

Appendix I

A Guide to the Metallurgy of the Edge Tools at the Davistown Museum Art of the Edge Tool

An Exhibition Opened in June 2007

The following steel- and toolmaking strategies and techniques were used for the forging of the edge tools included in The Davistown Museum's Exhibition *Art of the Edge Tool*.

I. Steelmaking Strategies 1900 BC – 1930 AD

1. Natural Steel: 1900 BC – 1930 AD

Natural steel was made in direct process bloomeries, either deliberately or accidentally, in the form of occasional nodules of steel (+/- 0.5% carbon content (cc)) entrained in wrought iron lumps. Natural steel was deliberately made by bloomsmiths for sword cutlers by altering the fuel to ore ratio in the smelting process, producing heterogeneous blooms of malleable iron (0.08 to 0.2% cc) and/or natural steel (0.2 to 0.5 cc and higher) or by carburizing bar or sheet iron submerged in a charcoal fire. Manganese-laced rock ores (e.g. from Styria in Austria or from the Weald in Sussex, England) facilitated natural steel production. As a slag constituent, manganese lowered the melting temperature of slag, facilitating the more uniform uptake of carbon in the smelted iron. The first documented production of natural steel occurred at the height of the Bronze Age in 1900 BC, by the Chalybeians, using the self-fluxing iron sands from the south shores of the Black Sea. Occasional production of bloomery-derived natural steel edge tools continued in isolated rural areas of Europe and North America into the early 20th century.

2. German Steel: 1350 - 1900

German steel was produced by decarburizing blast-furnace-derived cast iron in a finery furnace, and, after 1835, in a puddling furnace. German steel tools are often molded, forged, or cast entirely of steel, as exemplified by trade and felling axes without an inserted (welded) steel bit. Such tools were a precursor of modern cast steel axes and rolled cast steel timber framing tools. German steel shared the world market for steel with English blister and crucible steel until the mid-19th century.

3. Blister Steel: 1650 - 1900

Blister steel was produced by carburizing wrought iron bar stock in a sandstone cementation furnace that protected the ore from contact with burning fuel. It was often refined by piling, hammering, and re forging into higher quality shear or double shear steel or broken up and remelted in crucibles to make cast steel. Blister steel was often used for "steeling" (welding on a steel cutting edge or bit) on axes and other edge tools.

4. **Shear Steel: 1700 - 1900**

Shear steel was made from refined, reformed blister steel and was used for “steeling” high quality edge tools, such as broad axes, adzes, and chisels, especially by American edge toolmakers who did not have access to, or did not want to purchase, expensive imported English cast steel. The use of shear steel was an alternative to imported English cast steel for making edge tools in America from the late 18th century to the mid-19th century.

5. **Crucible Cast Steel: 1750 - 1930**

Crucible cast steel is made from broken up pieces of blister steel bar stock, which were inserted into clay crucibles with small quantities of carboniferous materials (e.g. charcoal powder). After melting at high temperatures, crucible cast steel was produced in 5 to 25 kg batches and was considered the best steel available for edge tool, knife, razor, and watch spring production. Due to lack of heat resistant clay crucibles, extensive production of high quality crucible cast steel didn't begin in the United States until after the Civil War.

6. **Brescian Steel: 1350 - 1900?**

Brescian Steel was a common Renaissance era strategy for making steel in southern Europe for the condottiers of the Italian city states for example. Wrought or malleable iron bar stock was submerged and, thus, carburized in a bath of molten pig iron. Brescian steel cannot be visually differentiated from German steel or puddled steel, both of which were produced from decarburizing pig iron.

7. **Bulk Processed Steel: 1870 f.**

After the American Civil War, a number of new strategies were invented for producing large quantities of steel, especially low carbon steel, required by the rapid growth of the industrial age and its factory system of mass production. The first important innovation was Henry Bessemer's single step hot air blast process, followed by several variations of the Siemens-Martin open-hearth furnace and electric arc furnaces. For edge tool production, the electric arc furnace supplanted, and then replaced, crucible cast steel in the early decades of the 20th century. A few modern drop-forged edge tools are included in this exhibition as examples of modern bulk process steel producing strategies.

For more information on these later techniques, including the drop-forging of the all cast steel ax, see:

Davistown Museum Hand Tools in History series Volume 11: *Handbook for Ironmongers: A Glossary of Ferrous Metallurgy Terms: A Voyage through the Labyrinth of Steel- and Toolmaking Strategies and Techniques 2000 BC to 1950*

This publication is available for hands-on perusal by museum visitors.

Also see the exhibition handout: **Edge Toolmaking Techniques**