APPENDIX 7. CLAST LITHOLOGY REPORT *(DR Bridgland)*

Clast Lithological Analysis for ALSF Medway Project

Clast lithology sample inventory

APHF 05 (Apton Hall Farm), sample <BH 33>, (depth 9.2m)
CXTN4 05 (Cuxton), Sample <1>, (context 14)
BRADH 05 (Bradwell Hall), sample <9>, (context 56)
UPNOR 05 (Upnor elephant site), Sample <1>, (context 16)
DGFM 05 (Dagnam Farm), Sample <1>, (context 33)
WTHF 05 (Whitehouse Farm), sample <1>, (context 93)
SLM 05 (Sandling Place), sample <4>, (context 21)
DOGF 05 (Doggets Farm), sample <3.5>, (context 33d)

Methodology

The samples were separated, by wet sieving, into 16-32, 11.2-16mm and 8-11.2 fractions for separate analysis. The first two are the sizes recommended by the appropriate QRA Technical Guide (Bridgland, 1986a); the third was added so for the purpose of supplementing undersize samples from boreholes and other localities where only small samples could be obtained. Clast-lithological analysis was applied only to the large and intermediate size fractions unless both of these were undersize. This method involves identifying all clasts in each size fraction, providing an indication of provenance and, in cases where characteristic signatures are present, allowing the river responsible for emplacement of the deposit to be identified (see Bridgland, 1986a).

The analyses were carried out with minimal sample information provided, providing a useful check against preconceived ideas influencing the analyses.

Sample descriptions (see Tables 1, 3 & 4):

APHF 05

This is an undersize count at 16-32mm, comprising entirely flint (78.5%) and Greensand chert (15.2%), except for 6.3% calcareous 'cementstone' (total only 79 clasts). The last-mentioned is clearly a local component, probably from the Tertiary. The five specimens have highly oxidized and, in some cases, cracked (? desiccated) surface rinds, with grey calcareous centres. The 11.2-16mm count, which numbered a reasonably healthy 281, was similar except for a small but unmistakable 'exotic' component. These were one each of vein quartz, metamorphic quartz, Carboniferous chert and a quartzose rock that is probably metamorphic. A sandstone counted as exotic might possibly be local or southern. The 11.2-16 count points to the Thames-Medway, so presumably this is a post-Anglian deposit from the East Essex Gravel Group.

CXTN4 05

This is a big sample yielding 609 16-32mm clasts, all local to the London Basin or 'southern' (50% each). This points to a Kentish Medway gravel. The presence of Kentish Ragstone, albeit only 4 pieces, suggests the middle reach of the Medway (between the Greensand escarpment and the estuarine reach, as does the paucity of Tertiary flint (7.7%), which is picked up in quantity once the London Basin is reached. The occurrence of Chalk almost certainly points to a location on the Chalk outcrop. Much of the Chalk is in the form of harder-than-normal varieties, often grey or rust coloured; these would survive better in fluvial bedload. There may be secondarily re-precipitated chalky limestones represented, since some contain streaks of sand grains. Hastings Beds rocks account for >10% of the total, more than half of them ironstones, which are the most resistant lithologies in the Hastings Beds.

In the 11.2-16mm fraction the story is similar, although the proportions are different. Hastings Beds double in importance, largely at the expense of Greensand chert, the other main southern indicator. Flint remains about the same but there is slightly more Tertiary (12%) and less nodular. Chalk is fully 10% of this smaller fraction. Ragstone is missing, although probably represented amongst the weathered porous cherts, which would have been partly silicified versions of ragstone.

These findings are as expected for Medway gravel at Cuxton; they are comparable with previous counts from the Cuxton Palaeolithic site (Cruse, 1989).

BRADH O5

This small sample yielded undersized counts at both the standard sizes, so a supplementary count at 8-11.2mm was undertaken. This can be pooled with the 11.2-16mm if desired. This exercise has underlined how certain components vary in importance with clast size. The 50 clasts in the 16-32mm count were all flint and Greensand chert, with no representatives of the ‘Thames exotic suite’. The dangers of making interpretations based on undersized counts are exemplified, however, by the fact that the smaller sizes contain exotic material, showing this to be a Thames-Medway gravel (as would be anticipated given its location at Bradwell, in NE Essex). Thus the 11.2-16mm fraction contained 3 exotic clasts (in a count of 96), 1 x vein quartz, 1 x metamorphic quartz and 1 x *Rhaxella* chert. Otherwise, like the coarser fraction, it consisted of flint and Greensand chert. The 8-11.2mm material yielded 162 clasts, still undersize but forming a reasonable sample if pooled with the 11.2-16mm material. There were seven exotics in this count, with both types of quartz represented, two orthoquartzites (probably from the Permo-Trias), a Carboniferous chert and an unknown chert (difficult to identify precisely at this size, but definitely not Greensand or *Rhaxella*). In addition to the inevitable flint and Greensand chert there was a single ironstone that, from its fine-sand grain size could be attributed with confidence to the Hastings Beds of the central Weald. The author does not favour counting such small material, as it is sometimes difficult to identify, especially when weathered (such small pebbles can often be weathered right through), but little difficulty was encountered with this sample. It is interesting to note the variations between this and the intermediate fraction, with flint generally declining and other types increasing at the smaller size. Nodular flint shows a particularly steep decline, partly because it is more difficult to recognize at the smaller size and partly because smaller fragments from larger flints are less likely to retain nodular cortex. Note that pooling of the exotic material from the two smaller sizes gives representation of all the main components of the 'Thames exotic suite'.

UPNOR 05

A sample from the lower Medway at Upnor, this was composed at both sizes of local and southern material, with no representation of the 'Thames exotic suite'. Calcareous and semi-durable material is included: Kentish Ragstone in both sizes, as well as cementstones and claystones. Hastings Beds material from the central Weald is an important component. Single 'vein quartz' clasts in both fractions are clearly not exotic; they would perhaps be better described as 'quartz beef', occurring as flat, fibrous clasts that represents quartz vein infills washed from otherwise non-durable Mesozoic strata (such veins are seen in the Kentish Lower Greensand). The 11.2-16mm fraction contained a bitumen-cemented aggregate of clear anthropogenic origin (tarmacadam), presumably a contaminant. A notable difference in comparison with the Cuxton sample, from a relatively short distance upstream, is the considerable boost in Tertiary flint pebbles at Upnor, a reflection of the fact that the Medway has entered the London basin, where it has access to the considerable quantities of Tertiary pebble beds material. Although the relatively soft Hastings Beds materials decline fairly sharply between Cuxton and Upnor in the 16-32mm fraction, they hold up well in the smaller 11.2-16mm count, remaining at ~20%.

DGFM 05

This is a gravel comprising mainly flint and Greensand chert, especially in the 16-32mm component, in which these together account for ~98%. There is also 1.4% Hastings Beds material in this coarser fraction, occasional Greensand sandstones and a clay ironstone of doubtful origin. Over half the flint is in the form of Tertiary pebbles (unbroken and broken), a clear indication that the sample is from the London Basin (downstream of the North Downs). From this 16-32mm material it looks like a typical Medway deposit from the Hoo peninsula (there is more Hastings Beds than would be expected in the High-level East Essex Gravel – see Table 1). However, the 11.2-16mm count, although generally similar, counts 3 'exotic' clasts (amongst a count of 778): a vein quartz, an orthoquartzite and a Palaeozoic (?Carboniferous) chert. All these types occur as rare clasts in Medway gravels, presumably reworked from Mesozoic pebble beds in the Weald (see Bridgland, 1986c), and the total of 0.4% exotics is not unprecedented in an 11.2-16mm Medway count (see Table 1), whereas it would be low for a Thames-Medway deposit, albeit one rich in Medway material, as would be apparent from the >30% Greensand chert proportion. The data is therefore interpreted as indicative of a Medway origin.

WTHF 05

This sample is dissimilar to any other in that it is heavily dominated by reworked Tertiary flint: 86.8% and 85.5% of the coarser and finer fractions, respectively. This is almost sufficient to warrant the archaic classification 'pebble gravel', as found on many hilltops in the London Basin. This would be one of the Greensand-rich pebble gravels that Wooldridge attributed to southern rivers flowing into the Pebble Gravel basin (see Bridgland, 1994, Chapter 3). Importantly, however, there is Hastings Beds material in both fractions, suggesting a Medway influence if not a Medway origin. This could be a very early Medway gravel, dating from the time when the Tertiary Pebble Beds were less denuded and therefore providing more bedload than during the latter half of the Pleistocene. Alternatively, if the gravel is younger, the Tertiary flint might be a local injection from a tributary draining the Tertiary outcrop. The 16-32mm fraction also has a possible (fine-grained) sarsen, whereas the 11.2-16mm count included a vein quartz clast and a Palaeozoic (?Carboniferous) chert. This gives a total exotic proportion of 0.3%, below that interpreted as Medway rather than Thames in the previous sample. Indeed, if this is a high-level gravel it is probably too old to represent the Thames, which flowed much further north prior to the Anglian (see Bridgland, 1994). There is a danger here; if the gravel is strongly diluted by a local injection of reworked Tertiary flint, then this could indeed be the 'Thames exotic suite'. The ratio of Greensand chert to exotics is probably within the range of post-Anglian Thames-Medway gravels (11.2-16mm counts), this ratio being unaffected by the Tertiary flint component. Another problematic aspect of the sample is the high ironstone count at both sizes, attributed to both Greensand and Hastings Beds types. There remains the possibility that some of this ironstone could be from localized occurrences in the London Basin Palaeogene, in which case the 'southern' component has been overestimated. As noted elsewhere, ironstones have been ascribed to Greensand or Hastings Beds origins, the principal sources of such material, on the basis of characteristic features such as grain size and shape; this is an inexact science and there are always 'grey area' (intermediate) types. Ironstone is known to occur locally in the Tertiary. All in all this is a difficult sample; I should like to have more details of its location!

SLM 05

This was an undersized sample for which an additional 8-16mm count has been carried out, to provide a statistically valid analysis (by pooling this with the 11.2-16mm a total of 338 can be achieved, with another 52 at 16-32mm). All three sizes consist solely of 'local' and 'southern' material. There is no representation of the 'Thames exotic suite'. Hastings Beds material is plentiful, especially in the smaller fractions (it is over 45% at 8-11.2mm), indicating that the sample is from close to the central Weald, presumably from the modern Medway valley. There are local mudstones and claystones and gravel aggregates present in the smaller fractions. The contrast between the different sizes is notable; Greensand chert dominates the 16-32mm count but fades as Hastings Beds increases in the smaller sizes. This provides another good indication of the importance of counting narrow size ranges and exercising caution when comparing analyses of different sized materials.

DOGF 05

This was another undersized sample for which an additional 8-16mm count was carried out (by pooling this with the 11.2-16mm a total of 286 can be achieved). The 16-32mm count, hopelessly undersized (12 clasts), contains only flint and Greensand chert. At 11.2-16mm the count of only 66 includes an exotic clast: an arkosic sandstone/quartzite. The 8-11.2 supplementary count yielded 220 clasts, of which 5% belong to the 'Thames exotic suite', including vein quartz, metaquartzite and orthoquartzites and another single arkose. No exotic cherts were encountered, which is surprising given the overall proportion of far-travelled material. This may result from the difficulty in distinguishing these cherts from flint at this very small clast size (a reason why I do not favour counting such material unless absolutely necessary). Nevertheless, it is clear that this is a Thames-Medway deposit of 'Low-level East Essex Gravel' type, as the presence of abundant Greensand chert and a couple of Hastings Beds siltstones in the 8-11.2 fraction further confirm.

Angularity-roundness analysis

This analysis used a modified version of the Powers (1953) method, adapted for gravel-sized clasts (Fisher & Bridgland, 1986) and using the categories defined in Table 2. Its principal purpose is to determine environment of deposition (see Fisher and Bridgland, 1986; Bridgland, 1999). Unbroken Tertiary flints were excluded from the data, as their rounded character is clearly a derived (marine) feature. Similarly, unmodified flint nodules were not included. As the results table (Table 3) indicates, all counts showed angular flint as the modal class. This is a typical feature of Quaternary flint gravels of fluvial origin, although in large rivers like the Thames the subangular class can sometimes reach dominance, usually in downstream locations, where much of the flint has probably travelled considerable distances. This is in marked contrast to beach and shallow marine gravels, which typically peak in the rounded half of the table, although Middle-Upper Pleistocene marine gravels are generally much less rounded than older ones (this is attributed to the instability of sea-level since the Mid Pleistocene Revolution, which means that beaches have been more ephemeral during this period).

Another notable characteristic is the variation in the proportion of 'very angular' flint, which contains the freshly broken material, much of it probably broken by frost activity. Because such material can be created *in situ* after deposition, it can be highly variable and localized. Samples from nearer surface situations, within the active layer during periglacial periods, will typically contain more frost-fractured flint. If the sole purpose of the analysis is to determine environment of deposition, it is sensible to recalculate omitting the very angular material (this has not been done here, although it would be a simple matter). In solifluction gravels, very angular flint is generally the modal class (see Table 3), reflecting the periglacial environment in which such deposits accumulate. Samples APHF 05, CXTN4 05 and WTHF 05 are particularly rich in very angular flint. Whether this is sufficient to suggest a solifluction origin is doubtful; such a determination would be unwise without considering other features of the sediment, such as bedding characteristics, particle size distribution, etc.

Several of the angularity/roundness subsamples are undersize, two of them drastically so (these are in red in Table 3). Generally this type of data is quite robust even when counts of only ~50 can be achieved, given the small number of categories involved. The two red samples should perhaps be disregarded, however, despite the fact that the findings are entirely in keeping with the larger counts.

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