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Ancient Monuments Laboratory
Report 26/98

ANALYSIS OF SAMPLES TAKEN FROM THE ENTRANCE GATES AT ELMORE COURT, GLOUCESTERSHIRE

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Summary

Samples from the historic gates at Elmore Court, Gloucestershire, were examined by metallography and scanning electron microscope (S.E.M.) based microanalysis. Cast iron, wrought iron and mild steel were identified as well as some possible puddled steel, and a low carbon bulk iron.

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Analysis of samples taken from the entrance gates at Elmore Court, Gloucestershire.

Rebecca Sutton

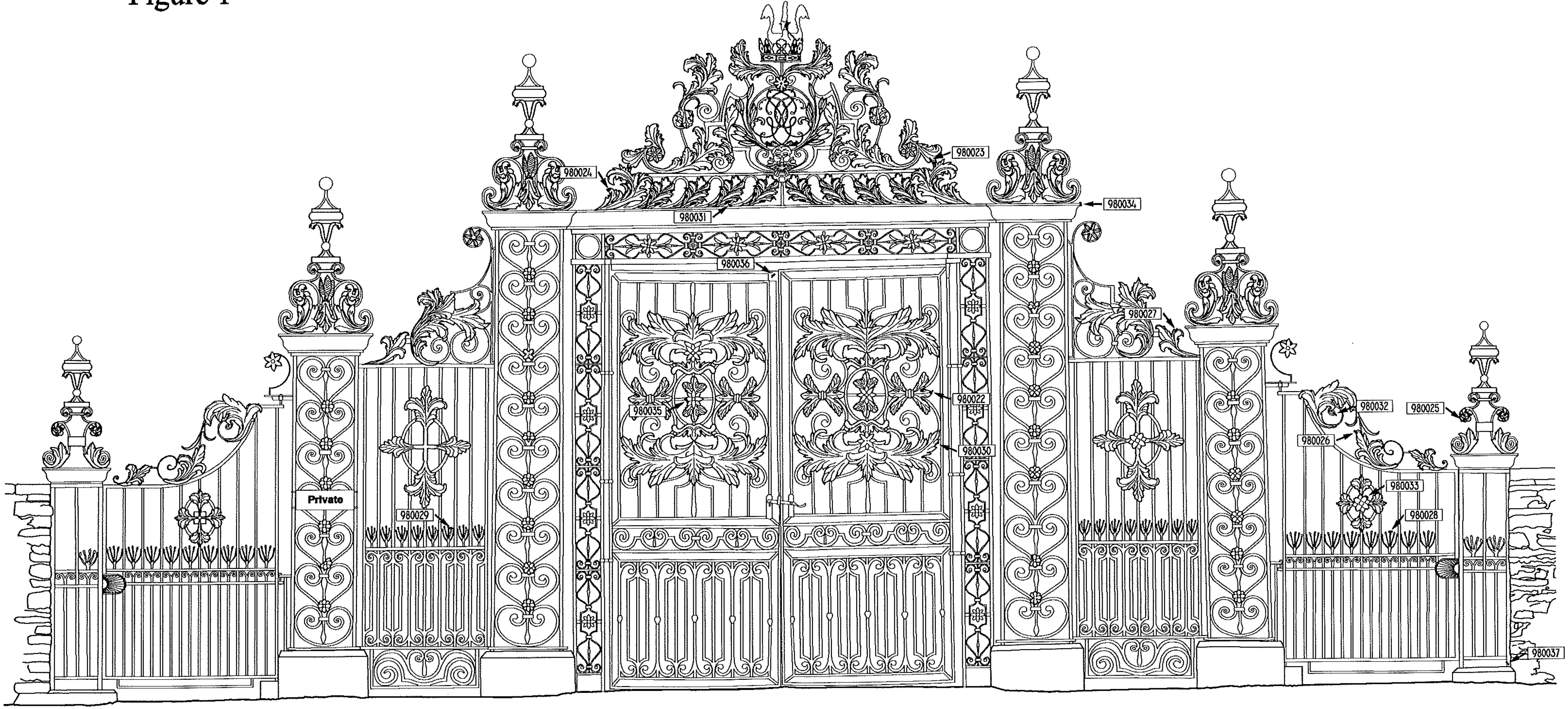
Background

The entrance gates of Elmore Court, near Gloucester are thought to have originally stood at Rencombe, near Cirencester. This was once a seat of the Guise family, who now reside at Elmore Court. The gates are based on a design by Tijou, published in 1693. The first illustration of them appears in Atkyn's *Gloucestershire* of 1712, so they were originally constructed between these two dates.
Removal of the gates from Redcombe to Elmore Court is thought to have taken place around 1863, when Redcombe was sold. At this time, the side pedestrian gates were added, and possibly the repoussé work on the main gate replaced, as there is no visible difference between the repoussé work on the side and main gates (figure 1). There is reason to believe that some repoussé work was renewed around 1962, as there are noticeable differences between a photograph of 1914 and the gates as they are at the present day. The history of the metalwork can be found in greater detail, in Jane Root's (1995) report on the gates.

Sixteen samples from the gates, were analysed to determine the types of metals used to produce the metalwork. This work was undertaken to help Keith Blackney of Architectural Metalwork Conservation decide on the conservation needed. It may also help to establish which parts of the gates are recent additions.
One small sample was taken from each of the seven repoussé decoration groups identified. The other nine samples were from areas of the gates which Keith Blackney highlighted as being of interest (See Table 1). The samples were examined using standard metallographic procedures. Each sample was mounted and polished, and the polished surface etched with nital (2% nitric acid in alcohol). They were then examined under an optical microscope Ten of the samples were examined using a scanning electron microscope (SEM) with an energy dispersive X-ray analyser (EDX). This was to determine the composition of the inclusions found in the metal. These techniques can give an indication of the materials and manufacturing processes used.

Table 1	Description and interpretation of Elmore Court gate samples	
AML ref code	description	interpretation
980022	group 3 decoration	wrought iron
980023	group 1 decoration	mild steel
980024	group 2 decoration	wrought iron
980025	group 7 decoration	"bulk iron"
980026	group 5 decoration	mild steel
980027	group 6 decoration	mild steel
980028	RH pedestrian gate, finger like decoration	wrought iron
980029	left side screen, finger like decoration	wrought iron
980030	group 4 decoration	"bulk iron"
980031	LH under stretcher bar	wrought iron
980032	RH pedestrian gate, cresting	wrought iron
980033	RH pedestrian gate, front elevation	cast iron
980034	end of stretcher	"puddled steel"
980035	LH main gate	wrought iron
980036	LH main gate, weld area	wrought iron
980037	pier F	wrought iron

Figure 1



Front Elevation

ELMORE COURT, ELMORE, GLOUCESTERSHIRE

1 0 1 2 metres

SURVEY BY	Survey Team Survey Unit
FOR	Survey Services Professional Services Rm 604/5, 429 Oxford Street London W1R 2HD Tel. 0171-973 3000

SURVEYED	: KB,WB,AC	JUL 1997
PHOTOGRAPHY	: WB	JUL 1997
CAD	: WB,AC	AUG 1997

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SCALE	MONUMENT NO.	DRAWING NO.
NOT TO SCALE	-	-

Metallurgical interpretation

There are three easily recognised types of metal represented in the samples taken from the gates.

1) Cast iron.
Cast iron is an iron alloy containing more than 1.9% carbon, though typically it contains 3 to 4% carbon. It can contain other elements such as silicon and phosphorus. The carbon can be present as graphite flakes (grey cast iron), iron carbide (white cast iron) or both (mottled cast iron). Historical cast iron is a brittle material. The non-malleable nature of the metal means that it cannot be hot or cold worked.

2) Wrought iron.
The term wrought iron often causes uncertainty as it can refer to iron produced by a number of different processes. It can be produced by either the traditional bloomery process, or by decarburising cast iron. The two most commonly used decarburisation processes were the finery, used in the UK from the last years of the 15th century, and from 1780 the puddling process. It is not possible at present to determine from the sample which method was used to produce it. Wrought iron tends to have a low carbon content and may contain phosphorus in sufficient quantities to slightly harden the metal. It is generally quite heterogenous, characteristically containing slag (iron silicate) inclusions. These inclusions are often elongated, showing the direction of hot working. In the period under consideration, this would have been undertaken in a rolling mill.

3) Mild steel.
This term describes an iron alloy with small amounts of carbon. Mild steel is a mixture of ferrite and pearlite. Ferrite is the name given in metallography to pure iron. Pearlite is a eutectoid mixture of ferrite and cementite, cementite being a compound of iron and carbon with the chemical formula Fe_3C (Rollason, 1973). Mild steel contains less than 1% of slag inclusions, because it has been produced as a liquid and large iron silicate stringers have not formed. Instead there may be small manganese sulphide inclusions. It is malleable and can be hot worked. Mild steel was produced by the Bessemer process, which was patented in 1856, and slightly later by the open hearth process. These produced "bulk steels" which were often used as a cheaper substitute for wrought iron in later periods.

Another two types of metal were identified in the samples from the gates. These are far less typical historically than the three above.

4) "Bulk iron"
This is a material comprising of pure ferrite with manganese sulphide inclusions. It seems to have been manufactured in a similar way to mild steel, but no carbon is present in the material. This would make it softer and easier to work than mild steel and would make it a good substitute for wrought iron in intricate metalwork such as repoussé work.

5) "Puddled steel"
This metal contains iron silicate inclusions similar to the inclusions found in wrought iron. However, unlike wrought iron it contains a surprisingly high amount of carbon. It may be the product of a puddling or fining process which was stopped early, so some carbon remains in the iron. From the sample it is not clear whether this was a deliberate or unintentional action, although the production of "puddled steel" is well documented in the mid 19th century (Parry, 1863).

Individual sample details

Cast iron

980033- RH pedestrian gate, front elevation
This contains carbon, present as graphite flakes. This is indicative of a grey cast iron. The sample also contains 1% inclusions, which are mostly manganese sulphide with traces of titanium, vanadium, silicon, potassium and aluminum.

Wrought irons

980022- group 3 decoration
The unetched structure shows 7% of inclusions in the sample. These are mainly single and dual phase slag, either elongated or with a cubic shape. Some corrosion surrounds the inclusions. They follow parallel lines in the sample.
The etched structure shows iron carbide occasionally at the grain boundaries, and 2% of pearlite.

980024- group 2 decoration
The unetched structure shows about 5% inclusions in the metal. They are concentrated mainly on one side of the sample, in parallel lines. The majority of the inclusions are single phase slag, with very occasional dual phase slag, and "spots" of corrosion.
The etched structure shows phosphorus ghosting over 2% of the sample. Acicular inclusions follow secondary grain boundaries. These could be either carbide or nitride "needles".

980028- RH pedestrian gate, finger like decoration
The unetched structure shows 5% of well defined dual phase slag inclusions. The slag appears as both small spheroidal and elongated inclusions. All the slag seems to be following parallel lines. The etched structure shows large ferrite grains.

980029- left side screen, finger like decoration
The unetched structure shows 5% of dual phase slag inclusions in parallel lines. The slag is mostly elongated but there are also some small spheroidal inclusions.
The etched structure shows large ferrite grains, with possibly some agglomerated iron carbide.

980031- LH under stretcher bar
The unetched structure shows 5% of dual phase slag inclusions and some very occasional manganese sulphide inclusions. Some "spots" of corrosion were also present.
The etched structure shows 2-3% of pearlite between the large ferrite grains.

980032- RH pedestrian gate, cresting
The unetched structure shows 3% of dual phase slag inclusions. They are both elongated and spheroidal, with some corrosion around them. The etched structure shows large uniform ferrite grains.

980035- LH main gate
The unetched structure shows 1% of three phase-slag inclusions concentrated in two clusters around the edge of the sample.
The etched structure shows that in the centre of the sample there is a large area of phosphorus ghosting, which covers 40% of the whole sample.

980036- LH main gate, across weld
A sample was taken across one of the welds on the left hand main gate. Unfortunately the sample broke in two whilst being removed. The sample therefore does not show the weld itself, but the surrounding metal. The unetched structure shows 5% of dual phase slag inclusions running in lines. The etched structure shows large regular ferrite grains.

980037- Pier F
The unetched structure shows 3% of dual phase slag inclusions, with some corrosion following the lines of the slag. The etched structure shows large ferrite grains.

Mild steels

980023- group 1 decoration
The unetched structure shows that this sample contains very little slag, less than about 0.5% manganese sulphide inclusions. There is some corrosion around the edges of the sample.
The etched structure shows 2-3% pearlite between the ferrite grains.

980026- group 5 decoration
The unetched structure shows around 1% of small manganese sulphide stringers in parallel lines. This suggests some sort of hot rolling. The etched structure shows around 5-7 % pearlite in the ferrite grains, and very occasional carbide at the grain boundaries.

980027- group 6 decoration
The unetched structure shows tiny spheroidal manganese sulphide inclusions. These make up about 1% of the sample. There is also some corrosion.
The etched structure shows grains getting larger towards the edge of the sample. There is possibly some carbide present, and around 1% of pearlite.

"Bulk irons"

980025- group 7 decoration
The unetched structure shows completely pure iron, apart from about 1% of spheroidal manganese sulphide inclusions. The etched structure reveals pure ferrite, with variable grain size, at the centre of the sample, and uniform and elongated grains at the edge of the sample.

980030- group 4 decoration
The unetched structure shows extremely small spheroidal manganese sulphide inclusions, which cover less than 0.5% of the sample. The etched structure shows pure ferrite in large grains.

"Puddled steel"

980034- end of stretcher
The unetched structure shows 1% of mostly single phase slag inclusions, but a small amount is dual phase. The etched structure shows some variability as banding. One band contains 70% pearlite, another 30% pearlite. There is also some cementite at some of the grain boundaries.

Conclusions

These results show a variety of metals have been used in the construction of the gates. It was hoped that these could indicate additions to the original gates, by looking at the date of the introduction of the technique used to produce each metal. Unfortunately conclusions are limited by the long use of cast iron and the difficulty of distinguishing the production processes of wrought iron. Thus distinguishing between the original (18th century) gate and 19th century changes will be difficult. However the mixture of wrought iron, mild steel and bulk iron used to make the repoussé decoration does show that much of this has been replaced, probably later than 1863.

The wrought iron components of the gates could easily be original features, though production of wrought iron did not finish in the UK until 1973. Therefore it is possible that even the most recent known repairs could have used wrought iron. If it was replaced it is more likely that it was parts of the decoration and repoussé work, rather than the actual frame work of the gates, as no major overhaul or replacement of an entire gate has ever been reported.
Historically, the side gates are thought to date from around 1863. The examination of the samples gives no reason not to accept this evidence, though cast iron was manufactured throughout this period. Although the frame work of the side gates was not sampled, visually and stylistically there are no grounds to believe that they are not cast iron.
The mild steel could be from the renovations associated with the move from Redcombe to Elmore Court. The Bessemer process was patented in 1856, and it is possible that it could have been used in 1863 to produce certain features, but such early use of an innovative and not particularly suitable material is thought to be unlikely. The material is therefore more likely to date later than this. Production of puddled steel was documented in the mid-19th

century. So if it is not original it is very likely that it was made at the time of the move to Elmore Court, and very unlikely to be as late as the 1962 renovations.
Finally the bulk iron is most likely a modern material that was used because it is ideal for producing intricate metalwork, such as the repoussé work on the gates. So this may also date from the 1962 renovations and almost certainly not as early as the 1863 move.

References

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Root J., (1995), *The Elmore Gates*, English Heritage - unpublished report

Rollason, E.C. (1973), "Metallurgy for Engineers" (4th edition), Edward Arnold, London.