ABSTRACT: For their best quality steel, Sheffield cementation steelmakers preferred iron from a small number of finery forges in Sweden and were prepared to pay a premium price for it. This study aimed to determine whether there was a scientific explanation for the steelmakers' preference. The abundance and composition of slag inclusions from 10 samples of premium and common grades of Swedish wrought iron and 10 samples of blister steel made from both grades of iron were compared. The samples were analysed using optical and electron microscopy, SEM-EDS, quantitative metallography and, where possible, bulk chemical analysis. Analysis found that premium brands of wrought iron had a lower volume of slag inclusions and a higher proportion of wustite within the inclusions. These characteristics meant that the premium brands of wrought iron would give a 'cleaner' blister steel. The results suggest that Sheffield cementation steelmakers had a valid reason for paying more for premium brands.

Introduction
The main aim of this study has been to determine whether there was a scientific explanation for Sheffield steelmakers' preferences, or whether their choices were based on conservatism. The approach taken has been to investigate the abundance and composition of slag inclusions in Swedish wrought iron to see if any differences exist between the cheap and expensive brands, and to see if these differences are reflected in the blister steel. The study was not intended as a characterisation of finery iron or blister steel, and focused on areas of difference rather than of similarity.

The choice of samples for analysis was dictated largely by the availability of the material. Although archaeologically the metal is relatively young, it is already rare. Bars of Swedish wrought iron and blister steel can be regarded as material in an intermediate stage of production. The Swedish wrought iron bars were brought to Sheffield specifically for conversion into blister steel. The blister steel bars would then have been reheated and worked into finished products, or broken into small pieces to be melted down to make crucible steel. Both the wrought iron and steel were relatively expensive and it seems unlikely that large numbers of bars would have been left lying around, even after the advent of new technologies or the closure of works. This may explain why it is very unusual to find wrought iron or blister steel bars in their original state, and why recent excavations of cementation and crucible steelmaking sites in Sheffield have found little in the way of wrought-iron or blister-steel bars.

The cementation process
In the cementation process, bars of wrought iron were packed in layers interspersed with charcoal in large refractory chests. The chests were then sealed, and heated for several days at around 1100°C. With the gradual heating and cooling of the furnace, a typical firing or 'campaign' would take up to four weeks to complete. During the process, the bars stayed in a solid state and would slowly absorb carbon by diffusion from the surrounding charcoal. Because of the way carbon diffuses during cementation, the carbon content of blister steel generally decreased towards the centre of the bars. The traditional term used to describe this low-carbon region was 'sap'. The degree of carburization was controlled by the time and temperature of the firing. During cementation, the reducing atmosphere caused the oxide component of the slag inclusions within the bars to react with carbon, forming carbon monoxide. The pressure of