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Some comments on various topics about Japanese Swords. Part 2: International trade with Japan before the end of the 19th century

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Introduction: In a previous article **Coutinho (2009)** the hypothesis that *Hizen* swords were made with *wootz* steel was discussed. This hypothesis provoked some questions that were partly discussed in another article **Coutinho (2011)**. The aim of this article is to continue answering some questions raised by one of the participants, Eric Hugelshoffer, in the following on-line threads in Nihontomessageboard. Here are the URLs:

<http://www.militaria.co.za/nmb/viewtopic.php?f=9&t=8526&st=0&sk=t&sd=a&start=5>

<http://www.nihontomessageboard.com/nmb/viewtopic.php?f=1&t=8325&st=0&sk=t&sd=a&sid=300c2342969f5b9074181c00a5bad0a3>

Eric asked:

"Assuming the Portuguese transported *wootz* in large quantities why is nothing seen of this miraculous steel in Swords, Sabers [and] épées made by Europeans? Toledo, for example, has a famous reputation. "

He goes on to conclude that:

"Damascus steel, *wootz* from India, was exclusively used in India and the Orient (Persia, Turkey, etc.) and hence never in Japan."

This article will try to answer the above questions including:

"...why nothing is seen of this miraculous steel in Swords, Sabers [and] épées made by Europeans?"

Before continuing to answer the questions posed by Eric Hugelshoffer, let's respond to a request by Carlo Giuseppe Tachini, the clarification of the use of the term *wootz* steel as used in this article. According to Oleg D. Sherby and Jeffrey Wadsworth of Stanford University, a piece of steel with a high (more than between 1% and 1.4% of carbon) should be classified as *wootz*. If properly forged, this steel will show the surface marks associated with *wootz*. This however is not generally accepted. See **Coutinho (2008 b)** and **Wadsworth (2001)**.

Why was *wootz* not exported to Europe?

The above is not strictly true. As will be shown below, some medieval swords were made of high carbon steel – probably *wootz* steel. What may seem mysterious is the fact that the use of this steel was discontinued much before the 16th century because it is true that, as mentioned by Eric Hugelshoffer, there is no mention of *wootz* steel in swords made in Spain (Toledo) or in the known manufacturers of swords in Italy (Brescia, Milan) or German (Passau, Solingen) made from the beginning of the 16th century onwards.

Much before the 16th century (9th and 10th centuries) swords called "**Ulfberht**" were reputedly made with crucible steel. The swords are called "**Ulfberht**" because they have this name inscribed in them. There are about 100 swords with this inscription, and 40 of them were examined by Alan Williams (**Williams (1987)** and **Williams (2000)**).

From (**Williams (2009)** page 143 we learn that:

"The original maker of "**Ulfberht**" was evidently a craftsman (or perhaps a craftsman/merchant) who had access to a source of high carbon steel. This may well have been ingots of crucible steel imported from the Middle East via the River Volga. In which case, his location was probably in the Baltic area, where this trade route terminated, and where most of these swords have been found."

The **Ulfberht** swords were made for 300 years so that **Ulfberht** is probably a name of a family or the name of a trademark of some sort (**Williams (2009)** page 124)

Here is a brief account of the history of how swords were manufactured in Europe until the 16th century. Refer to a previous article in this series (**Coutinho 2011**) and also to another article by Alan Williams (**Williams (1977)**); more details of the evolution of the European steel making and of the European swords are given in Appendix A and in Appendix B, respectively.

From (**Williams (1977)**):

"During the Dark Ages in Europe, the manufacture of the swords by the pattern welded method flourished....They were probably made by twisting together thin strips of iron followed by folding and forging in various ways. The advantages of pattern-welding were twofold. First, since a homogeneous bar of controlled carbon content could not be produced (perhaps as a consequence of very small hearths), the forging of small carburized and uncarburized iron was the only way of making a steel – like material of more controlled or less controlled properties. Second, it produced a much sought-after decorative effect. Yet others were made by forging

out cakes of high carbon steel, probably Indian "wootz" imported by the Vikings via Persia."

These **Ulfberht** swords are not pattern welded, have a very high carbon content, and are probably the best among the Viking swords. In fact **Ulfberht** swords were so good that they were faked. According to Williams (see <http://www.vikingrune.com/2009/01/viking-swords-ulfberht-fakes/>) European museums have many faked **Ulfberht** swords in their collections.

More details about the trade in steel between Europe and the orient, according to Williams, can be found in "The trade in steel from the orient is described in Zeki Validi, A ' Die Schwerter der germanen nach arabischen Berichten des 9-11 Jh ', Z, *Deutschlands Morgenlands-gesellschaft* (1936) 90, 19 ".

With the development of larger shaft furnaces, larger pieces of iron could be made, and pattern-welded blades went out of use around the 10th /11th centuries.

According to Williams (**Williams (1977)**):

"from the 16th century onwards, some swords blades are made by entirely different methods, which reflect contemporary methods of hardening armour." (See appendix A and B).

In fact, according to **Wells (1962)**, the use of mono-steel blades and special tempering techniques makes the European blades of this period more flexible and therefore less prone to break against armor when trusting. (See appendix B)

It is therefore likely that in the Middle Ages *wootz* steel was imported through Persia and swords manufactured with this steel were made in Europe. In fact, Williams states that (**Williams (2009)** page 143): "The Persian trade in crucible steel..., but the question remains - was any of this exported to Europe? " [After an analysis of the steel of the **Ulfberht** sword Williams concluded that]

"... this seems to be the first evidence that this might be the case. Indeed there was a well-established trade route from the Baltic to Persia via the Volga exploited by the Vikings in the 9th-10th centuries, during the period of their manufacture [of the swords **Ulfberht**]. After the fall of the Samanids, and the rise of various Russian principalities, the use of this trade route by the Vikings declined. It is notable that, at this time, the manufacture of these **Ulfberht** swords apparently ceases, presumably because raw material was no longer available."

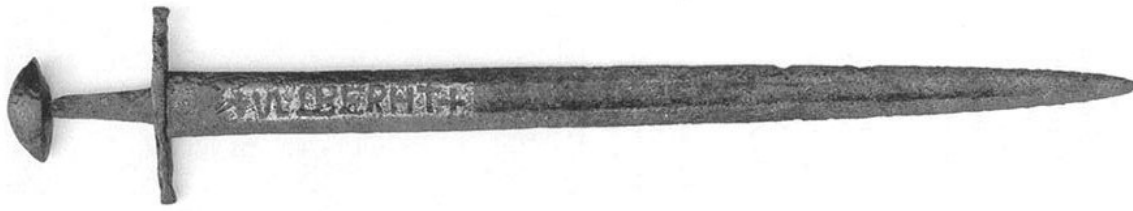


Figure 1 An Ulfberht sword.

It may be concluded, therefore, that *wootz* was not exported to Europe in the 16th century for political reasons. With the ascension of the Ottoman Turks and the fall of Constantinople, the trade with the Far East (and India) became very difficult and in fact this was the reason for the first European expeditions around Africa to reach the Far East. The difficulty in forging *wootz* steel was discussed at length in previous articles namely, (Coutinho (2008 a), Coutinho (2008 b) and Coutinho (2008 c)). A well-established fact is that forging *wootz* steel at temperatures below 650 °C results in cracking (Sherby (1983)). Forging it at temperatures above 850 °C causes it to "crumble under the hammer" (Sherby (1985)). The Europeans (at least not the ones that forged the **Ulfberht** swords) forged their swords at very high temperature and could not adapt to the *wootz*. In any case, the Europeans, at this stage, opted to have their swords made from a homogeneous material and for them their steel was perfectly fine. This was not always so. The European swords from before the 1200s, as explained above, were pattern-welded, very much like the Japanese swords except that the Japanese steel was much more finely forged. (Coutinho (2008 c).) Some of these mediaeval swords were made like the Japanese with a core of iron and an outer skin of steel. (See appendix B.)

International trade with Japan before the end of the 19th century

From the Japanese perspective in the 16th century, trade was carried out with "foreign" entities and companies rather than representatives of specific countries such as Portugal or France. In fact, the crew employed were often comprised of a mix of Portuguese, Dutch, English (and other) sailors. As a result, the Japanese, at first, did not distinguish between the individual countries of Western Europe. As a group, the companies formed in these countries often tried to exploit the commercial opportunities offered by the East. They had better ships and canon as compared to the Chinese or Japanese. This put them at an advantage.

The Portuguese arrived in Japan in 1543. They started trading with Japan almost immediately and offered a great diversity of products from China (but mainly silk), Indonesia, Philippines, etc., that were traded for silver and other things. In the beginning, the center of trade was Macau. It became one of the richest cities in the world. Other cities such as Batavia (Jakarta) were one of them. The point was to circulate merchandise in the

East and send the profit back to Europe. The profits were in the form of gold, silver and spices; spices could be easily sold in Europe. As part of this commerce steel (in the form of crucible steel) was one of the things obtained in India and sold to Japan.

The richness of this trade should not be underestimated. The city of *Nagasaki* was just a small fishing village until it was determined that it offered an excellent harbor. For a brief period after 1580 it was a Jesuit colony under their administrative and military control until it became a thriving city. Figure 2 illustrates a group of Europeans selling wild animals to Japanese. Note that the Japanese are armed with European swords, probably sword-rapiers (see **Coutinho (2011)**).



Figure 2

The king of Spain, Philip II was crowned *Philip I* of Portugal in 1581 as a result, previous connections between Japan and Portugal expanded so that the Spanish started to trade with Japan and send missionaries (mainly Franciscans) to Japan.

The Dutch (or rather the Dutch East India Company or in Dutch the *Vereenigde Oost-Indische Compagnie*, VOC) arrived in Japan around 1600 and soon established themselves in *Hirado*. In 1613 England opened a trading factory also in *Hirado*. Further information about this period of history of Japan is available through the books of **Boxer (1993)** and **Coates (1978)**. Along with the wealth generated by these connections came serious conflicts. Fights among Portuguese, Dutch, Spanish and English companies (any two or more of them fighting against each other) and increased intolerance against the Christian religion caused foreigners to be less and less tolerated in Japan. The Portuguese were forced to go to a small artificial island (*Deshima*) from which they were finally expelled and replaced by the Dutch.

After 1641, the trade with Japan was a monopoly of the Dutch East India Company at *Deshima*. An examination of the items traded back and forth in this exchange raises an important question regarding the demand and export of Japanese swords to Europe. The scarcity of Japanese swords exported to Europe during the late part of the 16th century is striking. Only four swords which were sent from Japan to Europe between the end of the 16th and the beginning of the 17th centuries are documented. Two of them were given to the king of England (**Bottomley (2004)**) the third belonged to the Dutch painter Rembrandt van Rijn (**Brujin (1999)**) and the fourth reputedly belonged, to Francis Drake (**Bottomley (1996)** page 140).

According to Max de Bruijn and Bas Kist ((**Brujin (1999)**):

"Since the late 16th century, Japan had developed an intensive weapons trade, first with the Portuguese, later with the English and the Dutch. The Japanese were mainly interested in firearms. On the other hand, Europeans purchased Japanese weapons primarily as curiosities."

According to Bashford (**Bashford (1916)** page 6):

"Swords appear to be rarely imported, their shape being unsuited for Japanese use, nor was their material desirable --the native blades have never been surpassed."

It is generally accepted that Japanese swords are superior to European swords; thus it is difficult to understand why Japanese swords were not exported to Europe in great quantities.

In order to understand why the Japanese sword was not in demand in Europe, it is necessary to keep in mind that at the end of the 16th century the sword was used primarily for fencing in Europe, in duels rather than in battle. The reason for this, advanced by Egerton Castle (**Castle (2003)**), is that **fencing** could be only developed after the development of firearms that made complete body armor useless.. In these circumstances, as described by Egerton Castle (**Castle (2003)**), **fencing** was developed first in Europe. By the end of the 16th century, the Japanese sword (*Sue Koto* swords) was not well suited for fencing in the European style: *Sue Koto* swords are design for slashing and European duels needed a thrusting sword. The art of fencing was developed as a ritualized martial art, in which two individuals engaged under very prescribed and regulated conditions (**Baldik (1995)**). For example, the two duelers were required to be armed with exactly similar weapons. Here is a description (**Rogers (1991)**) how duels and revenge were in Japan and how different they were from the corresponding duels in Europe.

"Unlike the seventeenth and eighteenth century duels in Europe where both combatants were typically armed with the same weapons so neither had an unfair advantage, participants in duels in Japan were allowed to employ the weapons of their choice.....In medieval Europe the Marshal of the lists took the utmost care in contests to ensure that weapons of both fighters were exactly the same."

A European armed with a Japanese sword could not use it in a duel unless he had an exactly similar sword to offer to his opponent; this would be extremely unlikely. Without this outlet, the Japanese sword has very little commercial value.

Shinto swords developed after the *Kanei* era (1624-1644) (**Nakahara (2010)**) were more suited for **fencing** in the European style and in Japan schools of fencing (in Japanese style) developed widely after the *Kanei* era. At this time, however, export of weapons from Japan was prohibited (**Kaempfer (1773)**) and Japanese swords could no longer be exported. According to (**Kaempfer (1773)** page 264), it was illegal to export:

"All kinds of swords, hangers and other weapons made in Japan, in imitation of those, brought by the Dutch."

Even so some European armor was exported to Japan. The Japanese armor influenced by the Europeans is called *nanban gusoku* (**Robinson (1954)**). According to Russell Robinson:

"...Western cuirass and helmets were always held in high esteem up to the last days of the SAMURAI "

"The true *nanban gosoku* first appear in the last years of the 16th century. These "Southern Barbarian Armours" might appear typical Japanese armours to the uninitiated, but on closer examination, certain alien features would become apparent. The helmet usually has as foundations a Spanish morion of the type commonly called cabasset. (See **Figure 3**.) To this the Japanese added a neckguard (*shikoro*) and a brown plate below the rim of the morion."

"The cuirass is of the long peascod of the 1580s (see **Figure 3**) and to this the Japanese gave the name of *nanban-do*. Metal shoulder straps (*watagami*) replaced the leather straps and buckles and the Japanese tassets (*kusazuri*) were attached to the flange at the base of the breast and back plates."

"Tokugawa Iyeyasu (1st Tokugawa Shogun, 1546-1616) was one such commander who himself wore one of these *nanban gosoku* at the bloody battle of *Sekigahara* (October 1600), one of the greatest battles of Japanese history. This armour [**Figure 4**] is preserved at the Tosyo-gu Shrine, Nikko, and illustrates an irregularity of which no contemporary European soldier would have approved. Only the main back and front plates of the gorget, (see **Figure 3**) probably supplied with the cuirass, were used and these were worn outside, instead of underneath to support the weight of the armour....."

"The Dutch traders exported quantities of obsolete [for the Europeans] armour to Japan throughout the 17th century. Some complete arms were sent but no trace of the pauldrons, vanbraces, graves, etc. [see **Figure 3**] ever having been used was found. Only morions and cuirass were adapted to Japanese fashion the other pieces appear to have been cut for making into plates of native fashion and in some cases etched and gilded pieces were used to decorate *tobacco-bon* (tobacco bags)".

"Long after the Dutch merchants had ceased to ship obsolete armour to Japan it remained in high favour amongst the samurai and this must have been apparent to the traders in *Deshima* for in the early 18th century as the Dutch traders once again brought armour to Japan from the West. This time it was the clumsy cuirass, surplus from the stores of the defeated Napoleonic cavalry. The breast plates were heavy and musket bullet proof and no doubt greatly impressed the Japanese. Once again the armourers got to work and almost completely transformed these mass products plates in objects of beauty. The surfaces were russeted with plum vinegar and then decorated with every theme of Japanese art in gold and silver overlay."

Figure 3 shows a complete European Armor to illustrate the modification for the Japanese armourers.

Robinson's opinion (**Robinson (1954)**) echoes Dean Bashford's (**Bashford (1915)**) much earlier contention that European armor was exported to Japan. Bashford (**Bashford (1915)** page 127) referring to the middle to late 16th century suggests:

"The Japanese were, au fond, just as enterprising then as they were today: in this particular matter we know that they appreciated the technical excellence of European Armor and were quite capable of changing their entire system of warfare had their Shoguns permitted it . They knew, for example, that the "foreign steel" (*nanban tetsu*) was better than the Japanese (for they liked to test it with musket-balls), just as they knew that foreign swords blades were inferior to their own. They adopted as much as the Western fashion as suited to their own needs. They bought eagerly European cabassets and morions and adapted them to their style transferring the plume-holder from the back of the cabasset to the front. They evidently appreciated the virtues of the European peascod corselet, which they called "pigeon-breasted" (*hato-mune*), for they used and copied it frequently (middle panoply, west wall)."

It is now known that the European armor was good because of the special hardening treatment it received as described in **Williams (2002)** and not because of *nanban* steel (in the sense used in this series) that were not used in it.

Also in (**Bashford (1917)**) (published in 1917 but written in 1906):

"Entire suits of armor were undoubtedly imported ...I have myself found in shops in various parts of Japan fragments of etched and gilded German armor, which have been broken up to form ornaments for tobacco boxes."

Bashford visited Japan at the beginning of the 20th century and so was in a privileged position to examine exports from Europe to Japan.

Opinions vary and not every author believes that European armor was superior to Japanese armor. In an excellent new book Trevor Absolon (**Absolon (2011)**) page 104) writes:

"initially, the limited number of imported pieces of *Nanban yoroi* could not keep pace with the huge demand amongst the samurai for these items. Thus, in a classical example of economic theory, enterprising Japanese armor makers rose to the occasion and began to create pieces that, though European in overall form, were much better suited to the eclectic needs of the Japanese warrior. These items were referred to as "*wasei nanban yoroi*" ("Japanese-made southern barbarians armour"), which clearly distinguish one from another."

"Being locally produced by native craftsman, made the *wasei* items cheaper, easier to obtain, and more appealing to the Japanese; as a result, the desire for imported articles of armor waned quite quickly. Eventually European-looking items were viewed with disdain by many as being inferior to Japanese armor."

The use of European armor by a person like *Tokugawa Ieyasu* in a battle of the magnitude of the battle of *Sekigahara* shows that European armor was trusted. This armor is illustrated in **Figure 4** and is now in the *Nikkō Tōshō-gū* shrine. *Tokugawa Ieyasu* who was "renowned by his frugality" (**Bottomley (1996)** page 137) had another European made armor illustrated in **Figure 5** adapted from (**Iwao 2009**). This armor is the *Kishu Toshogu Shrine* and was tested against bullets as can be seen from the two mosses in it. Furthermore it is also known that the prestige of European armor in fact continued until the 19th century. For example according to **Hurst (1981)**, page 81, in 1732 the *Shogun Yoshimune* received from the VOC two bullet proof armors that were eagerly ordered in 1723. In addition market forces do not perform well when there are laws interfering with the flux of merchandise. This was the case of Japan beginning mainly in the 17th century.

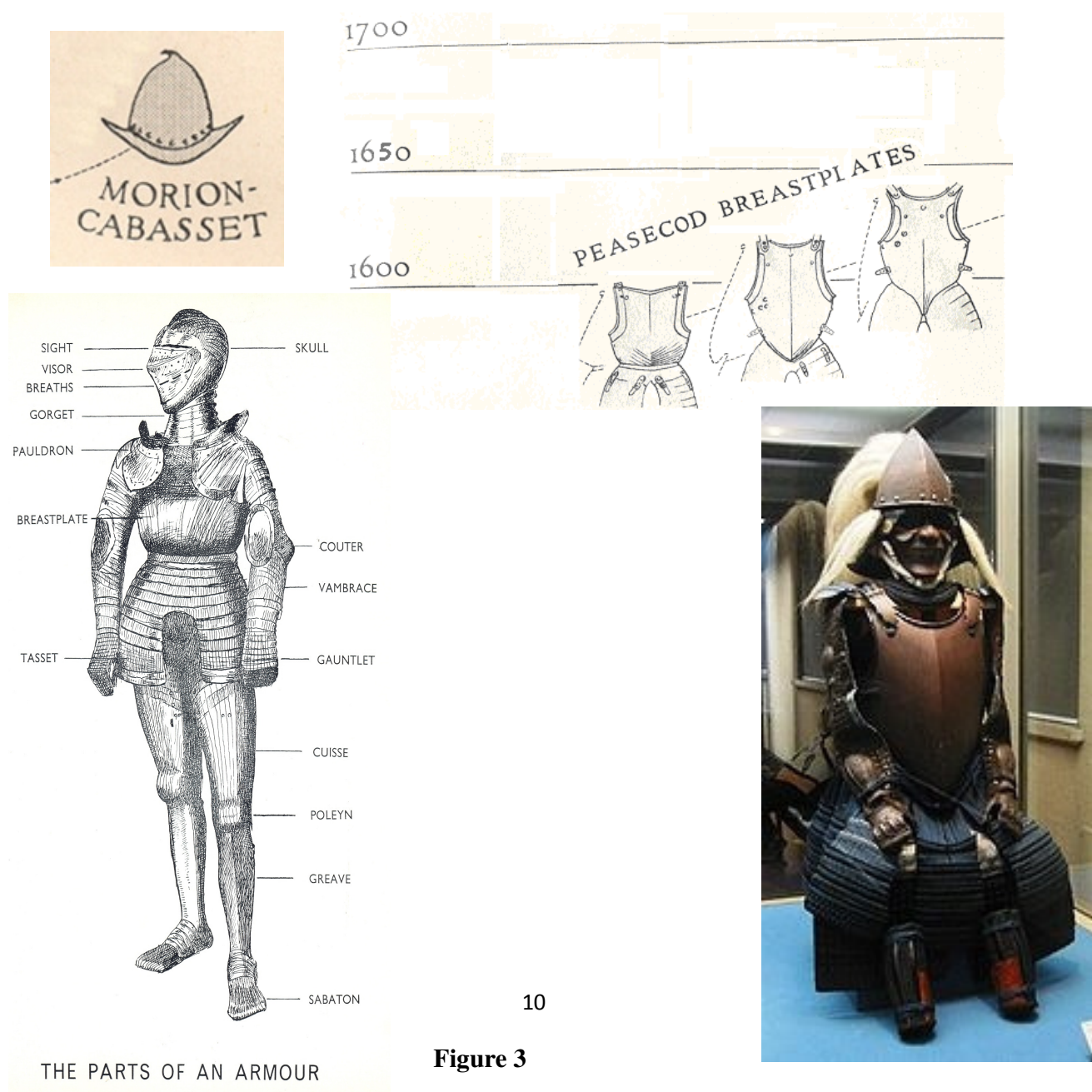




Figure 4



Figure 5

On the other hand many objects finished with lacquer enriched with gold were made in Japan and exported to Europe. Those objects included the hilt of small swords and until recently it was thought that they were made of *shakudo*. In fact they were finished with lacquer and are called *sawasa* (or *sawasu*) (**Bruijin (1999)**). A photograph of two hilts made in this style is shown in **Figure 6** (reproduced with permission by Bonham). The two pieces in **Figure 6** belonged to a well-known European collector of Japanese swords, Per T. Norheim (**T. Norheim (2010)** see also **Hartmann (2008)**). In **Figure 7** another four pieces which belong to London's Victoria and Albert Museum are illustrated. (From the books of **Hayward (1961)** and **North (1982)**, see **Figure 7** below.)



Figure 6.



Figure 7

There are many such pieces in Europe currently and some are on display in museums. The Metropolitan Museum has at least three such pieces that are illustrated in the book by Bashford (**Bashford (1929)**). In this book they are described erroneously as Pekinese hilts. The book by **Bruijin (1999)** has twenty-two more hilts, of incredible beauty illustrated.

Conclusions

Wootz steel was imported to Europe before the 16th century. It is found in Viking Ulfberht swords. Crucible steel was imported into Japan in the late 16th and early 17th centuries. Few Japanese swords were exported to Europe. These were considered curiosities rather than weapons for use in fencing. European armor was imported into Japan and modified for Japanese use.

Appendix A- A brief description of the development of metallurgy in Europe.

In a previous article, (**Coutinho 2011**) it was argued that up to 1200 C.E. the steel used in swords was made with bloom steel, that is, exactly the same as the *tamahagane* used to make Japanese swords. This was produced in **bloomeries** that were very similar to the *tatara* furnaces used in Japan.

The **bloomery** in Europe began to grow in size; also, the method of injecting air into it improved by the use of water-powered fans. Thus these two developments succeeded in increasing the temperature inside the **bloomery** and completing the fusion of iron (which had not been accomplished in the earlier **bloomery**). Accordingly, bigger pieces of high carbon steel became available to the armourers. As a consequence more carbon could be absorbed by the iron (carbon is more soluble in liquid iron and so it is more easily absorbed) and cast steel (pig steel) was produced. As mentioned in the previous article in this series (**Coutinho (2011)**) cast steel is almost useless to produce swords because it has such a high carbon content that is very brittle. There is a need to decarburize this steel. This was done in Europe in what is called a **finary**. In the **finary** cast steel was decarburized and very good steel resulted. The **bloomery** eventually developed into the **blast furnace** that produced almost only cast steel that therefore had to be decarburized. In summary the production of steel in Europe developed more quickly than in Japan.

The advantage of the big **bloomeries** in Europe was their capability of producing large pieces of steel economically. According to **Williams (2002)**, page 877, the weight of a medieval sword was about 1 kg to 1.5 kg. The weight of breastplates could reach 4.5 kg. The necessity of having large pieces of steel to make such large pieces explains why in Japan there were no single piece breastplates as in Europe. This explains why the European armor was considered better by many authors and so successful among the Japanese when introduced in the 16th century. The prestige of European armor in fact continued until the 19th century. For example, as mentioned above, according to **Hurst (1981)**, page 81, in 1732 the *Shogun Yoshimune* received from the VOC two Bullet proof armors that were eagerly ordered in 1723.

Appendix B - A brief comparison between medieval European swords and Japanese swords.

In a previous article, European swords from the 17th and 18th centuries were compared with Japanese swords (**Coutinho (2008 a)**). As mentioned above steel in medieval Europe was produced in a very similar way to the steel produced in Japan. (See **Coutinho (2011)** for a discussion of different opinions concerning the methods of steel production in Medieval Japan.)

Here are some similarities and differences between Japanese swords and European medieval swords.

1) European medieval swords were made of different kinds of steel; in particular they had an iron core. An analysis of such swords was made by (**Williams (1977)**) and is also described in (**Williams (2002)** page 12). Interestingly enough European swords made with a homogenous piece of steel are considered superior to the ones with an iron core and other

types of laminations. In fact Japanese swords are heat-treated in ways that make them much superior for slashing than European swords. This heat treatment is superior to the heat treatment of European swords. Some European swords have their edges hardened (they are usually double edged). Some Asian swords from the 18th to the 19th century are found with a fire-hardened edge; this hardening does not compare with the Japanese swords *yakiba*. For the effects of the heat treatment on the strength of the sword Japanese sword see **Weins (1992)**. For a criticism of the existence of an iron core in the case of thrusting swords see **Wells (1962)**). In the same reference it is argued that the best heat treatment for thrusting swords mono-steel swords is the one that gives the sword a much greater flexibility and therefore makes it less liable to break if the point of the thrusting sword meets armor. With respect to the use of mono steel blades it should be noted that some Japanese very old swords are assumed to be *maru gitae*. See for example **Yoshikawa (1987)** where a sword by *Ko-Bizen Masatsune* is described and "the characteristic *Ko-Bizen "maru-kitae"* is well exhibited."

2) European medieval swords (up to the 12th century) show *hada*. An interesting experiment was made by Maeder (**Maeder (2008)**) who took several old medieval swords to Japan where they were polished like Japanese swords. Not surprisingly the old swords show *hada*.

3) European swords were polished. It is difficult if not impossible to find old European swords in polished condition today. Blair (**Blair (1959)**) describes a sword found in a tomb in 1948 that belonged to King Sancho IV of Castile and Leon (1284-1295). According to Blair:

"The broad two-edged blade suffered somewhat from corrosion but in places it retains its original mirror-bright polish".

So the main differences between European Medieval swords and Japanese swords were the shape and the *yakiba*.

Acknowledgments

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Per T. Norheim (2010) The lots were sold in Sale 17944 on April 29 2010 at Knightsbridge lots 66 and 67.

[http://www.bonhams.com/cgi-](http://www.bonhams.com/cgi-bin/public.sh/WService=wslive_pub/pubweb/publicSite.r?sContinent=eur&screen=catalogue&iSaleNo=17944)

[bin/public.sh/WService=wslive_pub/pubweb/publicSite.r?sContinent=eur&screen=catalogue&iSaleNo=17944](http://www.bonhams.com/cgi-bin/public.sh/WService=wslive_pub/pubweb/publicSite.r?sContinent=eur&screen=catalogue&iSaleNo=17944)

Per T. Nordheim is mentioned in a recent article Newsletter (**Hartmann (2008)**) and one of his articles reprinted.

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According to another group of researches lead by Verhoeven (see **Verhoeven (2001)**) *wootz* markings is a consequence of high carbon content *plus* special impurities.

Wadsworth and Sherby contest this opinion by producing the *wootz* markings in their modern made high carbon steel presumably free of the impurities required by Verhoeven and his group. Here is how the authors finish their article. They show photographs of their product with *wootz* like markings and say "in the spirit of retaining blacksmiths secrets [12], the details of the modification to produce this aesthetically pleasant product will remain with the authors." In the authors' opinion, the issue is far from resolved but for simplicity Wadsworth- Sherby definition of *wootz* is being used.

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