window) do not continue in a uniform fashion along the whole wall, and some 'wedge' out from east to west along the elevation (Figs. 6 & 7). It appears that the eastern part appears to have been constructed as a 'separate build' from the rest of the elevation, and oddly, although the masonry block is itself of high quality, the building style is poorly executed.

Fig. 6: South elevation showing discontinuity in the masonry between the eastern section and the rest of the building (highlighted by vertical line).

Fig. 7: Detail of south elevation showing 'wedging out' of masonry courses along the wall from east to west (highlighted by arrows).

In addition, the two windows on the south wall have unusually poorly detailed stonework. Firstly, the central window has a lintel block that is greater in height than adjacent blocks in the same course (Fig. 8). Secondly, the moulded detail in the lintel block on the easternmost window has been very crudely executed, unlike the detailing in the vertical jambs and sill which have a rounded moulding. Both these features suggest that the lintel stones are not the original blocks for the windows –they have been crudely made to fit, apparently from large squared walling blocks.

Fig. 8: Window on south elevation with lintel block of greater height than adjacent blocks in the same course, suggesting that the lintel stones may not the original blocks for the windows.

3.5 West Gable

The belfry appears to be constructed from a similar type of sandstone and is relatively unweathered, in better condition than much of the rest of the masonry. Given its good condition it could be a later addition or replacement.

3.6 Evidence of reused masonry blocks

A number of obvious reused stones are present throughout the building. For example, the large arch infill on the east gable (interior) has a block with moulded detail (Fig. 9), with a similar feature at the interior of the west gable (Fig. 10). The interior of the south wall has a number of lintels that appear to be reused grave slabs (e.g. Fig. 11). Furthermore, the door on the north wall has lintel details that have been recut from an originally larger lintel, in order to fit the present doorway; and the block has been placed asymmetrically over the doorway (Fig. 12) suggesting that the lintel has been reused from demolition of a previous wall. In addition, an underlying rybat block has been cut to fit the walling masonry in order to preserve the presumably pre-existing corner detailing (Fig 13), again suggesting the stone has been reused from another building.

The features described above, in particular the reuse of specific blocks and the poor construction details (e.g. inconsistent coursing) provide evidence to suggest that the formal squared rubble masonry may have been reclaimed from a previous building, and has been reused in this building where in places it has been crudely 'made to fit'. In summary, the contrast between the fine stonework and the poor craftsmanship of the walling construction implies that the squared rubble stone has been obtained from a previous building.

Fig. 9: Arch infill on the east gable containing reused masonry block with moulded detail (arrowed).

Fig. 10: Reused masonry block with moulded detail (arrowed) on west gable interior.

Fig. 11: Entrance to south wall, showing lintel made from reused grave slab.

Fig. 12: Detail of lintel to door on the north wall showing detailing from an originally larger entrance (arrowed), recut in order to fit the present narrower doorway, suggesting that the stone has been reused from an earlier building.

Fig. 13: Entrance in north wall showing rybat block which has been cut to fit the walling masonry in order to preserve pre-existing corner detailing (arrowed), supporting evidence that the stone has been reused from another building.

4. GEOLOGY OF THE AREA

Westown Church is situated on a ridge in the Carse of Gowrie, a large low-lying estuary plain formerly occupied by the sea and comprising thick marine deposits dominated by clays. The underlying rock is red and yellow sandstones of Upper Devonian age (Glenvale Sandstone Formation) which are largely covered by superficial deposits. These sandstones are typically brown, red, purple, yellow and cream coloured feldspathic sandstone, commonly containing bands of red siltstone and pebbles of silty mudstone. The northern limit of the Carse is defined by the presence of basaltic volcanic rocks of Early Devonian age (Ochil Volcanic Formation, comprising basalts, pyroxene-andesites and other igneous rocks). The volcanic rocks make a strong topographic feature, rising rapidly to form a belt of high ground to the north known as the Braes of the Carse. The geology is illustrated in Figs 14 and 15.

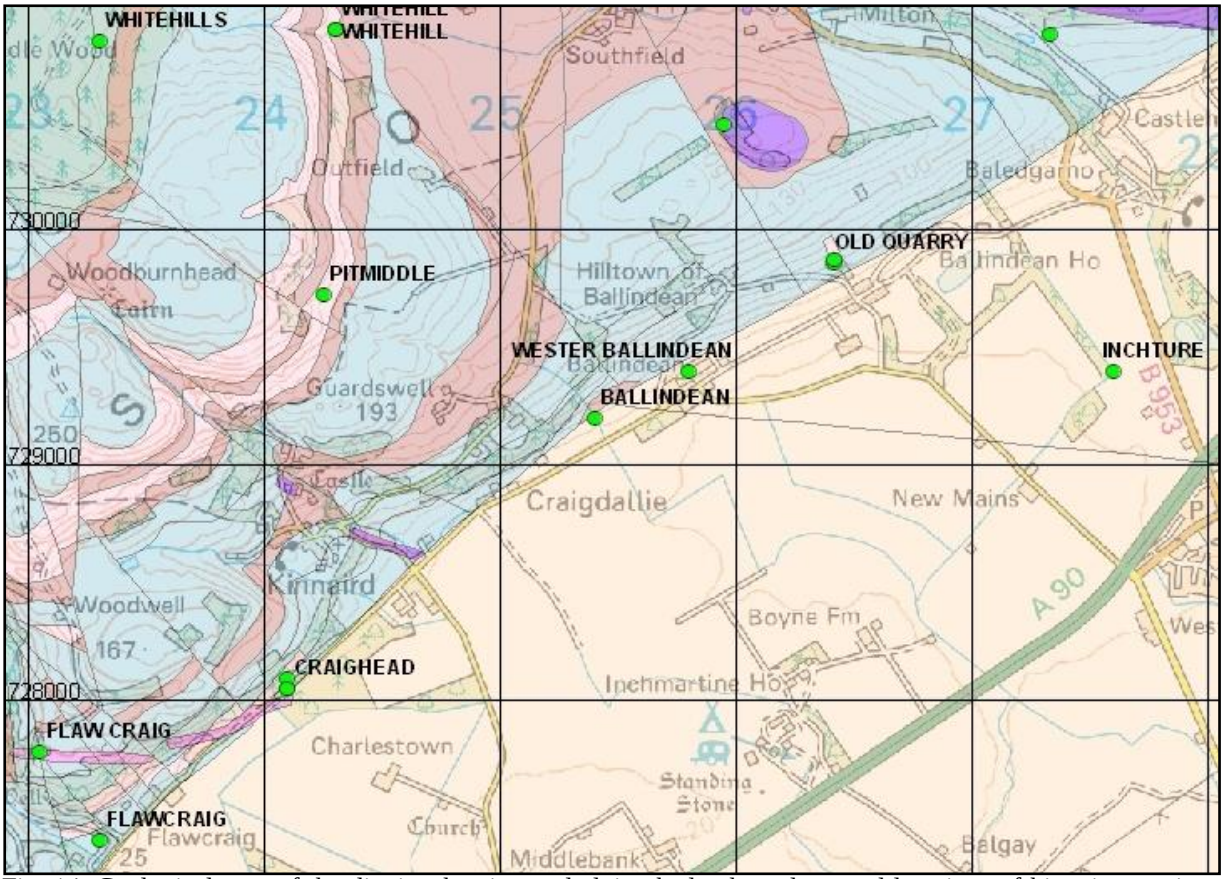


Fig. 14: Geological map of the district showing underlying bedrock geology and locations of historic quarries from the BGS quarries database. Westown Kirk lies on Upper Devonian red sandstones of the Glenvale Formation (pale salmon-pink colour) which was exploited in a number of quarries (e.g. Ballindean, Inchture). The sandstone are delimited to the northwest by the Ochil Volcanic Formation (blue colour) forming hills known as the Braes of the Carse, which contains interbedded Lower Devonian sandstones of the Dundee Flagstone Formation (elongate dark pink/brown bands) and the Scone Sandstone Formation (elongate light pink bands).

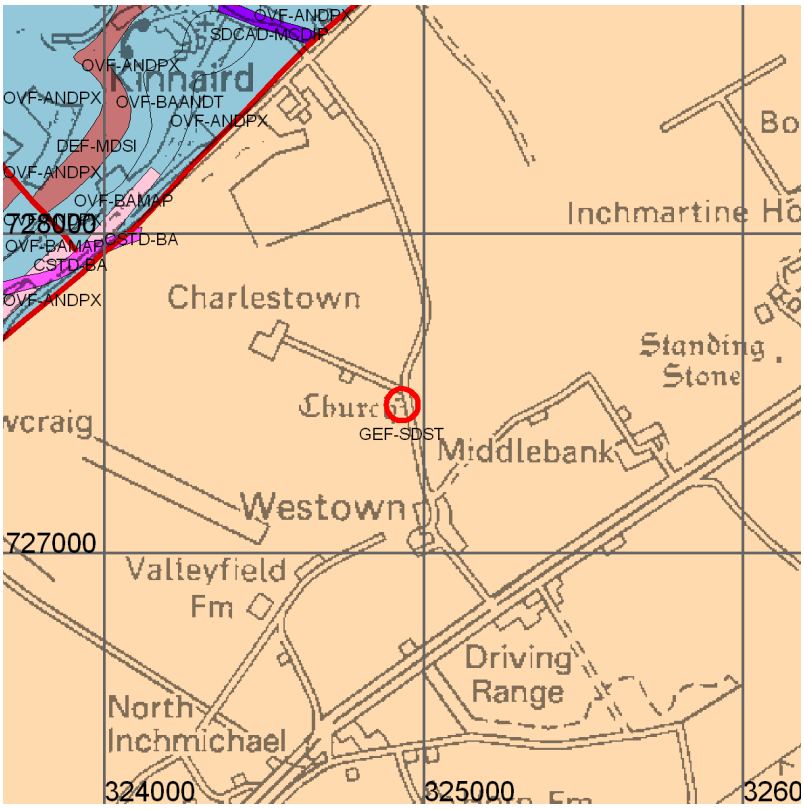


Fig. 15: Geology of the site (Westown Kirk shown by red circle). Key to geological units given in table below. Geological faults are shown as red lines. Scale: 1:25 000 (1cm = 250 m).

Key to Bedrock geology:

Map colour	Computer Code	Rock name	Rock type
	CSTD-BA	CENTRAL SCOTLAND LATE CARBONIFEROUS THOLEIITIC DYKE SWARM	BASALT
	GEF-SDST	GLENVALE SANDSTONE FORMATION	SANDSTONE
	DEF-MDSI	DUNDEE FLAGSTONE FORMATION	MUDSTONE AND SILTSTONE
	OVF-BAMAP	OCHIL VOLCANIC FORMATION	MACROPHYRIC BASALT
	OVF-BAANDT	OCHIL VOLCANIC FORMATION	BASALTIC-ANDESITE (TAS)
	OVF-ANDPX	OCHIL VOLCANIC FORMATION	PYROXENE ANDESITE
	SDCAD-MCDIP	NORTH BRITAIN SILURO-DEVONIAN CALC-ALKALINE DYKE SUITE	PORPHYRITIC MICRODIORITE

Lower Devonian sandstones (Scone Formation and Dundee Formation) occur as relatively thin interbeds within the volcanic rocks. Purple-grey cross bedded sandstones of the Scone Formation (Garvock Group) and grey to brown flagstone of the Dundee Formation occur as thin beds within the lavas. The main outcrop of the Scone Formation is to the north of the volcanic rocks, forming a broad area westward to Scone and Perth, whilst the 'Dundee Flags' are principally found at the eastern end of the Carse (Dundee area) and much further to the north (north of the Scone Formation).

The thick superficial deposits on the Carse form a thick blanket over the underlying Upper Devonian Sandstones and there are few sources of bedrock for quarrying. However sandstones are exposed in a few places and have been quarried at Ballindean and Rossie Priory at Inchture. This is seen as the vivid (and relatively soft weathering) red sandstones used for buildings around Ballindean, and as sandstone dressings (often used in combination with igneous whinstone rubble walling) for properties more distant from the sandstone quarries. Where the Lower Devonian Scone sandstone and Dundee Flagstone are present as beds within the volcanic rocks they have occasionally been locally exploited to provide building stone, for example Rait Church.

5. EXAMINATION OF OTHER BUILDINGS IN THE DISTRICT

Visual inspection of a number of traditional stone buildings in the district was made in order to identify the local stone types used historically, and relate these to the local geology and historic quarries.

Traditional buildings in the village of Rait, lying in volcanic rocks approximately 2 km northwest of Westown, are constructed with mixed random rubble of purple sandstone/flagstone and whinstone (Fig. 16). The dressings appear to be bedded sandstone/siltstone from the Dundee Flagstone Formation, most of which have spalled and repaired using cement or overpainted. All these rocks directly reflect the underlying geology.

Fig. 16: Traditional cottage in the nearby village of Rait, constructed of random rubble comprising mixed purple sandstones and whinstone boulders, with dressings of purple flagstone (mostly overpainted).

The ruinous Old Parish Church at Rait is a similar scale and plan to that at Westown, considered to be a contemporary pre-Reformation church to Westown Kirk. It is constructed from purple sandstone/siltstone with whinstone boulders, forming random rubble walling (Fig. 17). The dressed stone is a purple sandstone of moderate block size with simple carving details, and the quoins are roughly dressed and relatively small in size compared to those at Westown Kirk. The dressings are detailed in a way that suggests the rubble was formerly harled. Both rubble and dressings are likely to be from Lower Devonian Dundee Flagstone Formation, probably obtained from local sandstone interbeds within the volcanic rocks. This masonry style is that expected of a small village church of relatively low status, and contrasts with the relatively ‘high status’ masonry blocks present at Westown Kirk.

Fig. 17: Rait Old Parish Church contemporary to Westown Kirk. Random rubble walling with significantly smaller block sizes and masonry styles than found at Westown Kirk as illustrated in quoins (left) and the window surrounds.

Farm steadings near Rait are built using whinstone rubble which would have been sourced from the local Ochil Volcanic Formation rocks of the Braes (Fig. 18). The dressings are made from vivid red sandstone typical of the Upper Devonian Glenvale Formation, probably sourced from quarries such as that at Ballindean. The red sandstone would provide larger and more easily worked blocks which could be used to span windows and doors, unlike the whinstone which would be only available as small irregular blocks.

Fig. 18: Farm steading just outside of Rait built with locally sourced random rubble whinstone walling and fine grained, orange/red sandstone dressings. The red sandstone would have been sourced from the Ballindean area for its larger block sizes and brought in for door and window surrounds.

The village of Ballindean, situated approximately 2 km northeast of Westown, is constructed largely using the red sandstone typical of the Upper Devonian Glenvale Sandstone Formation (formerly quarried at Wester Ballindean). The sandstone is a vivid orange red colour with characteristic small white reduction spots (Fig. 19). It has been used mostly as squared rubble walling and for dressings of large block size. The quarry at Wester Ballindean appears to have been a significant supplier of red freestone sandstone to the local area, and has been transported to provide dressed stone for use in combination with local volcanic whinstone rubble. This sandstone is quite distinct from the building stone used for Westown Kirk, despite the Glenvale Sandstone Formation directly underlying the site.

Fig. 19: Wester Cottage at Ballindean. Early 19th century build with squared and coursed fine grained orange/red sandstone walling and dressings. The orange/red sandstone of the 19th century cottages has extremely characteristic reduction spots. None of which was found in the sandstone of Westown Kirk.

Further to the northeast, around Inchture and Rossie Priory, the red-orange Upper Devonian sandstone appears in many traditional buildings and boundary walls. It is recorded that the Inchture and Ballindean quarries were re-opened in the 1960s for the reconstruction of the boundary wall to Rossie Priory. A brief visual examination of these structures indicates that this is not the stone used at Westown Kirk.

In summary, examination of traditional buildings in the district surrounding Westown Kirk shows that local stone was typically used, directly reflecting the underlying geology. In the Rait area buildings were constructed using whinstone rubble from the Ochil volcanic rocks of the Braes and relatively poor quality Lower Devonian purple sandstones and flagstones which occur locally as interbeds within the volcanic sequence. Dressed stones are typically either local purple sandstone or Upper Devonian red-orange sandstone obtained from the nearby quarries at Ballindean and Inchture. These Upper Devonian sandstones dominant much of the stone built heritage of the villages and farm buildings north and east of Westown Kirk. The stone used at Westown Kirk itself is significantly different to the local stone, further suggesting it may have been imported into the district.

6. PETROGRAPHIC ANALYSIS OF THE STONE FROM WESTOWN KIRK

6.1 Introduction

A broken block of formal squared rubble sandstone masonry from Westown Kirk was received for analysis (Fig. 20). The external surface has been chiselled to give a relatively smooth surface. A small core plug c.50mm long and c.30 mm diameter was extracted from the broken inside face of the block. The small sample was taken in order that the masonry block could be reinstated into the building if necessary. It is considered that the sample is representative of the former squared rubble masonry present in the building.

Summary of sample

BGS Registered No. ED10700

Description: Purple-grey coloured, faintly bedded, almost uniform sandstone, fine to medium grained. The sample appears to contain relatively abundant muscovite and appears competent.

Dimensions of original block: c.200 x 140 x 110mm.

Fig. 20: Broken masonry block from Westown Kirk analysed in this study. Left-hand side: external masonry surface showing remnants of original tooling marks. Right-hand side: broken internal face cored to extract small sample for analysis.

6.2 Methodology

The core sample was gently washed with water and examined using a binocular microscope (Bausch & Lomb). Colour was determined using a standard Munsell® Colour Rock Chart (Geological Society of America). The sample underwent thin sectioning at the University of Edinburgh thin section laboratory, impregnated with blue dye resin in order to highlight porosity. The section is supplied on a glass slide measuring 75 by 25mm. The thin section was chosen to be as representative of the stone sample as possible, cut perpendicular to fabric and contains, where appropriate, the external surface. It was examined using a petrological microscope (Zeiss Standard WL polarizing microscope) following the procedures given in BS EN 12407:2000 'Natural Stone Test Methods – Petrographic Examination'.

6.3 Description of sample

Macroscopic Description

The sample is a mostly fine to medium grained, uniform sandstone. Colour is purplish-red. Munsell colour code for the fresh part of the stone is c.10R 5/2 to 4/2; *greyish red*. Bedding is only observed in the alignment of the relatively abundant white mica (muscovite) flakes as well as a hint of a faint parallel bedding lamination, but the overall general appearance is relatively uniform. A water bead test indicates moderate permeability. No reaction to 10% HCl, indicating absence of carbonates. The sample appears competent.

Microscopic Description

Grainsize	Fine to medium. Range: 0.05-0.5mm, avg. 0.2-0.35mm.			
Fabric	No particular orientation of grains apart from mica flakes.			
	Mineral/grain type	Percentage	Shape/ Angularity	Distribution/ orientation/ other
	Framework grains	Quartz	c.40-45%	Angular-subangular	Mostly clean, monocrystalline grains.
		Feldspar	c.5%	Angular, subangular	Generally in small sizes.

		Lithic grains	c.15-20%	Angular, subangular	Various different origins (sedimentary, metamorphic, igneous), mostly quartz rich.
		Muscovite, biotite	c.3-4%	Elongate flakes	Well oriented along bedding planes. Both biotite (black) and muscovite (white) micas.
		Opaques	c.4-5%)	Anhedral, shapes.	Iron oxides/hydroxides, both as discrete round grains and as stretched and mobilized grains.
	Matrix minerals	Clay minerals	c.14-15%	-	Complex associations of primary and secondary clays (a result from weathering of feldspars or lithic grains). Infilling pore spaces and intergranular spaces.
		Carbonate	c.12-15%	-	A rather large amount of carbonates (likely calcite) appearing as both sparry and as micritic crystals, homogeneously distributed.
Cement and grain contacts		Scarce effective silica cement overgrowth, only appearing covering grains that are not in contact due to being covered by carbonates or clay minerals. The major cementing agents are the matrix minerals. Grains are held by their contacts, mostly long. This is a moderately to well compacted sandstone.			
Porosity and permeability		The sample would have had a relatively high porosity (estimated at c.15%), but the abundant clay infill throughout the stone lowers this percentage, also affecting the permeability. Open porosity is much lower (2-3%). This is a moderately permeable stone.			
Classification		**Lithic wacke sandstone (Fig. 21)**			

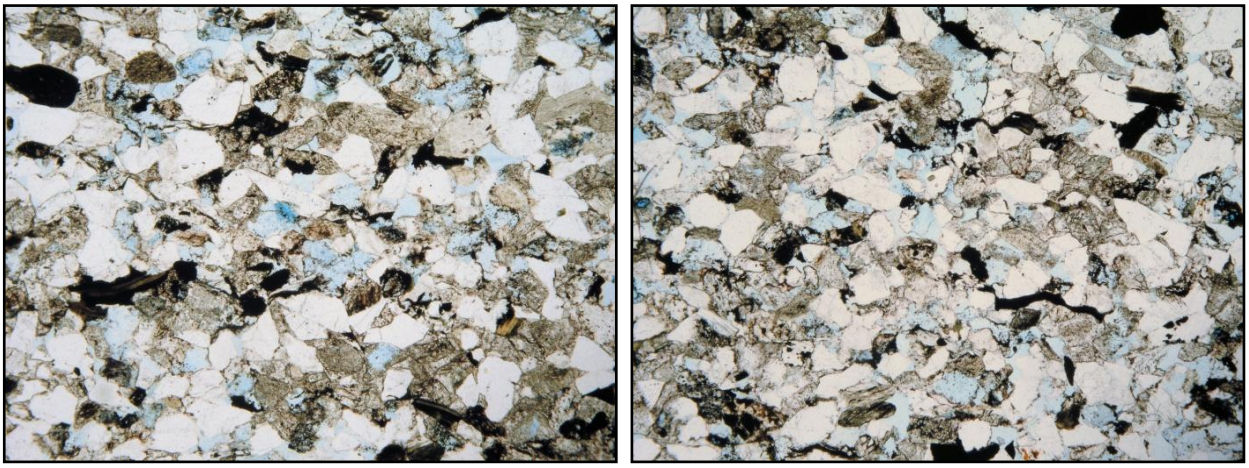


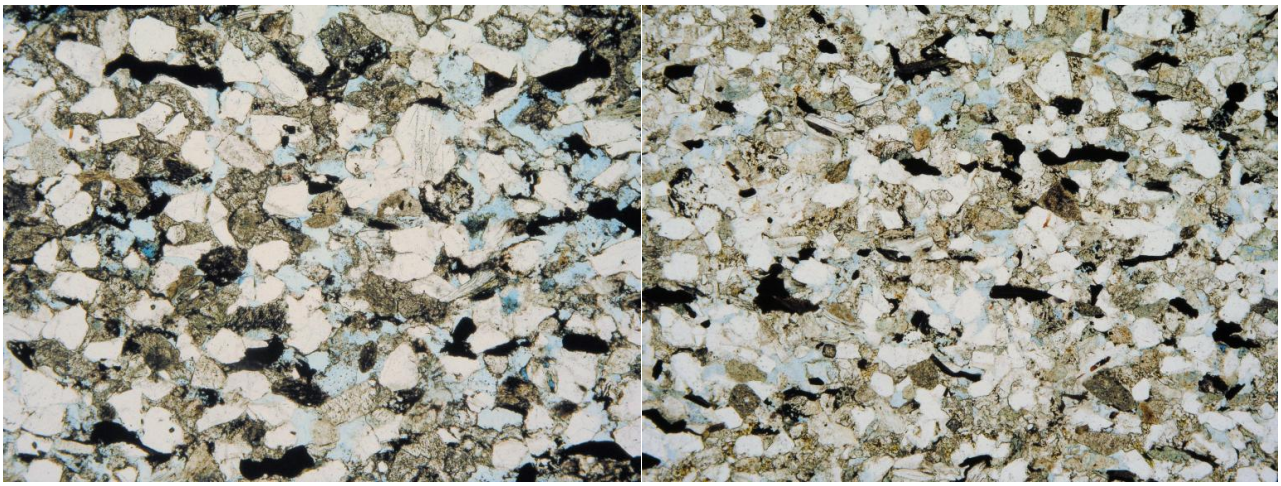
Fig. 21: Microscope images of sample ED10710 taken with plane polarised light. Porosity highlighted in blue dye resin. Images are c.3.3mm wide.

6.4 Geological origin of the sandstone

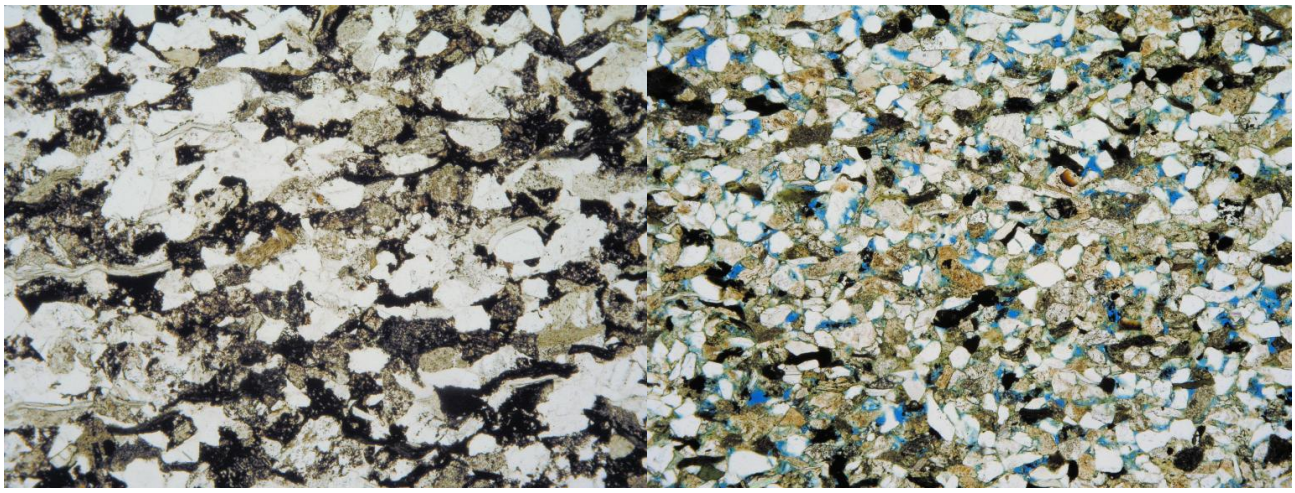
The stone is classified as a lithic wacke sandstone, containing quartz grains with relatively abundant lithic grains of igneous and metamorphic origin, and muscovite and biotite and flakes, with minor carbonate (likely calcite). The colour is purplish-grey, and it has a consistent, albeit faint parallel bedding lamination. The stone is well compacted and relatively competent. In terms of building stone it is of moderate quality, typical of the Lower Devonian sandstones of much of Angus and Perthshire. The relatively high content of metamorphic and igneous lithic grains is also consistent with such an origin (the sandstone would have been derived from erosion of Highland rocks from the north). However there is little in the sandstone that is characteristic enough in order to be more precise about its origin.

*6.5 Comparison with existing BGS sample*s

The masonry sample from Westown Kirk was compared microscopically to samples of Glenvale Sandstone Formation, Scone Sandstone Formation and Dundee Flagstone Formation, in order to test whether these geological formations can be ruled out or considered the likely source of the stone (Fig. 22). The Glenvale Formation is quite distinct and different, comprising well rounded quartz grains. The Dundee Flagstone Formation generally contains more darker minerals (iron oxides) and has a variable texture (from coarse grained to very fine grained); although the coarser variety (from Kingoodie quarry near Dundee) does bear similarities to the Westown sample. The sample of Scone Sandstone Formation (sample from the Perth area) is most similar to the Westown masonry, although it should be noted that the Scone sandstones also can be variable. In conclusion, none of the samples examined are identical to the stone from Westown Kirk; it is most similar to the sample from the Scone Sandstone Formation, although a source from the Dundee Flagstone Formation cannot be ruled out.



Westown Kirk masonry sample (ED10700) Scone Sandstone Formation (S99443)



Dundee Flagstone Formation (Kingoodie Quarry) Dundee Flagstone Formation (Pitairlie Quarry)

Glenvale Formation (S61756) Errol Borehole

Fig. 22: Comparison of microscopic thin sections of masonry sample from Westown Kirk with the main geological formations outcropping in the region. The sample from Scone Sandstone Formation is most similar in grainsize, mineral composition and amount of black iron minerals. The two samples of Dundee Flagstone Formation show a range of grainsize from coarse grained (Kingoodie) to fine grained (Pitairlie), both containing abundant dark iron minerals (black). The Glenvale Formation is distinct; finer grained with rounded quartz grains. None of the samples shown are an exact match to the Westown Kirk masonry; the Scone sandstone and coarser grained Dundee flagstone samples are similar.

7. DISCUSSION AND CONCLUSIONS

7.1 Source of the stone for Westown Kirk

The purple-grey sandstone masonry in Westown Kirk is distinct from the vivid red-orange coloured sandstones of the Upper Devonian Glenvale Formation that underlie the Carse of Gowrie. These sandstones were formerly quarried at a number of sites such as Ballindean and Inchture, and were used throughout the district for traditional buildings and boundary walls. The stone in Westown Kirk is more similar to the darker purple-brown cross-bedded sandstones of the Lower Devonian Scone Formation and the coarser grained varieties of the Dundee Flagstone Formation. These are known to occur locally as interbeds within the volcanic rocks of the Braes and have been used locally, for example in the village of Rait. Despite this similarity in sandstone type, the squared rubble block at Westown Kirk (with distinctive large block sizes and bed heights) is a relatively high quality masonry which is considered to unlikely to have been present in interbeds within the volcanic rocks; and is more likely to have been obtained from a larger scale quarry in the Scone or Dundee Flagstone formations outside the immediate district.

The above conclusions are based on geological observations, but are supported by the architectural form of the masonry and the method of construction observed at Westown Kirk, which show many inconsistencies. Although the stone masonry itself is of high quality, it has been reworked and constructed to a relatively low standard, suggesting it has been re-used from a pre-existing building. This supports the hypothesis that the stone was obtained from outside the district.

The petrographic evidence shows that the stone at Westown Kirk is not from the local Glenvale Sandstone Formation. It is most similar to the Scone Sandstone Formation which outcrops in a extensive north-east-southwest trending belt extending from north of Dundee (Kirrimuir and Brechin) through Coupar Angus and continuing farther to the southwest beyond Perth (Fig. 23). A further large outcrop lies to the east side of Dundee continuing across the Tay to north-eastern Fife. The widespread extent and uniform nature of the Scone Sandstone means that the origin of the stone at Westown Kirk cannot be identified more accurately than this. A second possible origin is from sandstones within the Dundee Flagstone Formation (also Lower Devonian), which outcrops in a broad area to the northeast of Dundee; however these rocks tend to be more thinly bedded with ‘flaggy’ mudstone layers which are not observed in the masonry at Westown Kirk.

Assuming that the stone at Westown Kirk is from either the Scone Sandstone Formation of Dundee Flagstone Formation it is difficult to postulate a potential source area. The presence of the volcanic rocks (Braes of the Carse) along the northern margin of the Carse of Gowrie provide a considerable geographic barrier to transportation, suggesting that the most likely sources would have been from the western part of the Scone Sandstone outcrop (e.g. Perth area) or from the Dundee Flagstones immediately west of Dundee.

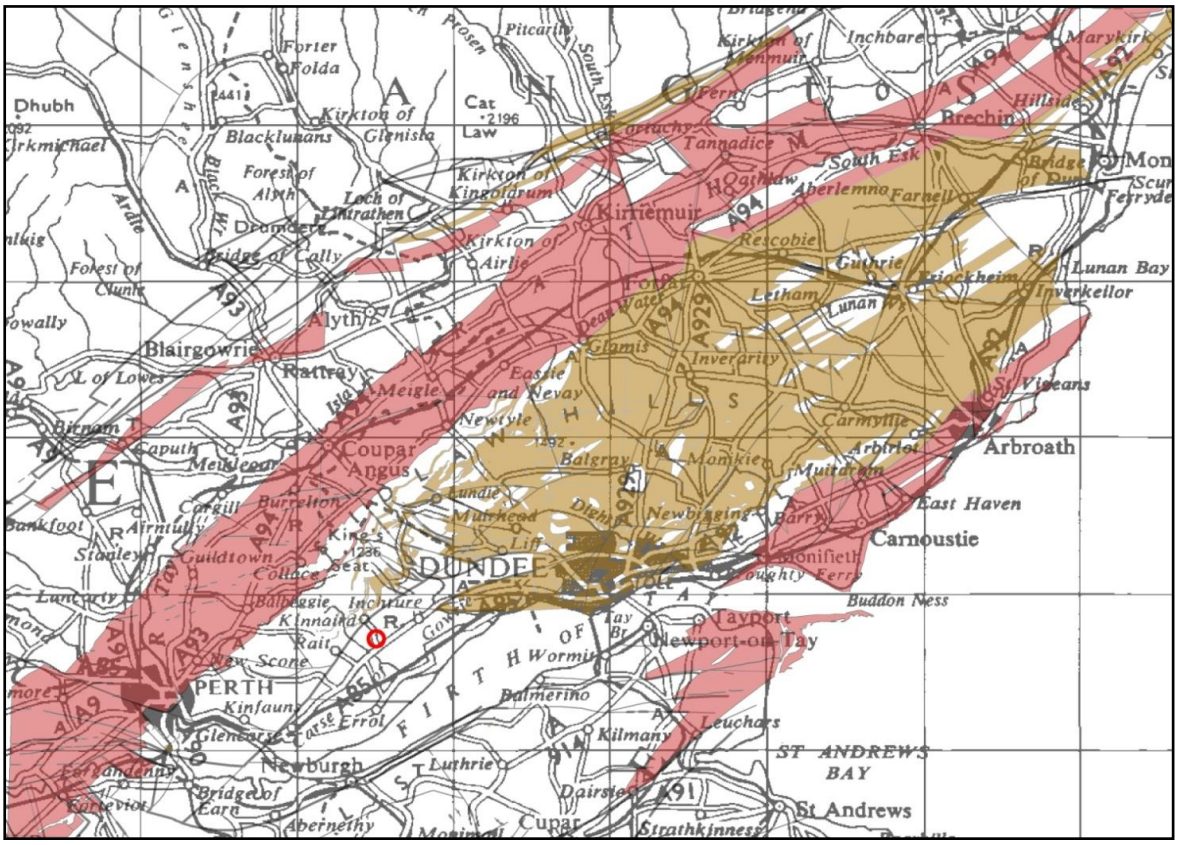


Fig. 23: Map showing outcrop of the two geological formations most likely to be the source of stone for Westown Kirk; Purple-red colour = Scone Sandstone Formation, Brown colour = Dundee Flagstone Formation. Location of Westown Kirk shown by red circle.

7.2 Summary of Conclusions

- Observations from the site visit suggest that the formal squared rubble masonry on the building has been re-used from a previous building. There are numerous masonry details indicating that stones were originally used for another purpose and have been modified and added to this building as a 'formal' masonry skin.

- The local building stone is a red-orange sandstone (Upper Devonian Glenvale Formation) quarried from nearby Ballindean, and typically used in combination with volcanic whinstone rubble. The stone at Westown Church is a distinct purple-grey sandstone more likely to be from the Lower Devonian. The quality of the masonry (e.g. bed heights, block sizes) suggests it has been obtained from a 'significant' quarry –there are none in this area, indicating it is likely to have been transported some distance.

- The nearby church at Rait has purple sandstone probably also obtained from the Scone Sandstone Formation or Dundee Flagstone Formation, but of lesser quality (smaller bed height and block size, and with flaggy siltstone component), and is likely to have come from sandstone beds caught up within the volcanic rocks of the Braes of the Carse.

- Petrographic analysis of a sample of the formal masonry from Westown Kirk identifies it as a lithic wacke sandstone, most likely to be from the Lower Devonian Scone Sandstone Formation or a sandstone from the Dundee Flagstone Formation. Comparison with existing samples from the Upper and Lower Devonian sandstones of the region confirms this as the most likely origin of the stone.

- Given the widespread outcrop of both the Scone Sandstone Formation and Dundee Flagstone Formation it is not possible to pin-point the stone to an exact quarry origin. If quarry samples or other masonry from a potential (suspected) site of origin (e.g. Scone Abbey) were available for comparison, it should be possible to make further comments to narrow down the source of the stone used at Westown Kirk.

8. TERMS AND CONDITIONS

This report includes mapping data licensed from Ordnance Survey: © Crown Copyright and/or database right 2010. Licence number 100037272. Geological observations and interpretations are made according to the prevailing understanding of the subject at the time. The quality of such observations and interpretations may be affected by the availability of new data, by subsequent advances in knowledge, improved methods of interpretation, and better access to sampling locations.

Raw data may have been transcribed from analogue to digital format, or may have been acquired by means of automated measuring techniques. Although such processes are subjected to quality control to ensure reliability where possible, some raw data may have been processed without human intervention and may in consequence contain undetected errors. Detail which is clearly defined and accurately depicted on large-scale maps may be lost when small-scale maps are derived from them. The most appropriate techniques for copying original records are used, but there may be some loss of detail and dimensional distortion when such records are copied. Although samples and records are maintained with all reasonable care, there may be some deterioration in the long term.

Data may be compiled from the disparate sources of information at BGS's disposal, including material donated to BGS by third parties, and may not originally have been subject to any verification or other quality control process. Data, information and related records which have been donated to BGS have been produced for a specific purpose, and that may affect the type and completeness of the data recorded and any interpretation. The nature and purpose of data collection, and the age of the resultant material may render it unsuitable for certain applications/uses. You must verify the suitability of the material for your intended usage. If a report or other output is produced for you on the basis of data you have provided to BGS, or your own data input into a BGS system, please do not rely on it as a source of information about other areas or geological features, as the report may omit important details.

The data, information and related records supplied in this report by BGS can only be indicative and should not be taken as a substitute for detailed site investigations and/or specialist interpretations, and other professional advice. You must seek professional advice before making technical interpretations on the basis of the materials provided.