Report on the industrial residues from Quartertown Lower, Mallow (11E0142)

Paul Rondelez
Wood House
Knocknamuck
Mitchelstown

2nd of October 2011

Introduction

The material submitted for study consists of 7 bags of vitrified material and 8 bags of iron objects. Three of the bags of vitrified material consist of samples from the three layers (S5 from c.13, S6 from c.14 and S7 from c.18) of the main body of industrial residues. These layers were sampled by the author and represent blocks of 50 x 50 x 10 cm of material. A fourth bag (S2 from c.13) is a sample of one of the former layers which was visible in a different section (Sondage 4). A fifth bag was retrieved from the fill of the wood-lined water-channel (S8 from c.41) and a sixth was collected from a layer next to this channel (S1 from c.7). The final bag contained material which was found on the base of the stream at the south of the site (S9 from c.56). This last sample was supplemented with material which was found earlier in this same stream.
Nearly all iron objects were retrieved from the layers in the large pit c.20, which also contained most of the industrial residues. Three of the bags contained iron objects from layers above the industrial material (F6 from c. 12, F7 from c.25 and F22 from c.30). The iron objects in a fourth bag were from the lower layer of industrial residues (F2 from c.18) and three bags of iron objects were found in layers below the latter (F10 from c.9, F11 from c.10 and F15 from c.33). A final bag was retrieved from a clayey layer to the south of c.20 (F14 from c.32).

Methodology

All the material was washed and dried. Based on observations aided by an optical microscope (magnification x10 to x60) each fragment was typologically classified, and the occurrence and types of organic (fuel) and inorganic (stone and metal) inclusions were recorded. Each piece was also tested with a magnet and classified accord to magnetic attraction. As most, if not all, fragments were pieces of larger bodies, each one was weighed separately, so the above criteria could be visualized by weight as opposed to amount of pieces.

Analysis

1) Weight of samples

All samples were weighed in bulk before and after washing (Fig. 1). Subsequently, all the samples were sorted on a sieve with a mesh of 1 x 1 cm. This allowed all the material weighing less than about 10 g to be discarded.

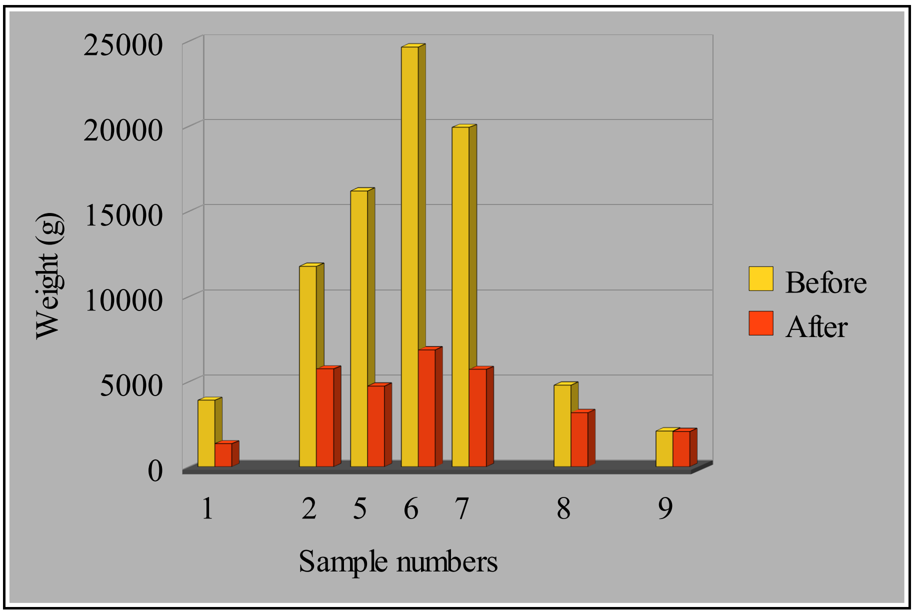

Fig. 1 : Weight of samples before and after sieving and washing

The bulk samples (S1 to S7) weighed from about 50% to 75% less after washing and sieving. The lower values of the other samples, and sample 2 to some extent, reflect the selective sampling which occurred.

2) Typology

The material was, based on visual characteristics, divided into two groups: slag and clinker (Fig. 2). The slag is dense, dark grey to black with slightly metallic aspect, with two pieces being attached to masonry luted with clay (Plates 1 and 2). Some parts and inclusions show a more glassy appearance. The clinker varies from light to rather dense, varies in colour and generally has a glassy appearance. This material also had more inclusions (fuel and stone) than the former and had a more blistery appearance on the upper side. Some of the clinkery material was very light and glassy, while other were covered with or were partially transformed into a rusty layer (Plate 3). The rusty material was largely confined to the material sampled from the middle layer of the main body (S6 from c.14).

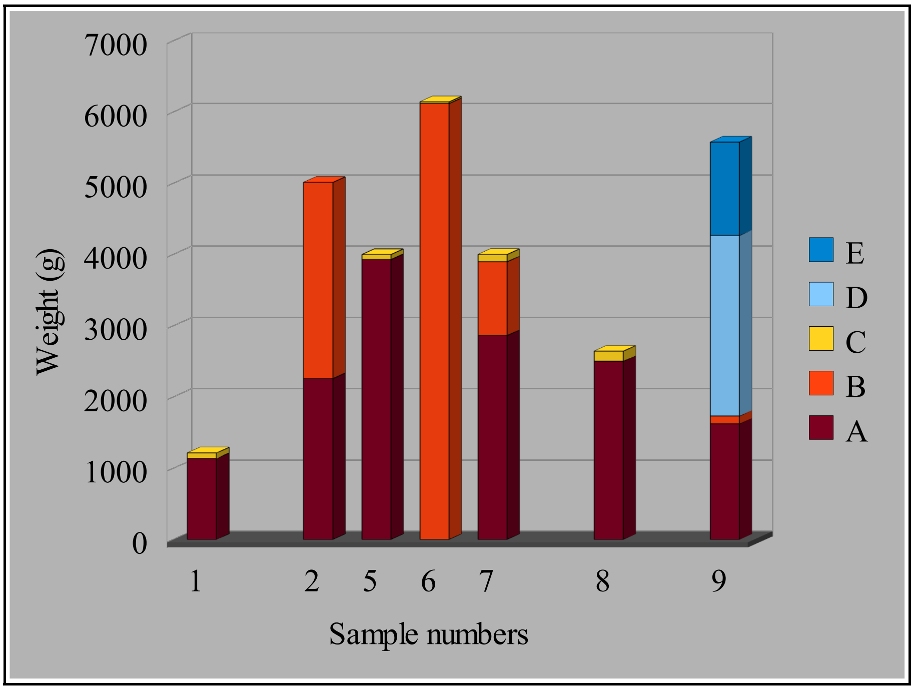

Fig. 2 : Types of industrial residues in all samples (A = clinker, B = rusty clinker, C = glassy clinker, D = slag, E = slag with masonry)

Context 14 containing sample 6 was defined by the rusty colour of the material, but probably represents only a level in the material were iron oxide was deposited because of fluctuations in the water-table. This would explain the content of 'rusty clinker' in sample 2 and the absence of it in sample 5, although both were classified as coming from context 13. The slag material types D and E are so distinct that sample 9 will henceforth be subdivided into 9a, which is the clinkery material, and 9b, the slag material.

3) Magnetism

Each fragment was tested with a block magnet and classified according to the following observations: no attraction, some attraction, average attraction (either the piece or the magnet moved substantially) or strong attraction (force had to be used to separate the two). The results are presented in Fig. 3.

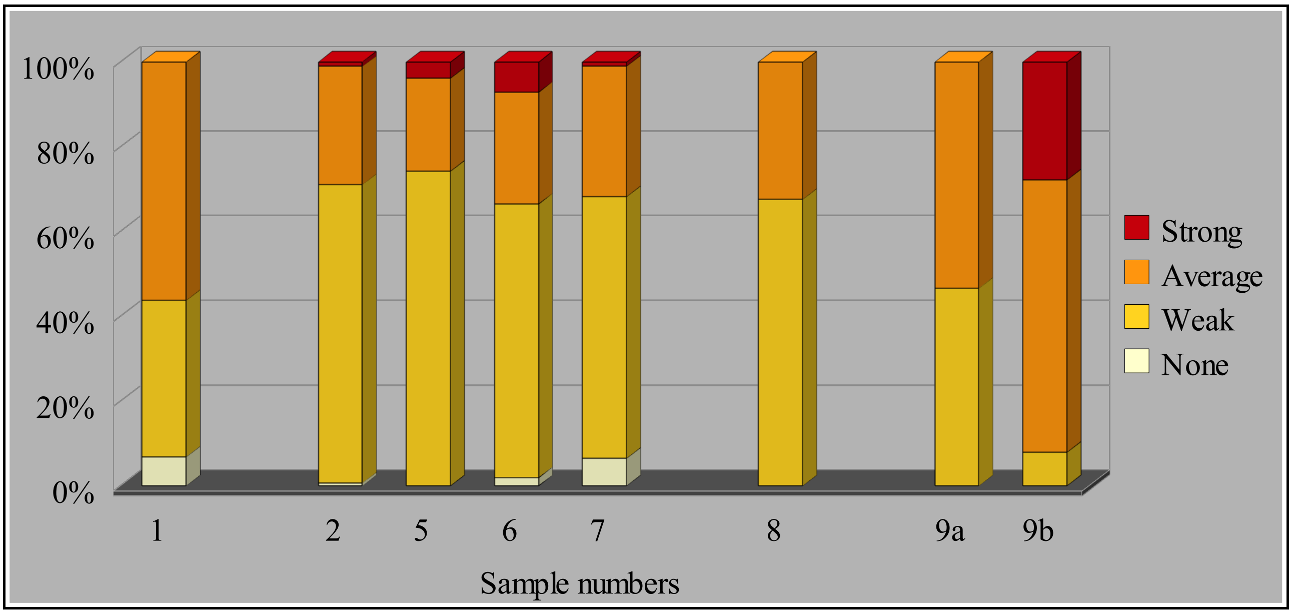

Fig. 3 : Magnetic attraction of all samples in % of total weight

Both samples 1 and 9a are small and probably biased towards larger and heavier pieces which tended to be more magnetic. The samples from the main body of material (2, 5, 6 and 7) and from the water-channel (8) show that nearly all material contained some magnetic material, with about 25% of the material (by weight) having average or stronger attraction. The slightly higher values noted in sample six could be connected with re-deposition of iron oxides on the material, as this was the 'rusty layer' in main body. The material designated as slag shows an appreciatively higher magnetic attraction than the other samples.

4) Fuel

All samples were checked for fuel and both coal and charcoal were encountered (Fig. 4). Some of the coal had the more frothy appearance of coke (coal with the sulphur removed), but several fragments showed also pieces with characteristics of both. It is therefore assumed that the frothy appearance is a result of combustion processes in the hearth and does not imply the use of coke.

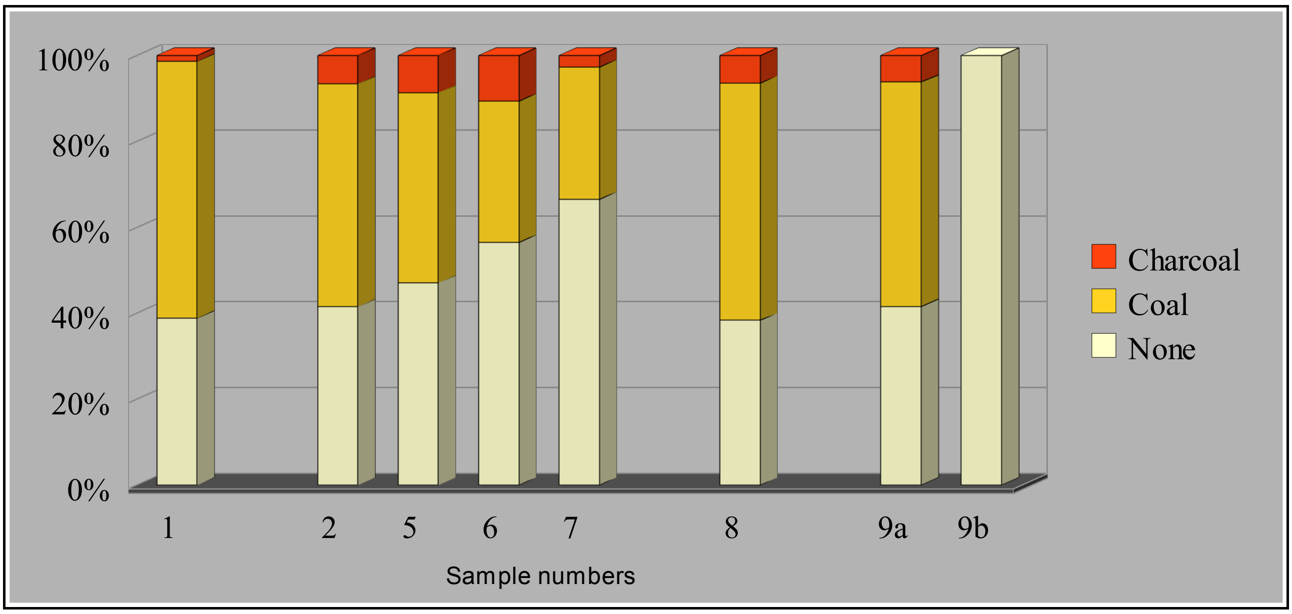

Fig. 4 : Fuel inclusions of all samples in % of total weight

All samples consisting of the clinkery material (S1 to S9a) show a rough average of about 50% of the material containing no fuel, 40% containing coal and 10% containing charcoal. It is unclear if the 'evolution' visible in the coal content of the material belonging to the main body (S2/S5, S6 and S7) is significant or the result of a statistical error, i.e. the sample is too small. If significant it could point to an increase or decrease in fuel burning efficiency, depending if the lower material (S7) is the older or younger material (if the material was re-dumped). Interestingly, the same trend is visible when comparing the weight of the fragments of pure coal found in the various layers of the main body of material (Fig. 5). The slag material (S9b) contained no fuel inclusions.

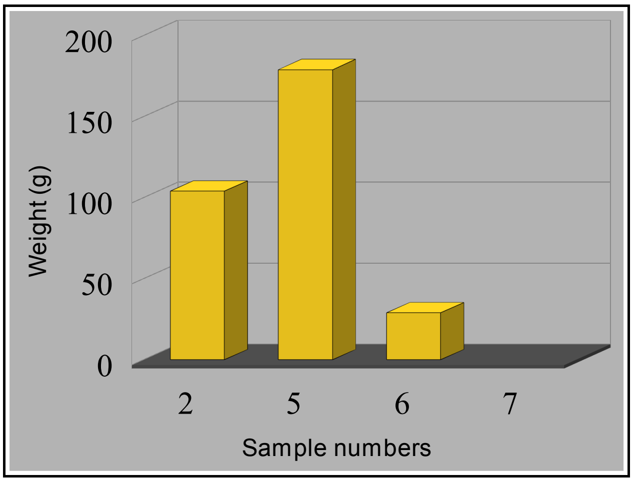

Fig. 5 : Weight of coal fragments in the samples from the main body of material

5) Stone inclusions

All samples were similarly checked for inclusions of stony material (Fig. 6). Some fragments had pebbles attached/included, but most of the recognizable material consisted of grey shale which on many occasions had turned reddish pink due to burning. Several pieces were seen were the shale was attached to pieces of coal (Plate. 4), which implies the material is coal-shale and is mixed in with the material because of the use of impure coal. A relatively large proportion of the material contained stony material which was so affected by heat as to defy characterisation. The material often showed a distinct honey-comb structure. Other pieces classified as 'unidentified' may well have been shale, but some seemed to be more quartz/feldspar-like. The unidentified material included in the slag (S9b), although heavily affected by heat, seemed to be similar to the stones forming the masonry, found attached to two pieces of this slag material (Plate 2).

Except for sample 9b standing out as different, no firm conclusions are possible when looking at the results. No explanation is offered for the high values of material in sample 6 (from the middle, rusty layer in the main body of material), although it could point to the use of purer fuel at some stage. When the weight of stony material which is not incorporated into the clinkery material (but still heat-affected) is visualized (Fig. 7), sample 6 again shows the same anomaly.

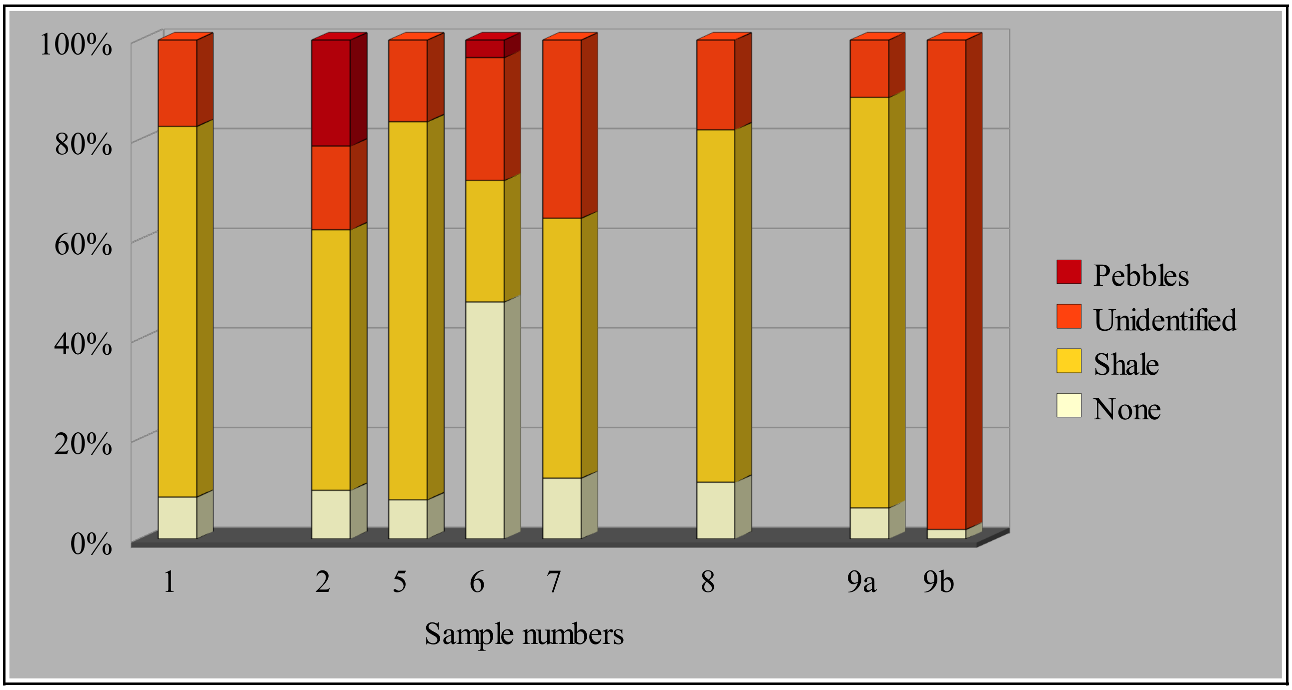

Fig. 6 : Stone inclusions of all samples in % of total weight

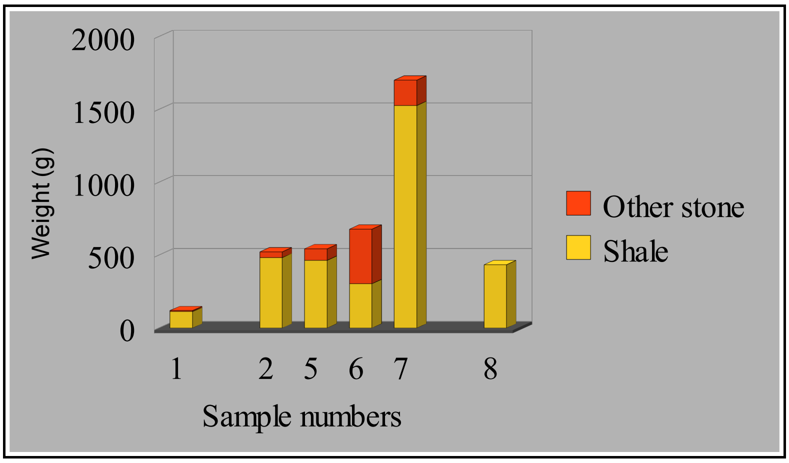

Fig. 7 : Stony material in samples 1 to 8

6) Iron objects

The iron objects from c.30 (F22), a layer above the vitrified material in the main body, consisted of two flat bars of iron (L 28 x W 4 cm and L 25 x W 5 cm), four fragments of iron mesh (Plate 5), a large nail and what seems to be three nails or pegs oxidised together. The material from another layer covering the residues (F6 from c.12) consists of four small nails and one big one together with three unidentifiable lumps of oxidised iron. Layer c.25, also over the clinkery material, contained a highly oxidised fragment of an iron bar (L 15 cm), probably with square section (F7). The lower layer of industrial waste produced three heavily oxidised pieces of iron, one of which might have been a flat bar (F2 from c.18). A layer below this consists of two fragments of larger plates, one of which shows a hole at one of its sides, together with three pieces of unidentifiable, heavily oxidised iron (F11 from c.10). The objects from c.33, also under the clinkery material, consist of three lumps of rusted iron and seven nail-shafts and nails, one of which is remarkably well preserved. The find from the final layer underlying the clinkery material (F10 from c.9) consists of one heavily corroded lump of iron. The last find came from the only layer not contained in c.20, but from a layer south of it (F14 from c.32). This consists of a heavily oxidised fragment which could be a square sectioned pin and what looks like the front end of a knife.

Discussion

In the bloomery process iron is obtained from its ores by smelting away all other substances from around while removing the oxygen from the iron oxides. The result is a solid bloom and iron rich slag. This bloom will subsequently be worked into bars and objects in a forge. By the 16th century both the bellows of the furnace and the hammer of the forge connected to the bloomery could be water-powered (Dungworth 2010:19). The slag produced in the classical, non-water powered bloomery is dense, iron rich slag often with a clear lava-like flow structure. The water-powered version is less understood, but seems to produce similar slag, but with a characteristic honey-comb structure on the lower side (ibid.).
The blast furnace uses higher temperatures and produces liquid iron and iron-poor, glassy slag. The liquid iron can be poured into a mould resulting in cast iron objects or as bars of pig/sow iron. This iron is high in carbon, brittle and cannot be further worked in this state. The bars are destined for the finery where most of the carbon is removed and the iron is thus converted into workable wrought iron. The resulting slag is rich in iron and, confusingly, can resemble tap (bloomery) slag both in appearance and chemistry (Pleiner 2000: 254).
In the 18th century coal became used in large amount in ironworking. On the one hand it was made in to coke (de-sulphurised) which could be used in direct contact with the metal. on the other hand coal was used in the reverberatory furnace (puddling), in which the hearth is kept separate from the place where the iron is converted pig iron into wrought iron or steel. These last furnaces would gradually replace the fineries. In the 19th century the vertical tube-like cupola furnace was used for the same purpose, also using coke as a fuel. These cupolas could be used to smelt iron ore, convert pig iron into wrought iron and recycle scrap iron into cast iron.

The slag material, although limited in amount, has the characteristics of bloomery tap slag/finery slag. Based on the historical data available, which seems to indicate that a blast-furnace and finery were operating around the Quartertown area at the end of the sixteenth century, it is likely the material is derived from this finery. The stone type used in the masonry has not been identified, but is undoubtedly some kind of refractory stone. Clay luting is common in metallurgy, as most mortars would not react well to the high temperatures. These pieces indicate the metallurgy at Mallow was carried out in an enclosed space, something which would clearly point to either a furnace or a finery being in use. The occurrence of this material at the base of what looks like a relatively modern artificial stream indicates that the material was moved in more recent times, either by building works around the house to the south of the site or, possibly, the modern housing estate further west.

Nearly all post-medieval ironworking processes leading to large amount of waste, produce glassy, dense slag or very iron-rich residues, with the exception of some cupola furnaces (those wherein no flux was used) which produce more clinkery material[1]. Hence the clinkery material, which was relatively dense, rusty and magnetic (this was checked on site), was provisionally interpreted as such during the excavation. But some clinkers from large fire-places such as industrial boilers etc. can exhibit very similar characteristics, the only difference being entrapped drops of cast iron ranging from a few microns up to 30 mm incorporated in the cupola slag. Although the material was not mechanically sectioned, no such droplets were seen on any of the fractures of the material. Additionally, impure coal such as is seen in the samples would not have been used in the relatively small cupola's as the larger pieces would have clogged up the installation. The high iron content of this material is somewhat unusual, but can be explained by the use of coal containing a high proportion of pyrite (iron sulphide), or as the result of iron absorbed from the casing of the installation. It thus seems more likely that the clinkery material is derived from a heating

1 The characterisation of the residues resulting from post-medieval industrial processes in general, and ironworking in particular, is a severely under-studied field. Most of the archaeological and technological information in the following is synthesized from e-mail traffic conducted with Tim Young of GeoArch Ltd. between 5 and 13 September 2011. I would like to sincerely thank Tim for sharing his knowledge.

installation not connected with iron working, but represent the debris cleared out of the drying kilns in the nearby flour mills. Although not found in the layers of vitrified material itself, both the iron mesh and the perforated floor-tiles would then be part of the same installation. The wire mesh fragments are potentially fragments of rotary cleaners, introduced in Ireland in the early 19th century (Rynne 2006:262). The fuel used in the process producing the clinkery material was found to be coal heavily contaminated with shale. Coal was regularly used for firing drying kilns in 19th century Ireland (ibid.:85). Interestingly, some 20 km upstream from Mallow, at and around Dromagh, coal was mined between the 1740's and 1882, with a short break in the early 1860's (ibid.:84). Both culm (low quality coal) and higher quality coal were extracted (Griffith 1814:xvii-xix). The charcoal observed in about 10% of the samples could represent fuel which was used for kindling the fire.

Conclusions

Although the probable discovery of the location and the material remains of a late 16th century water-powered ironworking site is of great archaeological interest, it seems likely that the installations (no trace of the furnace has yet been found) are either destroyed or buried under the 19th century remains of the flour mills to the south of the site. The more recent residues are most likely derived from the grain drying kilns connected with these mills, which appeared to have used impure coal fuel, potentially of local origin. These residues are probably not functionally related to the water-channel/pond/timbers/stones complex in and around which they were found.

Bibliography

Dungworth D. 2010. The possible water-powered bloomery at Goscote (Rushall), Walsall, West Midlands. *Journal of the Historical Metallurgy Society* 44 (1):15-20.

Griffith R. 1814. *Geological and mining report on the Leinster coal district, Volume 1*. Dublin: Graisberry and Campbell.

Pleiner R. 2000. *Iron in archaeology. The European bloomery smelters*: Archeologicky ustav AVCR.

Rynne C. 2006. *Industrial Ireland 1750-1930. An Archaeology*. Cork: The Collins Press.

Plates

Plate 1 : Slag with masonry attached (S9 from c.56)

Plate 2 : Same piece seen from the side

Plate 3 : Clinkery material with adhering iron oxides (S6 from c.14)

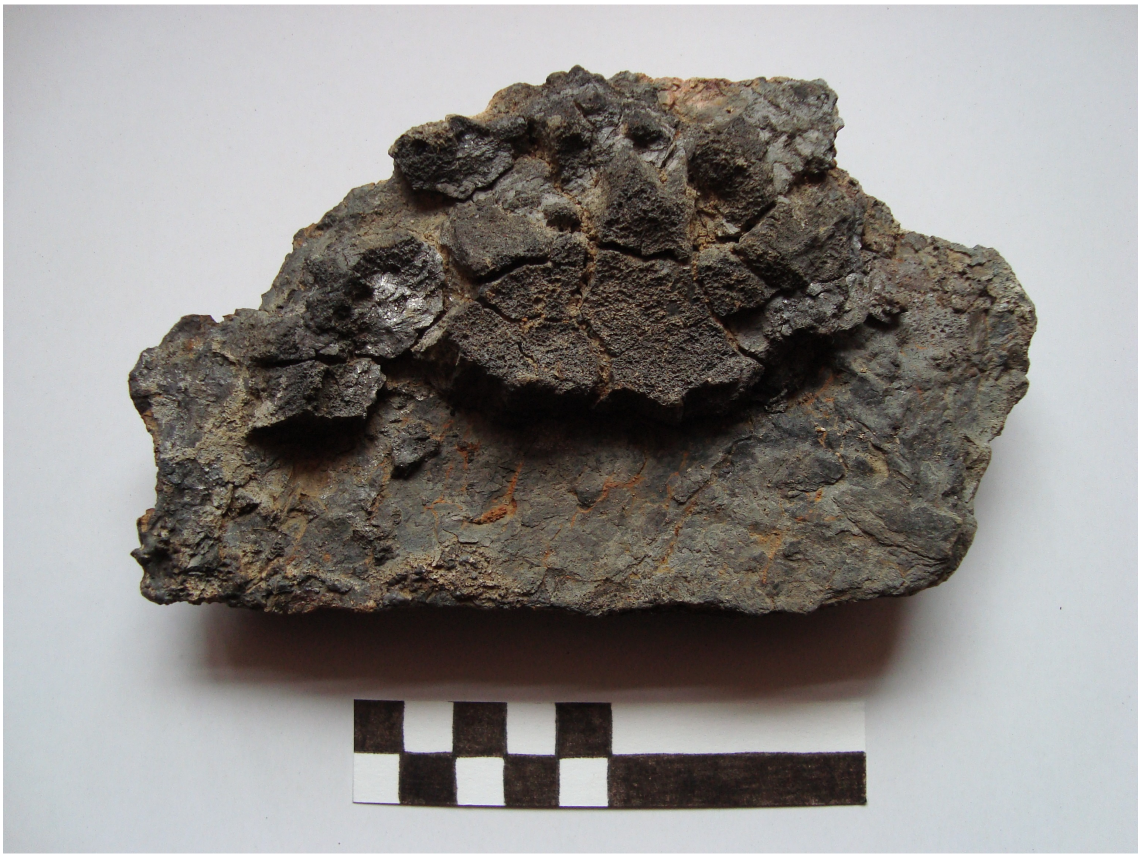

Plate 4 : Shale with adhering coal (S7 from c.18)

Plate 5 : Iron mesh (F22 from c.30)