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An investigation to establish the limestone source for the Roman lime mortars used in Wallsend, UK

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Overview

- Work aimed to explore potential sources for the lime mortar used in the Hadrianic fort baths and a third-century repair to Hadrian's Wall at Wallsend, UK.

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Hadrian's Wall

- Initial building started in AD 122 and lasted about a decade.
- Wall averaged 4 m high and 3 m wide
- Required 3,713,000 tonnes of bulk building materials (facing and core stone, clay and timber)
- Material sources for wall uncertain
  - likely Roman building stone quarries located between 300 m and 34 km from the wall (median value of 5 km)
- The eastern end extended from Newcastle to Wallsend a few years after main wall construction started (source of mortar used in this and later phases is unknown.
  - extension part of the "Narrow Wall," second stage)
- Pressures to complete work quickly resulted in changes to building programme.

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Roman Lime Production

- When work started on the wall, sources of limestone were already known and had been exploited in the Housesteads/ Vindolanda area.
- Surviving kilns from the Roman period within the vicinity of Hadrian's wall are relatively rare.
- The only two Roman lime kilns so far encountered in the wall zone are at Housesteads and Vindolanda.
- Some authors have largely assumed that much of the transport of raw materials would be facilitated overland (local sources for lime)
  - However others suggested that even relatively narrow water courses, less than 2 m wide, were used for moving heavy materials, such as stone in the Medieval period.
  - Therefore the use of water transport should not be discounted in the Roman period especially given the distances over which building stone was transported to the wall.

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Kilns

- Lime produced where limestone and a source of fuel readily available.
- A lime kiln to manufacture lime (calcium oxide) by “burning” [i.e. heating] calcium carbonate 900°C+
- The majority of excavated Roman lime kilns are of the 'periodic' type.
- After firing there would be some limestone which was unburnt, this could be removed during slaking.
- The presence of unburnt limestone was confirmed in field archaeology experiments
  - noted changes in lime colour due to fluctuating raw material properties
  - contamination due to vault collapse during firing.
- Clamp kilns were also used, and remains have been suggested at several Roman sites.

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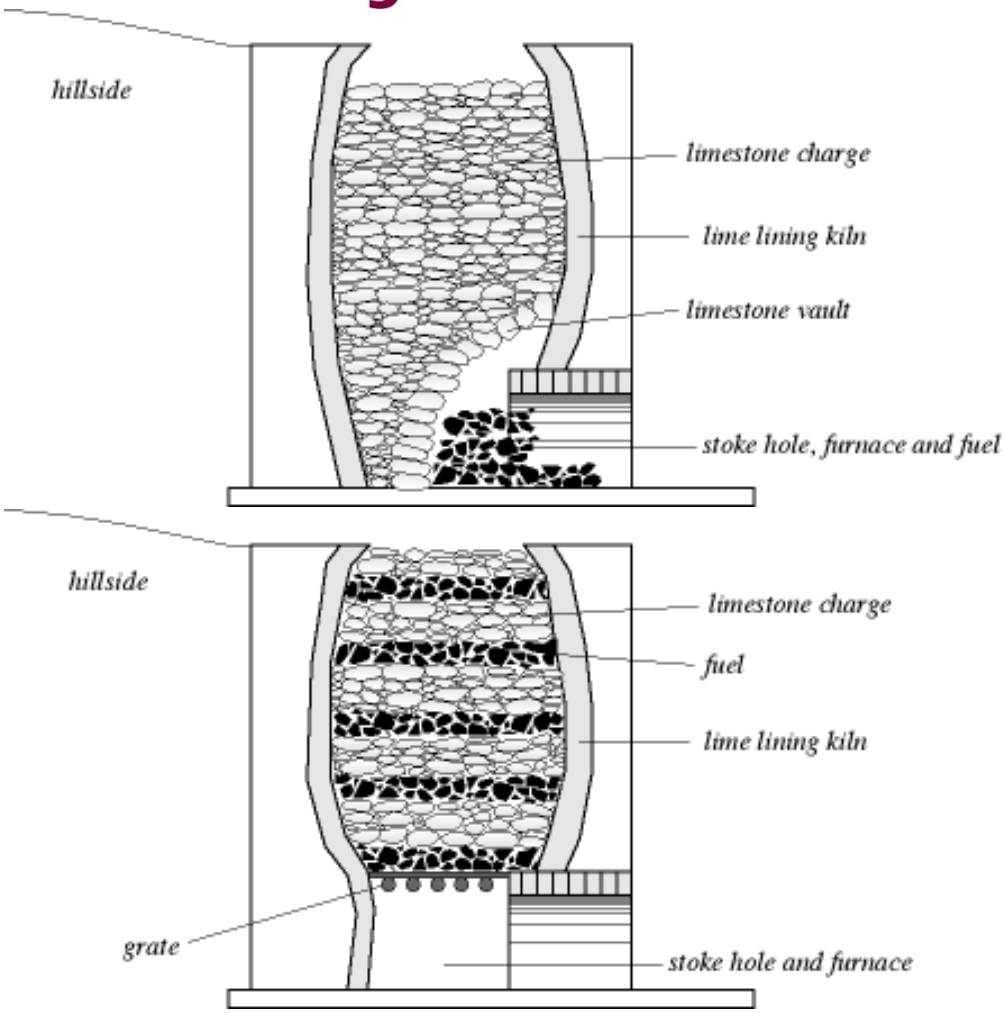
Kilns



Top Left: 'Flare kiln' (also known as 'intermittent' or 'periodic' kiln)
Flare kilns are loaded with a single charge of limestone which was burnt and then emptied before reloading.

Bottom Left: 'Draw Kiln' (also known as 'perpetual' or 'running' kiln)
Draw kilns were loaded with alternate layers of fuel and stone which was kept burning continuously while further supplies of raw material and fuel were fed in at the top and the lime was drawn off at the bottom.

Clamp kilns also used - layers of fuel and limestone burned in a similar way to charcoal burning

Pre-industrial Lime Kilns Introductions to Heritage Assets. Historic England. Swindon

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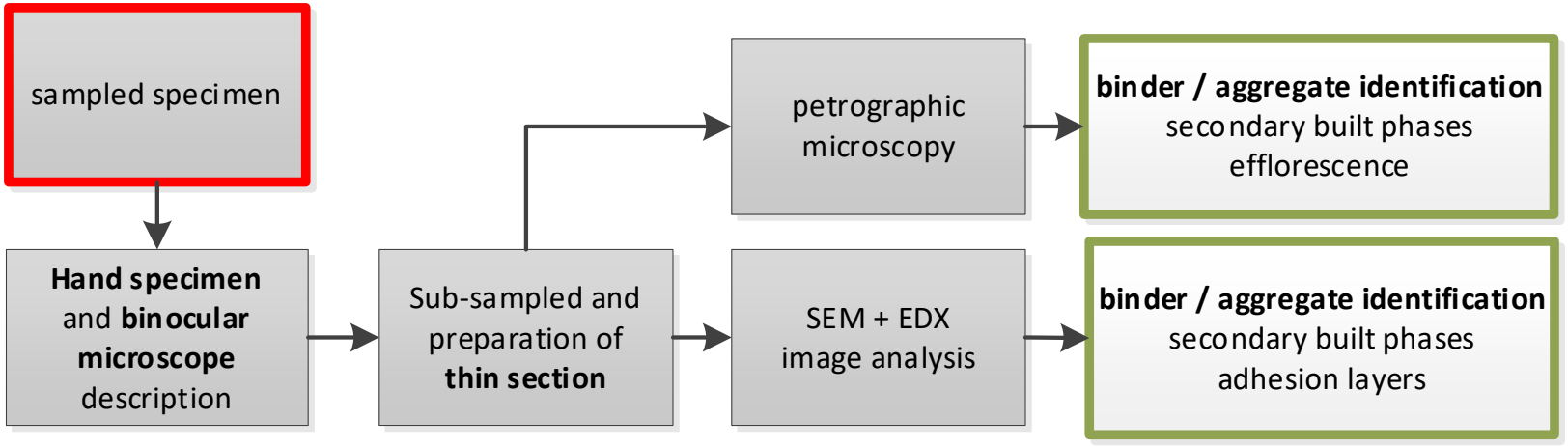
Analysis of mortar

Two samples from Hadrian's Wall were from one of several third-century rebuildings, but it was the only one in which mortar was used.

The baths were the only Hadrianic building at Wallsend available for sampling where mortar was used (1 sample from the original construction, 1 from a 3rd C partial rebuilding).

Sample code	Description	Location
WESH 1625	Hadrianic wall	Wallsend baths
WESH 1660	Used in build of SW flue, 3rd century	Wallsend baths
WBMT 8076	Repairs to Hadrian's Wall	Wallsend
WBMT 8083	Repairs to Hadrian's Wall	Wallsend



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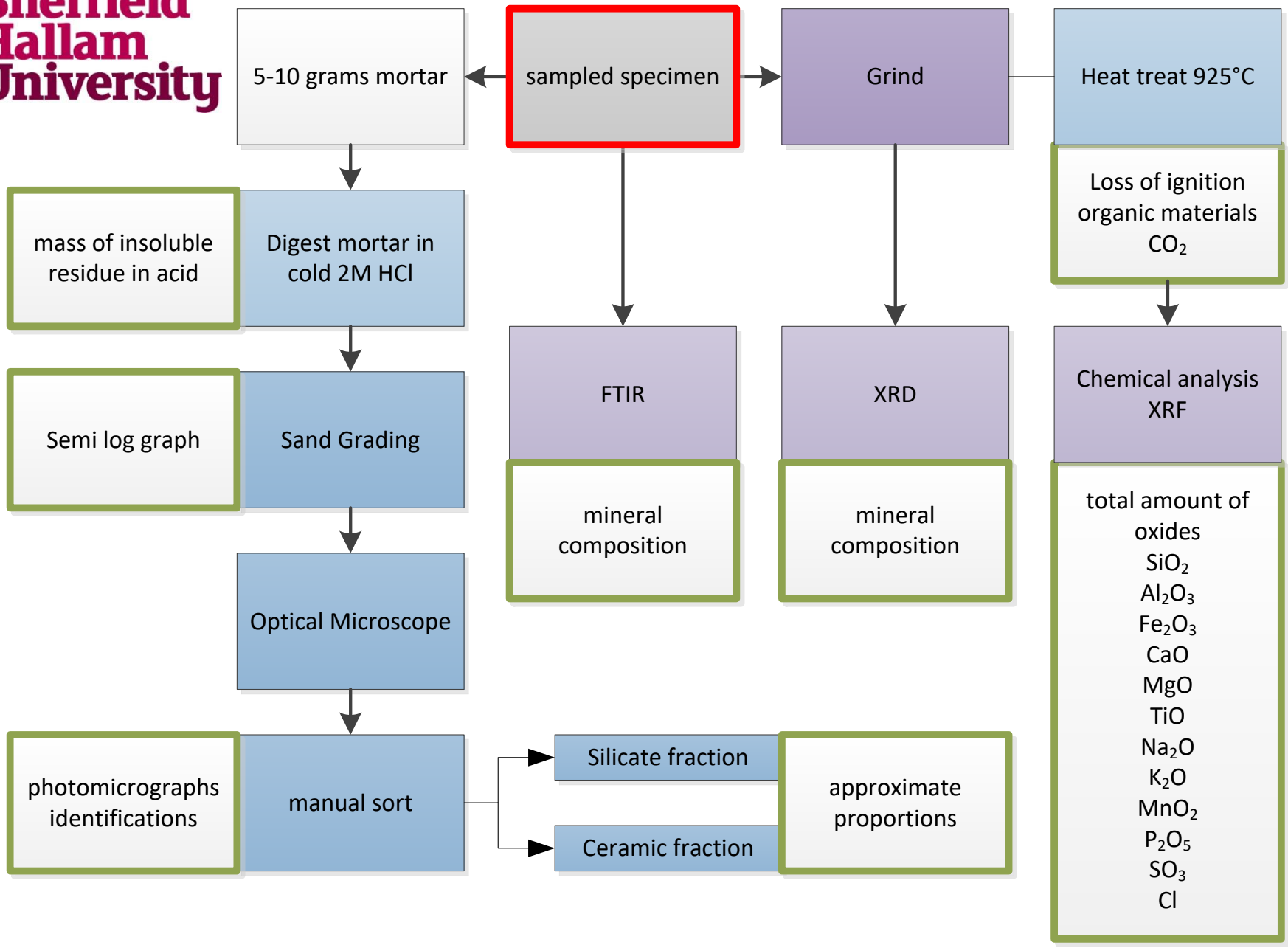

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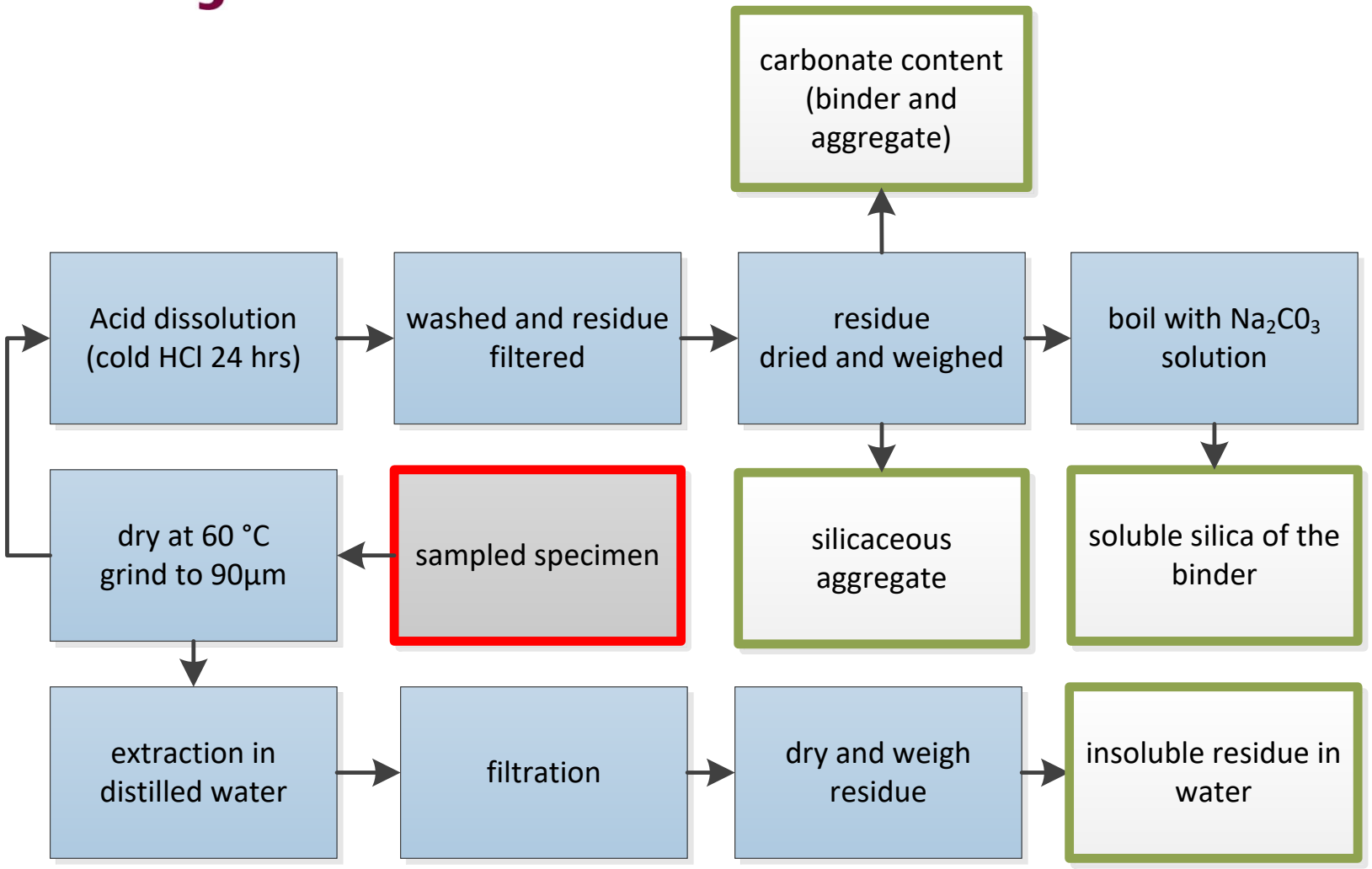

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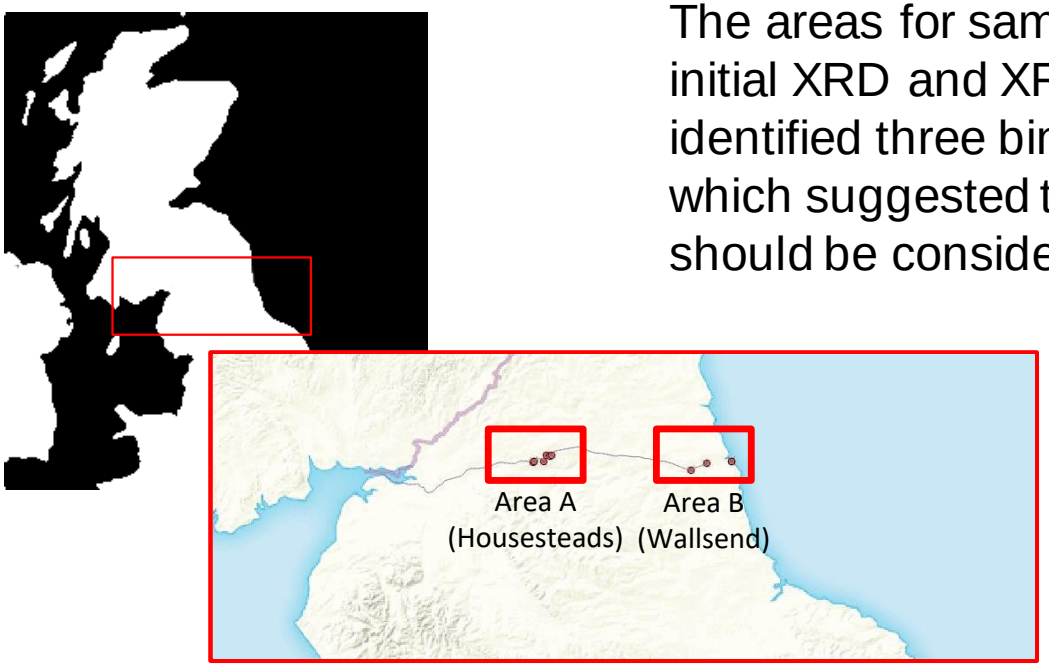
Potential sources



The areas for sampling were in part determined by initial XRD and XRF results on the mortars which identified three binders of low magnesium content , which suggested two possible limestone sources should be considered.

Area A) around Housesteads

* Known area of Roman Lime kilns
* Near resources of fuel (timber / coal)
* Source of transport (road / water)
* Generally of low magnesium content

Area B) Trow Point

* Close to end point use
* Source of transport as Roman stone extraction was often carried out at coastal areas
* Near a source of transport (coast and river Tyne)
* Near resources of fuel (local and imported)
* Some areas of limestone at the locality have low magnesium content

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Findings

- The work has indicated that the characteristics of the four mortars are very different and points to divergent sources for both the lime mortar feedstock and the locally derived aggregates.
- Limestones of similar lithology to those cropping out at Housesteads (and at other areas to the east) were identified in the mortar which was poorly sieved and contained fragments of charcoal.
- The presence of fine aggregate grains of petrographically and spectrographically similar characteristics to the rocks at Housesteads is suggestive, the evidence based on this initial work cannot yet be considered compelling when distinguishing poorly burnt lime feedstock present in the mortar rather than added later as aggregate.
- There is a common assumption that the lime mortar for the wall was sourced locally along its length. The lime however, was found to more closely match limestone from the west of Housesteads (35 miles to the west of Wallsend) and from the vicinity of the fort at Vindolanda.

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Discussion & Conclusion

- We suggest that there was a single source of limestone was used when the wall was built and that this was still in use a century after the work started on the wall.
- There is a parallel in this suggestion to long-distance transport of lime in Roman Germany. At Iversheim there was a bank of six large kilns operating in the second and third century. Lime from these kilns has been identified as being used in structures up to 100km away.
- While the Permian limestones around Trow cannot be entirely discounted, the more likely source of the lime mortar would appear to be the Carboniferous limestones near Housesteads.
- Confining the use of mortar to buildings such as the baths where it was essential and thus reducing the transport of lime over long distances would have speeded up the building of the wall.
- This fits with recent thinking about the building programme which emphasises that the work was completed as quickly as possible, not least because of the direct involvement of the emperor Hadrian.

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Discussion & Conclusion

- Mortar characteristics were remarkably different in terms of the type and ratio of binder and aggregate grading
- Calcined lime was poorly sieved and contained charcoal.

Further work

- More sampling of mortars and possible sources from along the line of the wall and associated buildings.
- It is not clear if the coal found in the vicinity of Housesteads was used to augment the local exploitation of timber in lime product during the Roman period.
- The brick content of some mortars appeared water worn, which may indicate dredging of material into which building waste had been previously disposed of. Further work on Roman age river sediments and modern river sediments would therefor provide an interesting comparison of the potential aggregate sources.

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Further information

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https://www.shoptwmuseums.co.uk/hadrians-wall-at-wallsend-book-38121-p.asp

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