Petrological and Chemical Analysis of Possible Roman Cement from Navenby, Lincolnshire

Alan Vince

A large lump of white cement with prominent red/brown aggregate inclusions was submitted to the author for identification and assessment. The lump was identified as being potentially of *Opus Signinum*, a type of cement introduced to Britain in the Roman period and used where a waterproof cement was required (e.g. in plunge baths and steam rooms where normal lime mortar would not set). However, the fragment did not have a distinct pink colouration found in *Opus Signinum* in the Lincolnshire area and further analysis was therefore recommended.

The fragment was subsequently studied at x20 magnification using a stereo microscope, in thin section and chemical analysis (inductively-coupled plasma spectroscopy – ICP-AES). This revealed that the fragment is a gypsum mortar with brick or tile added as aggregate. As such, it is not typical of Roman mortars in the Lincolnshire area (or, apparently, elsewhere) but is also unusual for recent mortars.

Thin Section Analysis

A thin section of a sample of the material was produced by Steve Caldwell, University of Manchester and stained using Dickson's method (Dickson 1965). In thin section, angular and subangular fragments of gypsum and red earthenware were observed in a groundmass of colourless cryptocrystalline material.

The gypsum inclusions have a sparry prismatic structure and range up to 2.0mm across.

The earthenware fragments vary in colour, texture and other characteristics. They range up to 4.0mm across. Some fragments contain subangular quartz and calcareous inclusions in a groundmass of dark brown baked clay. Others include few visible inclusions and have a light brown colour, probably as a result of a high calcareous content in the groundmass. Sparse subangular quartz, sometimes with a coating of dark brown baked clay, occur, ranging up to 0.3mm across. These are probably derived from the earthenware.

The groundmass contains abundant colourless euhedral crystals, less than 0.05mm across.

Chemical Analysis

A sample was submitted to Dr J N Walsh, at Royal Holloway College, London, where it was analysed using Inductively-Coupled Plasma Spectroscopy. A series of major elements was measured and expressed in percent oxides (App 1) and a series of minor and trace elements was measured and expressed as parts per million (App 2).

Silica is likely to be by far the most common unmeasured element and an estimate of the silica content was obtained by subtracting the total measured oxides from 100%. This gave an estimated silica content of 66.79%.

The chemical data were compared with analyses of a series of mortars and cements from St Paul's Cathedral, London (Vince 2007) which include hydraulic mortars (i.e. similar to *Opus Signinum*), although in this case powdered earthenware was replaced by a mixture of volcanic ash and crushed flint. Other sampled mortars from St Paul's Cathedral were lime mortars of two types – a hard white mortar and a soft, unset mortar which seems to have been badly affected by groundwater.

The estimated silica content of the St Paul's samples and the Navenby sample were plotted against aluminium content. Aluminium is likely to have been present only in the volcanic ash and red earthenware inclusions whilst the silica is likely to have been present mainly in the crushed flint and in added quartz sand, present in the London lime mortars. All the samples have similar silica contents (Fig 1) but the aluminium content of the Navenby sample is closer to the hydraulic mortar (Trass in Fig 1) than to the lime mortars.

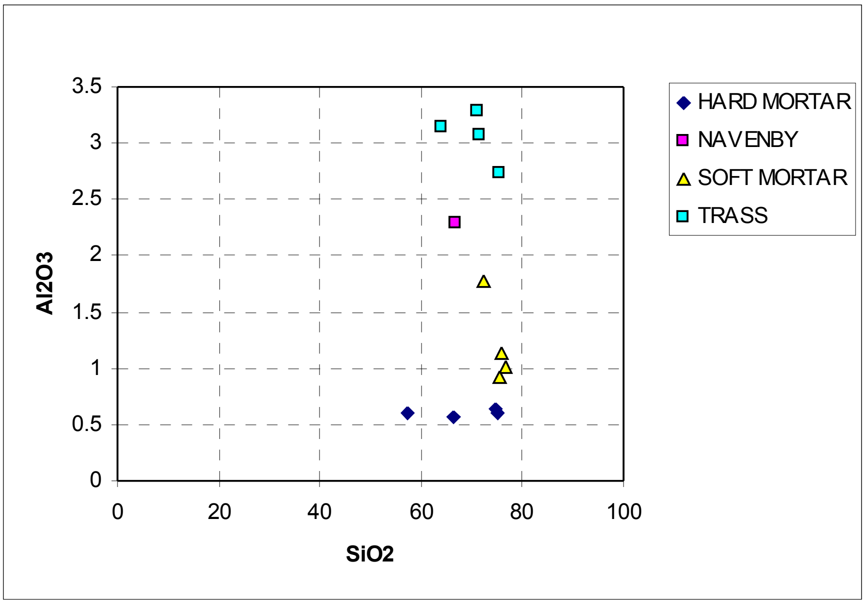

Figure 1

The data were normalised to aluminium and the Navenby and London data were compared element by element. The Navenby sample has higher barium and strontium values than any of the London samples. It also has the lowest iron, phosphorus, manganese, chromium, nickel, vanadium, zinc, cobalt and most of the rare earth elements.

A further comparison with the London mortars was made using the factor analysis program from the WinSTAT add-in for Excel (2002). Four factors were found and a plot of the first two (Fig 2) placed the Navenby sample on its own with a lower F1 score than any of the London samples but a similar F2 score to the London soft lime mortar. This low F1 score appears to be due to low rare earth element values whilst the high F2 score is due to high potassium and lithium values. A plot of F3 against F4 scores (Fig 3) indicates that the Navenby sample has a higher F3 score than any of the London samples. This is due to a high strontium score. Strontium is often closely correlated with calcium but in this case the strontium value is much higher than the calcium value, indicating that the calcium in the London samples has a different source (in this case burnt Upper Cretaceous chalk) than in the Navenby sample (where the calcium may be derived from the gypsum, which is likely to be of Triassic age and from Nottinghamshire).

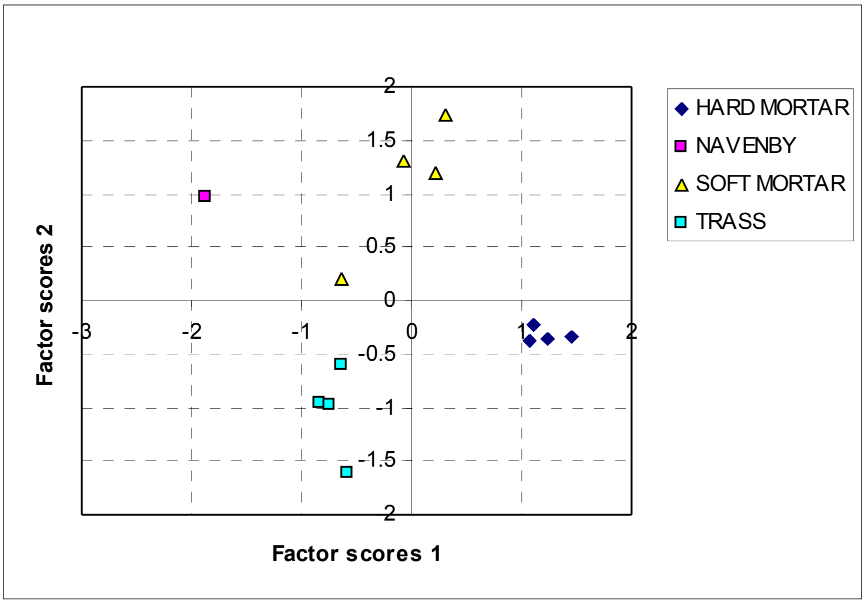

Figure 2

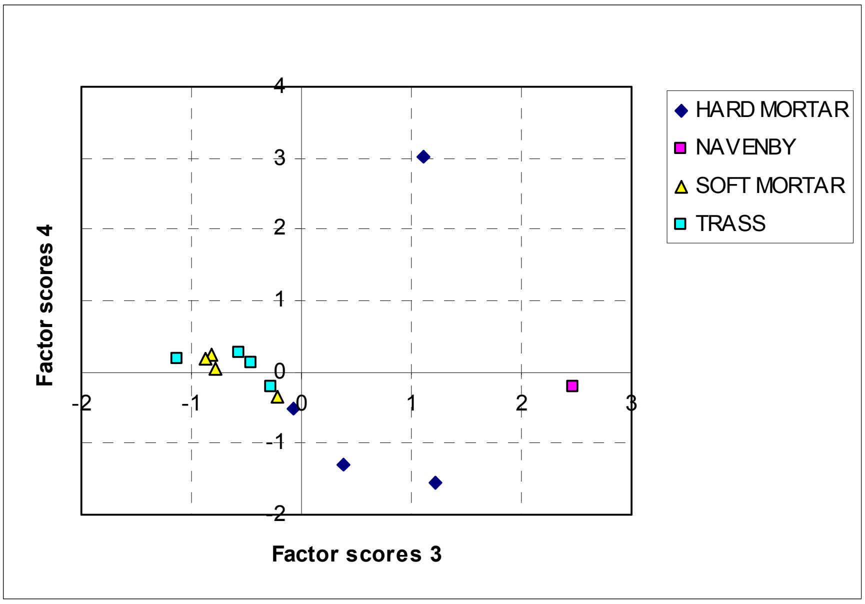

Figure 3

Discussion and Conclusions

The Navenby sample is probably from a gypsum mortar rather than a hydraulic mortar, although it is possible that the added earthenware fragments also encouraged the development of a hydraulic mortar. However, in contrast to the London hydraulic mortar the groundmass has a cryptocrystalline structure rather than an isotropic one. The earthenware fragments are very similar in colour range and texture to ceramic building material of Lincolnshire origin but good parallels for these fragments can be found both in the Roman period and in the post-medieval period, since in both periods the sample clays were being exploited and fired in similar conditions to similar temperatures.

The date and function of the Navenby mortar are therefore unknown, but distinctive. Therefore, if the study of local mortars continues it should be possible to say more about both date and function at some later date.

Bibliography

Dickson, J. A. D. (1965) "A modified staining technique for carbonates in thin section." *Nature*, 205, 587

Fitch, R K (2002) *WinSTAT(r)*. Fitch, Robert K. R. Fitch Software. 2001

Vince, Alan (2007) *Analysis of Mortar from the South Portico of Wren's Cathedral, St Paul's Cathedral, London*. AVAC Reports 2007/76 Lincoln

Appendix 1

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V4854	2.29	0.81	0.9	28.32	0.13	0.6	0.11	0.03	0.011

Appendix 2

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V4854	206	11	26	14	8	3	1,902	20	4	27	5	10	5	1	0	1	1	4	21	2