The provenance of some building stones in St Mary Spital by geological methods

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Abstract

The Museum of London Archaeology Service provided the author with six specimens of apparently identical building stone, all from the St Mary Spital site in London. They wished to know if the material was Reigate Stone, their own tentative suggestion, and if it was possible to determine the quarries from which it derived. They also wished to know if the specimens were from the same part of a quarry or if they were from different strata within it. The choice of tests available to the geologist for analysing archaeological material is very wide, and those most appropriate must be chosen with care — it is easy to repeat results or produce useless information through poor choice. The decision is based on the characteristics of the material as well as the requirements of the archaeologists.

The Priory and Hospital of St Mary Spital

St Mary Spital was one of the most important institutions caring for the poor and sick of medieval London[1]. It was founded in 1197 by Walter Roisia Brown on land on the east side of Bishopsgate near the bars. In 1235 substantial parts were rebuilt as the church was moved so the new west door was on the site of the original east end. The Hospital housed pilgrims, widows and the sick poor, with special responsibility to pregnant women and orphans. The resultant large requirements for water caused numerous winter flood problems, and caused destruction which contributed to the state of disrepair by the 14th and 15th centuries. Previous works refer to the use of moulded green sandstone, established by this research to be Reigate Stone, in arches, columns, foundations and coffins. At the Dissolution much of the existing material was incorporated into new constructions such as cess pit walls so that it was protected from the effects of weathering and the Industrial Revolution.

Reigate Stone in London

From the eleventh century onwards Reigate Stone was used in a variety of buildings in Surrey and London. After the invasion of William the Conqueror, Norman stonemasons were employed on buildings. Their native stone, Caen Stone, was a soft, easily carved material which they liked, but it was expensive to transport from Normandy to England. For example, Caen Stone was used for building Norwich Cathedral. The Norwich CommunarÆs Roll[2] shows that the stone for the cathedral was purchased in 1287 at a price of £1 6s. 8d. Transport was by barge which, although cheap for short distances, came to a total of £3. Therefore a local replacement was sought early on. Reigate Stone was found to have similar working qualities to Caen Stone: it could be sawn and worked like wood. In fact, the Domesday Book records the location of two Reigate Stone quarries near Limpsfield. Transport to London at this time was easy, with the River Mole about a mile away from the Upper Greensand quarries and joining the Thames at East Molesey, where Hampton Court now stands.

Early on, Reigate Stone was used for important buildings, including the old London Bridge, erected in 1176, and also the stone areas of the present Southwark Cathedral, erected in the early thirteenth century. By this time, although Caen Stone was still being used, many major buildings incorporated Reigate Stone. It was the only readily available and suitable local material.

The original Westminster Abbey was constructed mostly of Reigate Stone, and from then on it was the major stone in royal buildings. It was used in the Palace at Westminster in 1259 and between 1352-9 it was used extensively at Windsor Castle. In 1443 it was incorporated in Eton College, and in the sixteenth century it was used in Hampton Court Palace. Reigate Stone was also used for repair

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1. C. Thomas, C. Phillpotts, B. Sloane and G. Evans 'Excavations of the Priory and Hospital of St Mary Spital' *London Archaeol* 6 no 4 (1989) 87-93.
2. L. F. Salzman *Building in England down to 1540* (1951).

work; much of that done at the Tower of London in the medieval period was carried out using Reigate Stone[3].

Reigate itself features some buildings, mainly churches and walls, constructed of the local stone, but most of these are more recent structures.

Unfortunately, the durability of Reigate Stone, although adequate for internal and possibly underground work, is not by any standards adequate for external work. Hence there are very few medieval buildings remaining in London. In fact Wren, when writing his Memoir in 1713 commented that 'which is most to be lamented, is the unhappy Choice of Materials, the Stone is decayed four Inches deep, and falls off perpetually in great scales . . . Caen Stone . . . was found expensive to bring hither, so they brought Rygate-stone in Surrey, the nearest like their own, . . . but not durable, as is manifest; and they used this for the Ashlar of the whole Fabrick, which is now disfigured to the highest Degree: this Stone takes in Water, which, being frozen, scales off, whereas good stone gathers a crust and defends itself, as many of our English Free-stones do'[4]. In 1840, C. H. Smith noted that after 20 to 30 years of exposure to subaerial weathering processes, all architectural detail was lost[5].

Quarries and lithologies in the Reigate area

The Wealden District[6], in the south of England, is dominated by alternating beds of sand, sandstone, malmstone and clay, with glauconite[7], where present, giving a green hue to otherwise grey strata. Malmstone is a fine-grained silica-rich rock with a 2-3% calcareous matrix. The malmstone in this area has sponge spicules, colloidal quartz, mica and glauconite. Bands within it containing 20-25% calcareous material are known as Firestone[8], a material traditionally used as a building stone. Sandstone bands within it are soft, friable and poorly suited to exterior structural purposes, and this is known as Hearthstone.

The Upper Greensand of the Reigate area[9] outcrops at the base of the North Downs escarpment, above the flat expanse of Gault Clay, and below the Chalk. Firestone and Hearthstone are found in alternating units, but unfortunately, as nearly all old quarries, mines and adits are either infilled, overgrown or collapsed, it is rarely possible to view these relationships in the field. The best place to see the Upper Greensand now is in mines used for drainage from the motorways, for example the mine under Merstham, at TQ 299 538, visited by the author. A list of locations of quarries, mines and exposures is available from the author on request.

Tests available for the study

There is a large range of tests available to the geologist, but not all would be appropriate for all rock types. The immediately obvious test for these specimens was that which would be carried out for all rock types, that is petrological study to determine mineralogy, textures and fabrics. A study of fossil evidence would be restricted to those sedimentary rocks with enough sufficiently preserved fossil remains to warrant it. Beyond these studies the tests become more specialised, for example X-ray diffraction (XRD) reveals the structures of minerals. This can be useful when faced with identifying minerals that have the same petrological characteristics such as calcite and aragonite, but it can be time-consuming and expensive, so is not always appropriate. Individual mineral chemistry can vary according to source material, chemistry of pore waters percolating, subsequent history and exposure to weathering agents. Therefore tests such as the electron microprobe and ICP (trace element quantification) can be useful. Percentage contents of component minerals in rocks can help to distinguish specimens, whether done by extraction techniques or by point counting. The latter may be more appropriate for igneous material than the former, which should be straightforward for most sedimentary rocks.

Regardless of what tests are carried out, it is important to remember that material used for building stone has been out of its natural environment for some time. In the case of medieval buildings, the material may well have been exposed to the effects of subaerial weathering for several years and then buried in made ground conditions, for example in cess pits, for several hundred years. Therefore chemi-

3. T. Tatton-Brown 'Medieval building stone at the Tower of London' *London Archaeol* 6 no. 13 (1991) 361-6.

4. A. Clifton-Taylor *The Pattern of English Building*.

5. J. McInally *Materials in Medieval Mid-Surrey* unpublished essay.

6. F. H. Edmunds *The Wealden District British Regional Geology* Geol. Survey, HMSO (1948) 2nd edn.

7. Glauconite is a mineral unique to sedimentary rocks. It may grow *in situ*, or may be a detrital grain. It can be a sand-grade green grain or a hydrated iron-rich clay mineral. There are many shapes of *in situ* grains, for instance they may grow in fossils, or replace micas. The colour reflects ferric iron content: more gives a darker green, and as glauconite weathers, it alters to limonite, a brown mineral.

8. A. J. Jukes-Browne *The Cretaceous Rocks of Britain, Vol. 1, Gault and Upper Greensand of England* Mem. Geol. Surv. UK (1900).

9. H. G. Dines and F. H. Edmunds The Country around Reigate And Dorking *Mem. Geol. Surv*, Sheet 286 (1933).

cal alteration is an important aspect to remember when testing the specimen both chemically and mineralogically.

Tests and results

Features to be considered in identifying the Museum specimens were the mineralogy, textures, fabrics and fossils. These features were studied on macro and micro scales using, to begin with, hand specimens and thin sections. This level of study allowed identification to general lithology level, while concurrent study of geological literature allowed identification to a more specific lithology. From this stage the next step was to confine the source area as tightly as possible. Having identified the specimens, it was necessary to undertake a more in-depth literature study to find information regarding specific features of the specimens.

Field work was undertaken at this stage so that specimens could be compared with samples drawn from known locations, but unfortunately, as medieval quarries have since been filled in and built upon, they could not be investigated, so outcrops along strike had to suffice.

All six specimens from St Mary Spital were very similar in appearance as hand specimens and under the petrological microscope — a fine-grained (Wentworth Scale) pale green calcareous glauconitic sandstone, with globular silica and sponge spicules alongside glauconite and mica as characteristic components. The glauconite varied in shape and colour between yellow to different greens, or blue in different specimens, but gave the rock its characteristic overall green colour. The specimens with blue glauconite had suffered the effects of burial, indicated by an apparent brown leaching rim a few mm from the worked surface. Muscovite mica was present in all specimens with biotite present in those with a lower glauconite content. (It is possible that the conditions for biotite preservation are not conducive to glauconite formation.) Microfossils were present in all specimens: recrystallised foraminifera, sponge spicules and worm tubes were seen in each, but sizes and condition varied. Many spicules contained glauconite in the central canals.

It was using all of these features that the specimens were compared with detailed descriptions of the two glauconite-bearing lithologies within reach of medieval London, the Upper and Lower Greensands of the Cretaceous. The Lower Greensand is almost invariably buff coloured through the weathering of the glauconite, and coarse grained, while the Upper Greensand is pale green, fine-grained and retains its microfossils, while those of the Lower Greensand have been leached out.

In an attempt to define relative source areas detailed tests were carried out on particular characteristics of the specimens from the Museum and those collected in the field[10]. Features indicating possible different sources were the variations in colour and morphology of the glauconite, the presence of particular micas, small variations in microfossils and the opaque mineral content, so the choice of tests centred upon these.

As glauconite colour is determined by chemistry, and variations in muscovite micas may provide source information, samples of each were analysed with the electron microscope. At the same time textures in the specimens, and relationships between minerals were studied under the Scanning Electron Microscope (SEM). It was discovered that each mica tested was unique, that each specimen had its own group and the specimens could as a result be divided into two categories. Likewise each glauconite was unique and all contained over 7% potassium oxide, so indicating that they were mature, but all the specimens had similar groups of grains. Under the SEM it was found that the blue glauconite grains often had rims of apatite, possibly linked to the effects of burial in the cess pit.

The results of this stage clearly provided an indication of relationships between the specimens, but in order to distinguish the glauconite grains in different specimens they were extracted to find percentage content and to study morphology. The specimens thus fell into two categories by percentage content of glauconite, those with less than 2% and those with more than 3%. (Two collected specimens tied in with these groups.) There appeared to be no link between colour of the glauconite in thin section and as whole grains, although certain shapes possessed specific ranges of colour. The overall colour was mid to dark green indicating mature young grains. The dominant shapes were y-shapes and rods, both having formed in the canals of sponge spicules.

Following this, the calcite content of the specimens was determined to find which, if any, were Firestone or Hearthstone. All the Museum specimens were discovered to be Firestone, although there was quite a wide variation in calcite content. Only one collected specimen matched the calcite content, but it did not have sufficient glauconite.

10. Full descriptions of all the methods plus results, whether useful or not, can be found in C. A. de Domingo *Paragenesis and Provenance of Archaeological Material* MSc thesis (1992) QMW Univ. of London.

By this stage, then, the specimens were divisible into groups by mica chemistry alone. Trace elements in the whole rock were tested using an Inductively Coupled Plasma Emission Spectroscope (ICP)[10] because very small variations in such elements, undetectable under the SEM, can indicate different sources. Oxide contents were also found through this method, which allowed the calculation of the expected mineralogy. The Museum specimens were all very similar in trace elements except for zirconium in one specimen, and they fell into three groups. The collected specimens were all different from the Museum specimens. Statistically it was possible to show that the two groups of specimens (Museum and collected) were related by the levels of individual elements present, although results of the other tests showed that the rocks in the collected set did not often compare with the Museum specimens, and were therefore not indicative of source. The oxide results from the ICP test indicated that the Museum and collected specimens were all similar in an assemblage of quartz, calcite, glauconite, mica, iron oxides, as expected from the petrological study.

The effects of burial

Aside from the sourcing problem was the fact that some specimens displayed the apparent effects of burial in made ground for a considerable length of time. The brown colouring was assumed to be attributable to iron content, and so levels of ferrous and ferric iron were determined[11]. The total and ferric iron contents of the whole rock samples corresponded with the glauconite content, but the ratio of Fe^{3+} to Fe^{2+} showed an excess of the former possibly due to the presence of heavy minerals.

Conclusions

Although the specimens could not be sourced accurately following this research, the material was firmly identified as Firestone from the Reigate area, and hence called Reigate Stone, and certain areas were eliminated from the study. The six specimens were sourced in relation to each other according to the chemical and petrological information derived from the tests. The archaeologists were therefore provided with information regarding the relative sources of the specimens, and could then continue with their study of the methods and requirements of medieval stonemasons. Because the field relationship of Firestone and Hearthstone is one of alternating units, and the specimens were all Firestone, the medieval workers were evidently careful to some extent about their choice of material.

Further work

The area north of Reigate has an extensive mine system running through the Upper Greensand. Only one such mine was sampled for this research, but with more time, a more thorough exploration could be undertaken, which may prove invaluable in sourcing the Museum specimens, and so providing the archaeologists with much more information.

Further work for these or any other specimens that may prove useful would be:

a detailed study of the iron oxides, by analysing the material at different depths from the surface - the effects of leaching by groundwater may then be established.

a study of buried material, in this case the contents of a cess pit, may also help to show the effects of long term burial.

In combining the results from these two tests information may be derived that could then help future conservators in their work on the archaeological material.

Applications

The value of this work lay in the ability of the geological test methods to reveal information about the relative source of each individual specimen, and therefore help the archaeologists in their quest to understand the methods of excavation of medieval workers. Similar work may be done on any archaeological material such as building stone, mortar or ceramics to establish a link with the source area and provide the archaeologists with an extra tool for their own analyses.

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11. J. N. Walsh and R. A. Howie 'An Evaluation of the Performance of an ICP Source Spectrometer for the Determination of the Major and Trace Constituents of Silicate Rocks and Minerals' *Min Mag* 43 (1980) 967-974.

12. W. French and S. Adams 'A Rapid Method for the Extraction and Determination of Iron (II) in Silicate Rocks and Minerals' *Analyst* 97 (1972) 828-831.