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Evaluation of pyrotechnological residues from Magheracar, Co. Donegal (E354)

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Abstract

The submitted assemblage comprised approximately 460g (10 pieces) of highly vitrified and glazed rock, probably originally a well-foliated fine-grained sandstone.

The degree of heat alteration of the pieces is very high, with vitrfication, minor vesicle formation and the glazing of cavity surfaces to at least 50mm below the external rock surface. The highly vesicular rock passes outwards into a dark glass with remnant quartz grains and possibly neomorphic feldspars. The dark glass also bears, in some cases, detached blebs of the relict substrate. The outer surface of the pieces is either a dark glass, or where the glaze extends over clasts of substrate rock, the thinned glaze is clear to green, sometimes with bright green devitrification spherulites.

Interpretation of the material is uncertain. The degree of vitrification of the sandstone is high, certainly comparable to that observed in structural materials from limekilns. The glaze colour is also similar to that produced in limekilns, but similar glazes can also be produced from the high calcium ash in wood or charcoal fires – or perhaps from calcium derived from the rock itself. None of the material gives any evidence for contamination by metalworking (nor is there any independent evidence), so the material is unlikely to be from a metalworking hearth or furnace. The most likely interpretation is that depth of vitrfication is the result of the fluxing properties of material, probably calcite, present pervasively in the original rock. This means that the degree of alteration is much greater than that observed in rocks which do not contain calcite. Although the observed textures are typical of contexts such as lime kilns or kelp kilns, it remains possible that in this case a lower temperature process was involved. The possibility that the textures might have been developed during cremation would be unusual, but in this instance cannot be excluded.

In addition to the heat-altered rock, the collection included four lead spheroids, all from the sod layer and all probably birdshot.

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Methods

All materials were examined visually with a low-powered binocular microscope where required. As an evaluation, the materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional. The summary catalogue of examined material is given in Table 1.

This project was undertaken for Valerie J Keeley Ltd.

Results

Heat-affected stone

The degree of heat alteration of the pieces is very high, with vitrfication, vesicle formation and glazing of cavity surfaces to at least 50mm below the external rock surface. The development of these small vesicles suggests loss of one or more minerals from the assemblage, leaving a quartz-dominated relict. Much larger vesicles appear about 4mm below the rock surface. Some of these larger internal vesicles have a pinkish or maroon coating. The highly vesicular rock passes outwards into a dark glass with remnant quartz grains and possibly neomorphic feldspars. The dark glass also bears, in some cases, detached blebs of the relict substrate. The outer surface of the pieces is either a dark glass, or where the glaze extends over clasts of substrate rock, the thinned glaze is clear to green, sometimes with bright green devitrification spherulites. Several pieces show some degree of flow or sloughing of the external glaze. In one case of a larger rock fragment, the original foliation in the sandstone is seen to be curved, but it is unclear whether this is original or a product of deformation during the vitrification process.

Metallic spheroids

The collection also included four examples of metallic spheroids, almost certainly lead or lead alloy birdshot from a shotgun. Three of the four spheroids are heavily oxidised, the fourth is fresh metal, but is more highly deformed.

Interpretation

The supplied materials included rather broken examples of the vitrified rocks, including some very small fragments. If this is indicative that there was retrieval of all the vitrified material from the site, then the fragmentary nature of the evidence might suggest the materials were not produced on site but have been moved.

Interpretation of the heat-affected material is uncertain. It would be very unlikely that a simple hearth would develop sufficient heat to generate the degree of vitrfication observed in a simple sandstone. It is likely that the presence of significant quantities of one or more elements like sodium, potassium and calcium has fluxed the melting of the sandstone and induced partial melting at a lower temperature than usual.

The big question with this particular material is whether the sandstone contained sufficient calcite to permit this fluxing effect, or whether additional external fluxing was required. The local Mullaghmore Sandstone Formation is known to include calcareous sandstones – so it is possible that the sandstone contained sufficient calcite to react and melt, producing the pervasive fine porosity and internal glazing observed in many of the pieces. Indeed, it is hard to envisage the degree of internal vitrfication being fluxed by migration of alkali elements from the outside inwards.

The melting and reaction of calcium-rich materials at relatively low temperatures is behind many of the so-called *fuel ash slags*. This may occur in fairly low temperature contexts, with examples known from corn drying kilns (Young 2005, 2010) as well as from domestic hearths when dug into calcareous substrates (Young 2005, 2011). Domestic cooking fires that were kept burning for long periods are likely to be behind a particular phenomenon of the British Middle Iron Age, in which there is a particularly common type of fuel ash slag that has become known as 'Iron Age grey slag' (Cowgill 2000, 2008; Cowgill *et al*. 2001; Swiss & McDonnell 2001). These examples differ from the present one, however, in exhibiting vitrification and sintering of an unconsolidated substrate, rather than solid rock.

The degree of vitrification of the sandstone is certainly comparable to that observed in structural materials from limekilns. Somewhat similar material has recently been described from a Roman limekiln at Tremadog (Gwynedd, Wales; Young 2011b).

The glaze colour is also similar to that produced in limekilns, but similar glazes can also be produced from the high calcium ash in wood or charcoal fires. Metalworking hearths occasionally produce small green-glazed stones, presumably accidentally incorporated into the fuel either from the hearth side or through contamination of the charcoal. None of the material gives any evidence for contamination by metals (nor is there any independent evidence), so the material is unlikely to be from a metalworking hearth or furnace. The fuel ash slags described above do not show well-developed glazes, but this may be function of their heterogeneous sintered structure.

An alternative interpretation for the development of the glaze is that might be a sodium-rich glaze derived from the burning of kelp. Isolated glazed stones from Dunnyneill Island (Co. Down; Young 2006) proved to have a sodium-rich glaze and a tentative suggestion that these were generated during kelp burning was made. The significance of these vitrified materials may depend somewhat on aspects of their occurrence. If the materials were securely stratified in prehistoric deposits, then an origin in lime-burning or kelp-burning is unlikely (kelp-burning in particular was essentially a post-medieval activity).

The most likely interpretation is that depth of vitrfication is the result of one, or perhaps many, episodes of intense heating such that the calcium present in the sandstone as calcite was able to flux the partial melting of the silicate material in the sandstone. What is less clear is whether the calcium released in this process would have been sufficient to generate the thick external glaze. It is possible that this glaze may be more indicative of the general conditions within the 'hearth' – being produced by the wood ash, kelp ash or lime, depending on what the 'hearth' actually was. The generation of such extreme vitrification during the process of human cremation would not normally be considered likely, but given the evidence that the rocks may have contained fine-grained calcite, such an origin cannot be excluded

Evaluation of potential

As described above, there are several possible origin for the generation of the vitrified materials. If interpretation of the vitrfication was deemed to be a useful archaeological aim, then there are several possible routes to attempt to refine the interpretation.

In terms of study of the material itself, then analysis of the vitrified material could be undertaken. At its

simplest, such work might entail the analysis of the external glaze either to give a qualitative result by mounting a chip on a stub for examination under the SEM, or for a quantitative analysis a polished block could be prepared for the SEM (which would also allow analysis of the internal vitrification). Such analysis would be intended to determine the elemental composition of the glaze (particularly the sodium, potassium and calcium contents – which allow a differential interpretation of the source of the glaze).

The investigation of the archaeological materials would be greatly enhanced through investigation of a piece of unaltered sandstone (either from the archaeological collections, such as sieved residues, or by collection of new material from a local rock outcrop). This would allow a reasoned assessment of the degree to which the observed vitrification might be associated with the properties of the rock, rather than with the external process.

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Table 1: Summary Catalogue of possible pyrotechnological residues from Magheracar (E354).

cutting	square	location	#	no.	weight	notes
1	h10	cell 4, S side	39	1	7.68	Spalled vitrified material; pale quartz grains in green-clear glass. Irregular shape - so this may be a slumped slurry.
1	j10	cell 4, 0.41m below datum	166 (a and b)	1 (2)	0.74	A 0.47g, B 0.27g. Two conjoining pieces of a flake of glazed surface. 3mm thick dark glass, cleaved at point where merges to grain-rich material with vesicles. Original piece seems to have been from edge of rock or edge of protrusion on rock, since surface curves 90 degrees at edge.
1	j10	cell 4, 0.48m below datum	178	1	11.13	Dark rock fragment, angular, glaze is pale-green on protuberances on surface, but appear black in hollows and extending into interior of piece. Internal voids have either a clear or maroon glaze. Black glaze extends down between sand grains, but largely disappears by 20mm in (edge of piece). Surficial 4mm are darkest and most vesicular.
1	j11	cell 2	299	1	9.01	Spalled vesicular dark vitrified rock fragment. Cleaved roughly parallel to face - which is a convex, glazed bump. Glaze dark with pale remnants (to 30x10mm), all vesicular, max 10mm thick. Remnant textures suggest similar rock to other pieces.
7	j11	cell 3	331	1	28	Vitrified layer from surface of material, 23mm deep. Very smooth green glazed, possibly flowed surface, on top of variegated green glass/pale relict rock (to 20mm) with abundant vesicles. Even the pale rock fragments are locally moderately vesicular. Glaze is dark, but bearing pale relict crystals (and possibly neomorphic feldspar), but bears frequent bright green devitrification spherulites.
1	j11	cell 3, 0.54m below datum	334	1	0.24	Small chip of dark glaze with brownish rains. Has internal void partly surviving with a maroon veneer.
1	J1/1	cell 3, 0.54m below datum	335	1	216	Rock slightly reddish, pale with laminations picked out in dark red-grey. The foliations are not planar - it is uncertain if this is original, or substantial internal deformation has occurred during vitrfication. Major vesicles extend locally to 15mm below rock surface, but often less; minor (sand grain size) vesicles extend through whole thickness (i.e. to 50mm below surface. Rock has cracked and internal cracks have a clear glaze. The external glaze is locally dark, but is mostly a clear green, with pale vitrified rock clasts. Vitrification seems to wrap around and diminish away from one end - as if this was the end of a rock extending into the heat.
1	J11	cell 3, 0.55m below datum	336	1 (2)	36.56	Broken prism of altered foliated rock, following foliation at about 40 degrees to highly slagged surface. Some vitrification to end of piece, c55mm below surface. Mainly just vitrified stone with enhanced porosity. Major vesicles appear c. 4mm below surface. Surface bears up to 12mm of green glaze and pale stone fragments, Foliation in rock as seen in other pieces, picked out by darker laminae in a reddish-pink colour.
1	j11	cell 2	354	1	146	Foliated pale rock, showing pervasive vitrification. Main outer face is complexly shaped and has a clear to clear-green glaze. The specimen extends to 45mm below this surface. It is well cracked and has enlarged voids. These voids and bubbles in the internal glaze show a pink-maroon colour on top of the clear layer. The whole rock shows alteration. The vitrfication is dark for about 17mm below the external surface. The external surface shows a sharp-edged angular indentation which could either be contact with an adjacent stone or a fuel lump.
1	j11	cell 3, 0.60m below datum	362	1	0.13	Small chip of dark glaze bearing pale grains; has part of internal void which shows a maroon veneer.

Table 1: Summary catalogue of probable lead birdshot from Magheracar (E354).

cutting	square	location	#	no.	weight	notes
1	h11	from sod	82	1	0.36	lead shot - lead spheroid c. 4.0mm diameter (deformed) (no. 1 birdshot?)
1	k14	from sod	427	1	0.20	lead shot - deformed lead spheroid c. 3.2mm in diameter (no. 4 or 5 birdshot?)
2	f3	from sod	493	1	0.31	lead shot - lead sphere c. 4.0mm in diameter (no. 1 birdshot?)
1	h11	from sod	811	1	0.13	lead shot - lead sphere c. 2.7mm diameter (no. 7 birdshot?)

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