The Pebble Surfaces at Washingborough Pumping Station 2004

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Excavations at Washingborough Pumping Station revealed several surfaces composed of limestone and quartzose pebbles. Within each surface, the stones were planned, individually numbered and retained for study. A preliminary examination suggested that there were variations in the lithology of the pebbles and that some of the quartzose pebbles were definitely fire-cracked, and had therefore probably been obtained from a mound of burnt stones. Such mounds, sometimes associated with troughs, appear to have created during the Bronze Age, either as a by-product of some domestic activity (cooking, bathing or a sauna) or a religious activity (such as using steam to enter an altered state and communicate with spirit world).

To investigate these surfaces further, a randomised sample of the stones recovered was submitted to the authors for identification and study. For each stone, a record was made of the lithology and evidence of use.

Lithology

One hundred and thirteen samples were examined at x20 magnification and in the hand. They were classified into two major groups, limestones and quartzose pebbles.

Limestone

Most of the limestone fragments contained abundant fragments of bivalve, gastropod and echinoid shell. Some of the bivalve shells have a prismatic structure and may be inoceramids. The gastropods often have sparry calcite filling of the shell. The echinoid shell is much less common than the other two types. The groundmass consists of fine-grained micrite. In total, 32 samples of this type were present.

A minority of the limestone fragments contained ooliths and pellets, mostly comprising shell fragments with a micrite coating. The groundmass of these fragments, of which three examples were noted, was similar in colour and texture to the bioclastic limestone.

All the limestone fragments had rounded edges but were essentially irregular blocks, either roughly cubic or flat slabs. Whilst it is possible that they were formed by the mechanical erosion of a limestone outcrop, cut by the Witham, their lack of rounding is more suggestive

of aerial erosion and it is more likely that the fragments were collected from a ploughed field or cliff-side exposure of limestone pavement.

The fragments are mainly stained and coated with light to dark brown concretions, probably as a result of deposition under water after the fragments were laid in the surfaces.

Quartzose Rocks

The quartzose rocks are mainly fine-grained sandstones. Some have a silica cement, which in a few cases was sufficiently well-developed to allow the rock to be classed as a chert, whilst some consisted of overgrown quartz grains. In most cases light-coloured minerals (presumably quartz with some feldspar) accounted for most of the rock but others contained a small quantity of dark-coloured minerals, muscovite laths, and voids from the presence of organic matter, present as casts only. Bedding is recognisable in a minority of the samples, sometimes being quite pronounced, with beds being 1.0-2.00mm thick. A minority of the samples (5) contained veins of quartz, 2.0-3.00mm thick.

A small number of samples (6) were probably composed of vein quartz but with no evidence for the country rock in which the vein formed.

In contrast to the limestone fragments, the quartzose rocks were well-rounded (“waterworn” in catalogue), although none approached the near-spherical or ovoid shape of the quartzose pebbles found in the Triassic sandstones such as the Sherwood Sandstone. Sandstones do occur in the Jurassic sequence in the Witham Gap area (and the Jurassic rocks of the North Yorkshire Moors) but they tend to have a light brown limonite or calcareous cement. The sandstones in these samples are more similar to erratics originating in north-east England, Scotland or Scandinavia.

They were probably obtained from fluvio-glacial gravels deposited in the Vale of Ancholme or the dip slope of the Jurassic ridge. Again, it is possible that they were eroded from such deposits where they were cut by the Witham but as likely that they were collected from exposures such as ploughed fields or cuttings.

Staining

About two thirds of the samples had evidence for iron staining, presumably gained in situ. Twenty-six of these stained fragments came from surface 509 (44% of the samples from this surface) whilst the remaining 38 came from surface 519 (70% of the samples from that surface). This difference is in part a function of the proportion of limestone fragments from each surface, since these fragments are, with only one exception, iron-stained. However, even omitting the limestone samples there is still a higher proportion of staining on the

samples from surface 519 (15/31 for 519 and 15/47 for 509, or 48% versus 32% respectively).

Use

Two of the fire-cracked pebbles from surface 519 joined (12147 and 12419).

No examples of excessive wear, such as might have been produced by repeated walking or riding over the surfaces, were noted. Nor was there any evidence that the quartzose pebbles were chosen for their sphericity, such as might have been expected if they had been re-used sling shot. However, a minority of the quartzose pebbles (36 examples) were definitely fire-cracked. This had imparted a light grey colour to the rock, which otherwise was usually either white or sometimes with a pink tinge. This colouration may be due to the presence of carbon in pores in the rock or, more likely, the reduction of the small amount of iron present in the cement. The fire-cracked pebbles usually have crisp hackly broken faces, caused by thermal shock. This probably indicates that they were rapidly cooled after heating, either by being immersed in water or by water being sprinkled on the hot stones.

Distribution

The samples were obtained from two surfaces, 509 and 519. Table 1 shows the composition of the two sets of samples by lithology. It indicates that there is little difference in the composition of the two surfaces and that in both, the majority of the pebbles are fragments of white sandstone.

Table 1

Subfabric	509	519	Grand Total
CHERT	2		2
	3.39%	0.00%	1.77%
LST A (Biomicrite)	10	22	32
	16.95%	40.74%	28.32%
LST B (Oolite)	2	1	3
	3.39%	1.85%	2.65%
QUARTZ CONGLOMERATE	1		1
	1.69%	0.00%	0.88%
VEIN QUARTZ	4	2	6
	6.78%	3.70%	5.31%
WHITE FINE-GRAINED SST	37	27	64
	62.71%	50.00%	56.64%
WHITE FINE-GRAINED SST WITH QUARTZ VEINS	3	2	5
	5.08%	3.70%	4.42%
Total	59	54	113

Table 2 shows the incidence of fire-cracked pebbles in each surface. Surface 519 has over twice the frequency of fire-cracked pebbles as surface 509. This difference is even more

pronounced if only the quartzose pebbles are included. In surface 509, there were 47 sampled quartzose pebbles of which 12 (26%) were fire-cracked, whereas in surface 519 there were 31 sampled quartzose pebbles of which 24 (77%) were fire-cracked.

Table 2

FUNCTION	509	519	Grand Total
FIRE-CRACKED	12	24	36
	20.34%	44.44%	31.86%
PEBBLE	47	30	77
	79.66%	55.56%	68.14%
Total	59	54	113

Further work

It would be possible to analyse the fire-cracked pebbles using thermoluminesence and one could use samples of the unburnt pebbles to gain an estimate of background radiation. This might be able to show whether the interval in time between their heating and reuse was appreciable (i.e. measured in centuries). It is also possible to narrow down the potential source of the limestone fragments by comparison of their lithology with that of samples collected from the locality.

Appendix 1

Context	REFNO	Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
509	2508	CHERT		PEBBLE		WATERWORN; OLD BREAK; GREY	BS	1	1
509	10177	CHERT		PEBBLE		WATERWORN; OLD BREAK; GREY	BS	1	1
519	12711	LST A		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRONSTAINING	BS	2	1
509	2756	LST A		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
519	12713	LST A		PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12514	LST A		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRONSTAINING	BS	1	1
519	13029	LST A		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRONSTAINING	BS	1	1
519	12863	LST A		PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12420	LST A		PEBBLE		ROUNDED; GREY WITH WHITE DEPOSIT AND IRONSTAINING	BS	1	1
519	13025	LST A		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
519	12307	LST A		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	2721	LST A		PEBBLE		ROUNDED; GREY	BS	1	1
509	2538	LST A		PEBBLE		ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	1948	LST A		PEBBLE		2 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	2085	LST A		PEBBLE		ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	2478	LST A		PEBBLE		ROUNDED; GREY WITH HEAVY IRON STAINING	BS	1	1

Context	REFNO		Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
509	2759	LST A			PEBBLE		ONE OLD BREAK; ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	2380	LST A			PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2747	LST A			PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
519	13030	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12714	LST A			PEBBLE		ONE OLD BREAK;ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	13072	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12812	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12255	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING & BLACK DEP	BS	1	1
519	12834	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12300	LST A			PEBBLE		2 OLD BREAKS; ROUNDED; GREY WITH IRONSTAINING	BS	1	1
519	12351	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING AND GREY DEP	BS	1	1
509	2470	LST A			PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
519	12392	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12973	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12618	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12861	LST A			PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING AND WHITE DEP	BS	1	1

Context	REFNO	Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
519	12144	LST A		PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING	BS	1	1
519	12720	LST A		PEBBLE		ROUNDED; GREY WITH SOME IRONSTAINING AND WHITE DEP	BS	1	1
519	12188	LST B		PEBBLE		SEVERAL OLD BREAKS; SLIGHTLY ROUNDED; IRONSTAINING	BS	1	1
509	2733	LST B		PEBBLE		3 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	1959	LST B		PEBBLE		ROUNDED; GREY WITH HEAVY IRON STAINING	BS	1	1
509	1687	QUARTZ CONGLOMERATE		PEBBLE		WATERWORN; GREY	BS	1	1
509	1885	VEIN QUARTZ		PEBBLE		WATERWORN; GREY	BS	1	1
509	11423	VEIN QUARTZ		PEBBLE		WATERWORN; GREY	BS	1	1
509	1972	VEIN QUARTZ		PEBBLE		WATERWORN; GREY	BS	1	1
519	12005	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12551	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2434	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	13007	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH BLACK DEP	BS	1	1
509	2423	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	2372	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2241	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	2068	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	2067	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	1987	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	2244	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1

Context	REFNO	Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
509	2696	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY; IRON STAINING	BS	1	1
509	2439	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	2108	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; OLD BREAK; GREY WITH IRON STAINING	BS	1	1
509	2836	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY; OLD BREAKS	BS	1	1
519	12042	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; WHITE WITH SOME IRONSTAINING	BS	1	1
509	10084	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; OLD BREAKS; GREY WITH IRON STAINING	BS	1	1
509	2919	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; OLD BREAK; GREY WITH IRON STAINING	BS	1	1
509	2411	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
519	12370	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2897	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY; OLD BREAKS	BS	1	1
519	12677	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2795	WHITE FINE-GRAINED SST		PEBBLE		2 OLD BREAKS; ROUNDED; GREY WITH IRON STAINING	BS	1	1
509	2053	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	10141	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH BLACK DEP	BS	1	1
509	2190	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH BLACK DEP AND IRON STAINING	BS	1	1
509	2954	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
509	2009	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2243	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH BLACK DEP	BS	1	1
509	10038	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1

Context	REFNO	Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
509	10076	WHITE FINE-GRAINED SST		PEBBLE		2 OLD BREAKS; ROUNDED; GREY	BS	1	1
509	2812	WHITE FINE-GRAINED SST		PEBBLE		WATERWORN; GREY	BS	1	1
519	12056	WHITE FINE-GRAINED SST WITH QUARTZ VEINS		PEBBLE		WATERWORN; 2 OLD BREAKS; GREY	BS	1	1
509	2488	WHITE FINE-GRAINED SST WITH QUARTZ VEINS		PEBBLE		WATERWORN; GREY	BS	1	1
509	2071	WHITE FINE-GRAINED SST WITH QUARTZ VEINS		PEBBLE		WATERWORN; GREY	BS	1	1
509	1658	WHITE FINE-GRAINED SST WITH QUARTZ VEINS		PEBBLE		WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12081	WHITE FINE-GRAINED SST		FIRE-CRACKED	END OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
519	12793	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKED STONE	ROUNDED; GREY	BS	1	1
509	10039	VEIN QUARTZ		FIRE-CRACKED	FIRE CRACKED WHERE END OF PEBBLE MISSING; REDDENED	WAS WATERWORN	BS	1	1
509	2437	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKED; BROKEN	WAS WATERWORN; GREY WITH RION STAINING	BS	2	1
509	2428	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKED; BROKEN	WAS WATERWORN; GREY	BS	1	1
509	2107	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKED; BROKEN	ONLY ONE WATERWORN SURFACE; GREY WITH IRONSTAINING	BS	1	1
509	2126	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKED; BROKEN AND CRACKED STONE	IRON STAINING	BS	1	1
509	2164	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKED; BROKEN AND CRACKED STONE	WATERWORN; GREY	BS	1	1
509	2113	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKING; MULTIPLE CRACKS ALL OVER STONE	WATERWORN; GREY	BS	1	1
509	10055	WHITE FINE-GRAINED SST		FIRE-CRACKED	FIRE CRACKING? ONE FRESH BREAK	WATERWORN; GREY	BS	1	1
519	12783	VEIN QUARTZ		FIRE-CRACKED	FRAGMENT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY	BS	1	1

Context	REFNO	Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
519	13107	WHITE FINE-GRAINED SST		FIRE-CRACKED	FRAGMENT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING & BLACK DEP	BS	1	1
519	12176	WHITE FINE-GRAINED SST		FIRE-CRACKED	FRAGMENT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
509	2284	WHITE FINE-GRAINED SST		FIRE-CRACKED	MULTIPLE FIRE CRACKING; BROKEN ON THREE SIDES	WAS WATERWORN; GREY	BS	1	1
509	2775	WHITE FINE-GRAINED SST		FIRE-CRACKED	MULTIPLE FIRE CRACKING; BROKEN ON TWO SIDES	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1
509	2211	WHITE FINE-GRAINED SST		FIRE-CRACKED	MULTIPLE FIRE CRACKING; LOST ONE END	WAS WATERWORN; GREY	BS	1	1
519	12772	WHITE FINE-GRAINED SST		FIRE-CRACKED	MULTIPLE FIRE CRACKS	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
519	12147	WHITE FINE-GRAINED SST	SHL=12419	FIRE-CRACKED	PART OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12419	WHITE FINE-GRAINED SST	SHL=12147	FIRE-CRACKED	PART OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12531	WHITE FINE-GRAINED SST		FIRE-CRACKED	PART OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY	BS	1	1
519	12735	WHITE FINE-GRAINED SST		FIRE-CRACKED	PART OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING & BLACK DEP	BS	1	1
509	2262	WHITE FINE-GRAINED SST		FIRE-CRACKED	PART OF FIRE CRACKED STONE	ONLY ONE WATERWORN SURFACE	BS	1	1
519	12857	WHITE FINE-GRAINED SST		FIRE-CRACKED	POSS FIRE CRACKED/BROKEN	WAS WATERWORN; GREY	BS	1	1
519	13016	WHITE FINE-GRAINED SST		FIRE-CRACKED	POSS HEAT CRACKED	TWO WATERWORN SURFACES; GREY WITH IRON STAINING	BS	1	1
519	12158	VEIN QUARTZ		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12060	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY	BS	1	1
519	12608	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1

Context	REFNO	Subfabric	Description	FUNCTION	Use	Condition	Part	Nosh	NoV
519	12938	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12688	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY	BS	1	1
519	13126	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
519	12968	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
519	12904	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
519	12835	WHITE FINE-GRAINED SST		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1
519	12630	WHITE FINE-GRAINED SST WITH QUARTZ VEINS		FIRE-CRACKED	REMNANT OF FIRE CRACKED PEBBLE	WAS WATERWORN; GREY WITH BLACK DEP	BS	1	1
519	12610	WHITE FINE-GRAINED SST		FIRE-CRACKED	SEVERAL CRACKS; BROKEN FACETS; FIRE CRACKED?	ONE WATERWORN SURFACE; GREY WITH IRON STAINING	BS	1	1
519	12258	WHITE FINE-GRAINED SST		FIRE-CRACKED	SEVERAL FIRECRACKS; REDDENED PATCH	WAS WATERWORN; GREY WITH IRON STAINING	BS	1	1