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Part 3 - The *hada* of Japanese swords

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One problem and three solutions: The steel of the European, Indo-Persian and Japanese swords compared.

Part 3 - The *hada* of Japanese swords

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This year, the Brazilians, who are Japanese descendents living in Brazil, are commemorating the first centenary of the arrival of the first ship with 800 of them from Japan. This series of articles is dedicated to this group, who, although few in numbers, have made an enormous contribution to their adopted society.

The second article in this series, discussed the secret of how the Indo-Persian swordsmiths made tough swords with high carbon content. The secret is to break the **cemetite** network into **spheroidal** bands**.** Note that **cementite** which is mixed with **ferrite** forms **banite** when quenched. Japanese swordsmiths also work with steels with very high carbon content. Good Japanese swords are made of at least three kinds of steel.

Because of this, Jeffrey Wadsworth et al. [1, 2] classify the Japanese sword as a laminated welded product. However, in the usual laminated blades (old Merovigian swords and less old *krisses* from Indonesia), the different steels are forged together in layers, in the whole blade, to make it tough. Forging steels of different carbon content, as mere decoration, also produced other blades as in the case of famous 19th-century welded blades. In the case of Japanese swords, however, laminations are carefully (some would say scientifically) calculated to make the blade both incredibly tough and very sharp.

In fact, on the surface of a Japanese blade one can see only two or three types of steel: The steel of the *yakiba*, the steel of the *ji* and the steel of the *shinogi-ji*. Those steels are separated and the *hada*, mainly seen in the *ji* appears in a homogeneous surface of steel. Therefore one must conclude that the *hada* does not arise mainly as a result of welding steels of different content as it is in *krisses* and other welded *damascus* blades. (Exceptions to this will be discussed later.) Thus, the first important point is that *hada* is not the result of welding steels with different carbon content.

Figure 1 below illustrates the laminated nature of the Japanese sword. This was taken from an article by William Weiss and Peter Bleed [3].

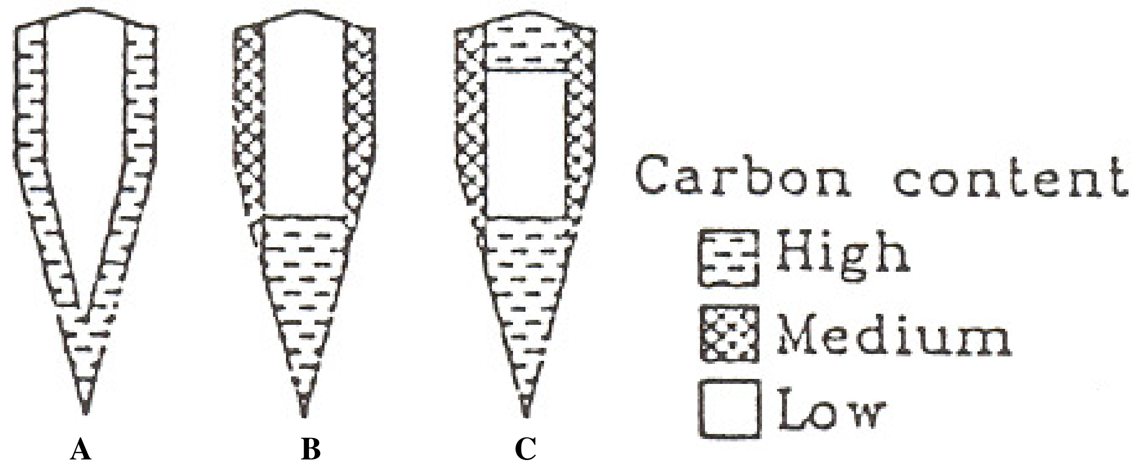

Figure 1

Figure 1 illustrates three different types of *kitae* (steel construction). Figure 1A shows the simplest construction (*kobuse*) since it has only an external jacket steel of high carbon content (*kawagane*) and an inner core with less carbon (*shingane*). Figure 1B shows a three-piece construction (*honsanmai*) while Figure 1C shows a four-piece *kitae* called *Shihozume Kitae* (See William Weiss and Peter Bleed [3])

In Figure 1, *hada* is seen where the steel on the sides of the blade, the *kawagane*, is found. This steel has medium carbon content or high carbon content. *Shingane*, core steel, when it shows through the *kawagane,* usually has a coarse texture. Generally it is folded fewer times than the *kawagane*.

This may raise the question as to whether *hada* is the same as *damask* seen in the Indo-Persian swords. Actually, *damask* is the result of different response to etching between **cemetite** (whitish zones) and **ferrite** (blackish zones). Japanese swords are not etched. If the forging of the Indo-Persian blade is very thorough, **cementite** and **ferrite** will be so thoroughly mixed that the *damask* will not appear and the blade will be of superior quality.

Japanese steel is very thoroughly forged. In this case, the **cemetite** and **ferrite** is very thoroughly mixed, which from a metallurgical point of view, is much better. However, in this case one cannot see the difference between **ferrite** and **cementite** which constitute the *damascus* in Indo-Persian swords. So one can conclude, that in the majority of cases, *hada* is not the same as *damask*. In fact the lines that constitute the *hada* are much thinner than the lines seen in the *wootz*. They are actually similar to ***mechanical damascus*** which may be made by punching holes and forging.

It is important to examine the exact nature of the *hada*. Leon Kapp [4, 5] describes in great detail the origin of *hada* which comes from both the oxide boundaries present in the original pieces of *tamahagane* and from further layers of oxide produced during the forging of the sword. The usual argument that we cannot see the layers resulting from folding the metal is false because every time a fold is made a new layer of oxide is formed. The layers of oxide formed when folding the steel ultimately results in the *hada* in Japanese swords. The last few layers make the greatest contribution to *hada* as they form the very outside of the blade.

The two basic types of *hada* depend on the surface of the billet being forged that is used to form the *ji.* These two basic forms are show in the Figure 2 below.

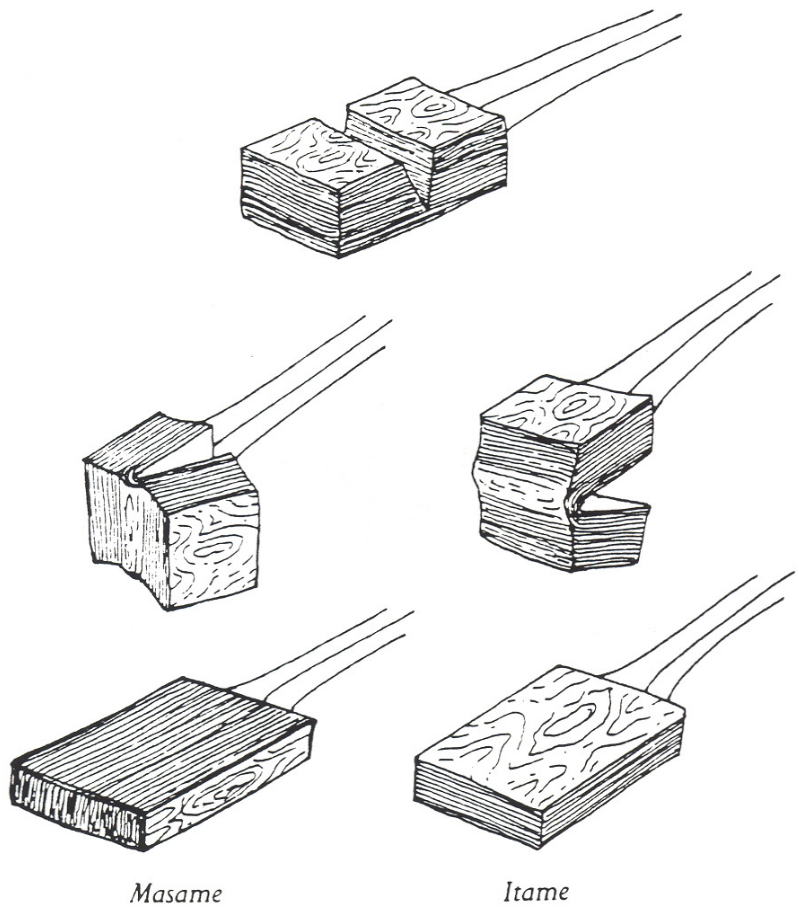

Figure 2

Figure 2 illustrates two forging procedures that give the two basic types of *hada: masame and itame* (Kapp [4]).

As pointed out in part two of this series, the temperature used for the forging should not be too high, lest a network of **cemetite** be formed in the cooling-down process, thus resulting in a brittle sword. The *hada* is prominent or subdued depending on the range of temperature used when forging the billet. According to Kapp, if the billet is forged by heating it until it is dull yellow and forged down until it is bright red, a *hada* (in this case *itame)* forms such as the one shown in Figure 3 below.

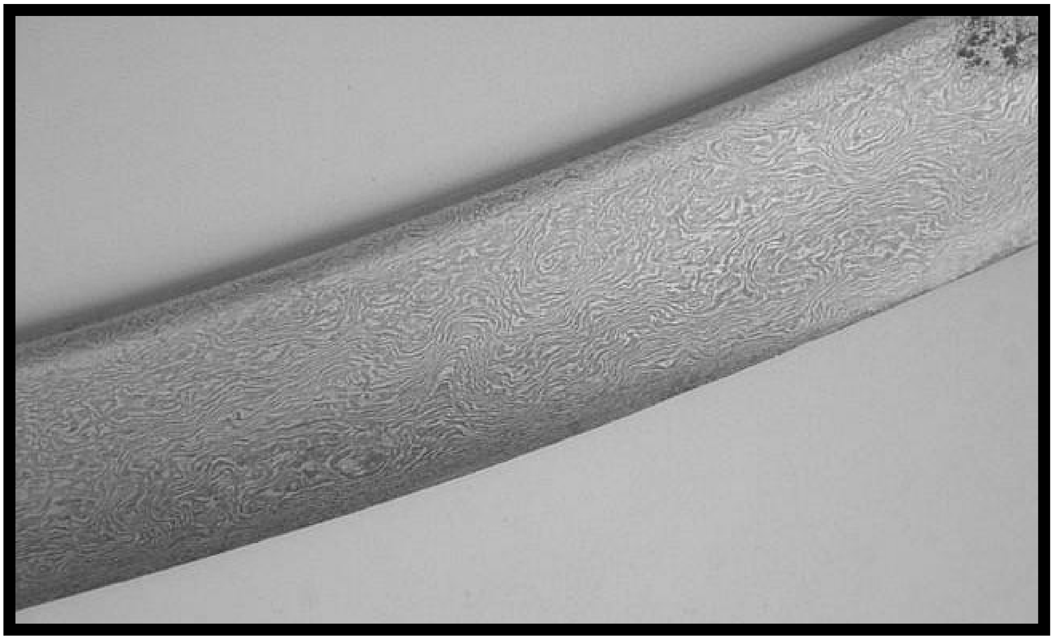

Figure 3 A

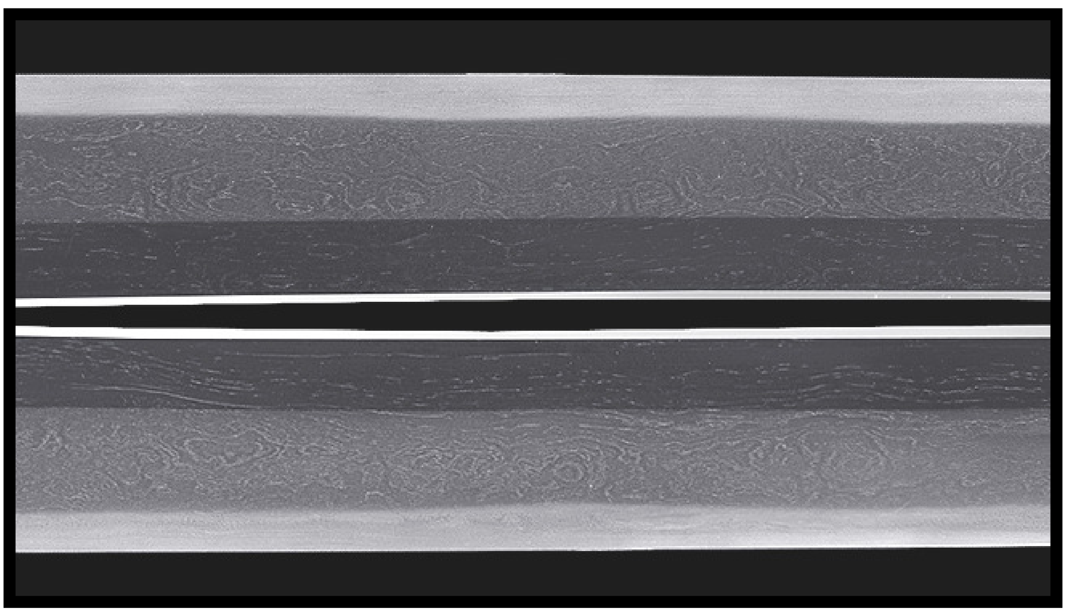

Figure 3 B

Figure 3

Figure 3 A illustrates an Indo-Persian blade with prominent *wootz* steel. This blade is signed Amale Mohamed Bikar (The work of Mohamed Bikar) and Sahebe Fazel Karim (The owner Fazel Karim)
Figure 3 B shows the *itame hada* of a blade by Kanemitsu (c.1500 C.E.)
The lines in the structure of the *wootz* are larger than in the well-forged steel of the Kanemitsu. The *hada* lines should be present in the Indo-Persian blades but one cannot notice them in the middle of the contrasting cemetite/pearlite pattern structure. The differences are more apparent in "person". The dark lines in the *wootz* are much darker than the Japanese steel and its white lines (of cementite) are wider and whiter than the thinner and grayish oxide lines (resulting from the forging) of the *hada.*

If however the billet is forged, heating the steel until it is bright yellow and then forged down until it is dull red, a pattern known as *ko-itame,* will result as shown in Figure 4 below. By varying the temperature range when forging the blade, the swordsmith can change the pattern of the *hada.* This is seen in some Shinshinto blades with *muji hada*.

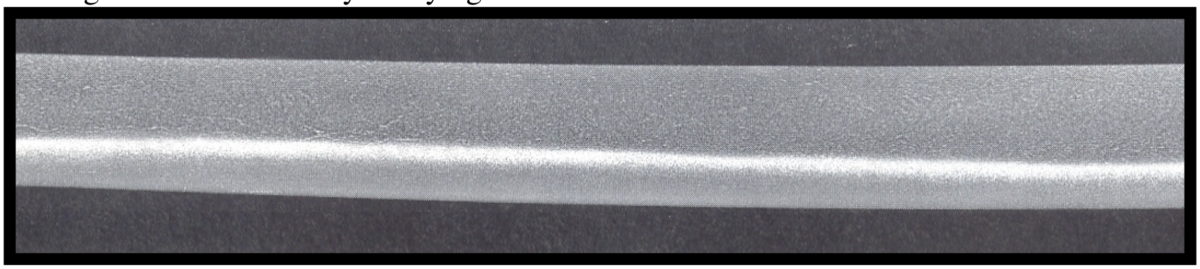

Figure 4

Figure 4 shows a tight *itame hada*.

The same can be said about the swords forged in such way that the resulting *hada* is *masame.* The Figure 5 below compares the *sham* in one Indo-Persian dagger with the typical *masame* of a Japanese sword.

Indo-Persian swords are forged in a manner similar to the Japanese sword. The contrast between **cemetite** (with the network broken) and **ferrite** in the Japanese swords can not be seen because the Japanese forge their steel very thoroughly. An Indo-Persian sword very thoroughly forged would not show the characteristic *damascus* pattern. One could see *hada* in an Indo-Persian blade that was thoroughly forged in the middle of the thick **ferrite-cementite** pattern if properly polished.

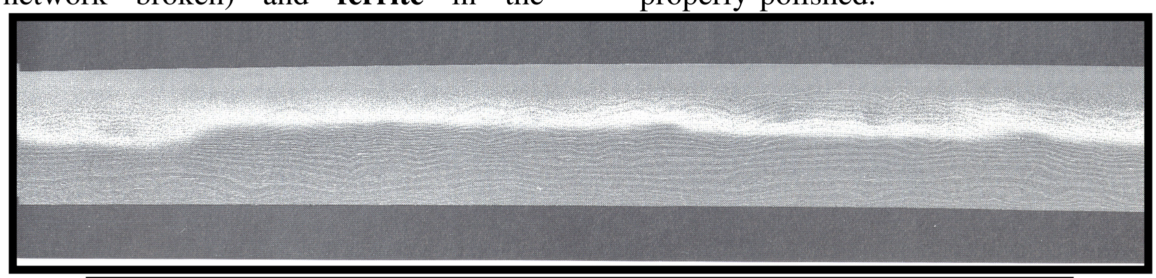

Figure 5 A

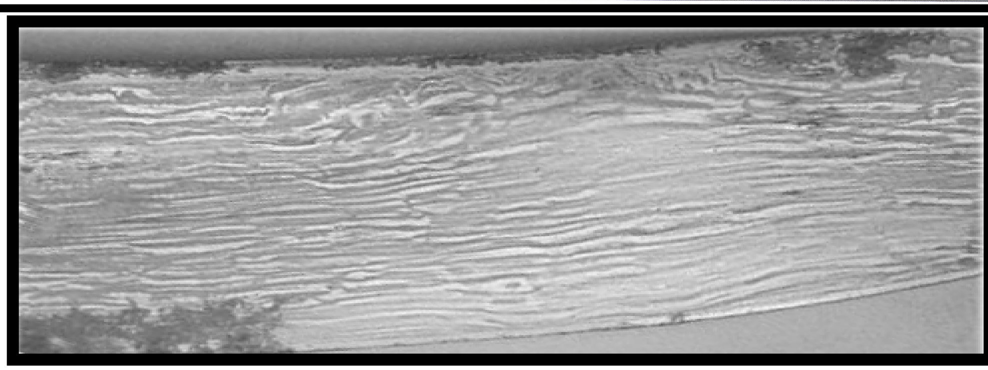

Figure 5 B

Figure 5A shows *masame* compared with *sham wootz.* Figure 5B shows an Indo-Persian dagger. Just as in the case of *itame hada* and *wootz*, here again one sees the thicker lines of *wootz*. In the case of the *sham wootz* the darker lines are darker than the Japanese steel (ferrite) and the thicker white lines (thicker compared with the *masame* lines) are cementite. The lighter lines in the *masame* are oxide lines produced in the forging process and the darker areas are banite with a lot of martensite (*ji nie*).

In conclusion, the pattern seen in the *ji* of the Japanese swords, known as *hada,* depends on how it is forged. The Japanese are capable of forging very fine but conspicuous *hada.* As an example Figure 6 below illustrates the so-called *konoka hada* found in some Hizen swords and a *mokume hada*.

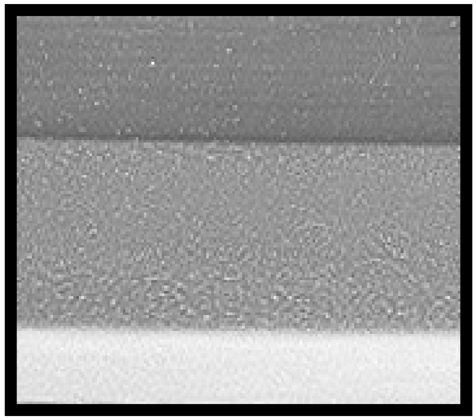

Figure 6

Figure 6 A shows *konuka hada*, found in the *Hizen* swords (this is a sword by Yukihiro).

Furthermore, Japanese swordsmiths were very clever. They used many techniques to enhance the beauty of the *hada* of their swords. For instance, a Japanese smith might use steel on the sides (*ji*) of his swords, which has different carbon content and therefore shows differences in **ferrite** and **cementite** content**.** In this case Japanese *hada* begins to show a pattern very close to "true *damascus* watering" (see Jeffrey Wadsworth et al. [1]).

Figure 7 below shows an example of this "true *damascus* watering". It is difficult not to compare the watering of this sword with *damascus*.

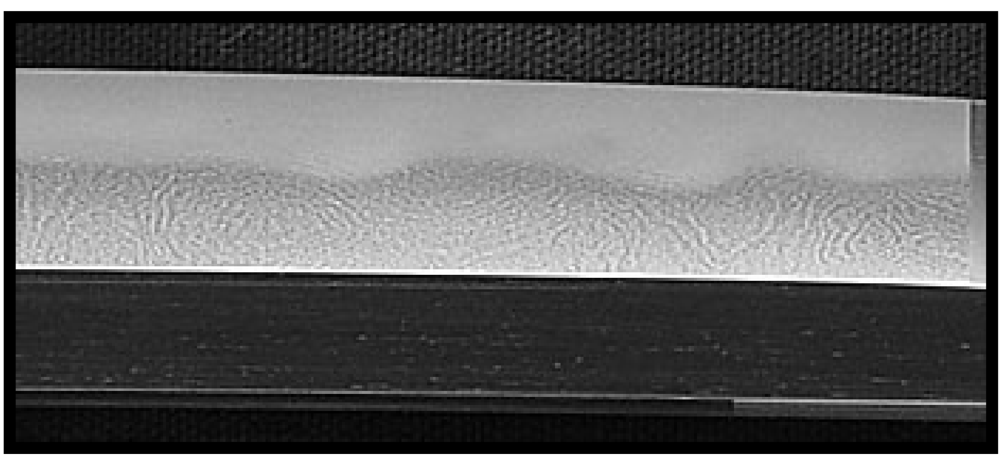

Figure 7

Figure 7 shows "true watering" in a Japanese sword, to use the nomenclature of Jeffrey Wadsworth [1]. Note that the white lines are thicker, in fact, comparable with the darker lines.

The work of some Osaka smiths—Kunisada, Kunisuke, as examples—as well as the Shinshinto smith, Kyomaro, further support this practice. All the aforementioned mixed steels with different carbon content when preparing the steel for the side of their blades. (Kapp [5]). As a result, the steel with greater carbon content has more **cementite** and **martensite** and therefore appears brighter than steel with less carbon. When this "enriched" steel is combined with the normal lines formed when forging the steel, the result is known as the very beautiful Osaka jihada, illustrated in Figure 8. A further example is described by Kapp et al. [5] Figure 58 in his book.

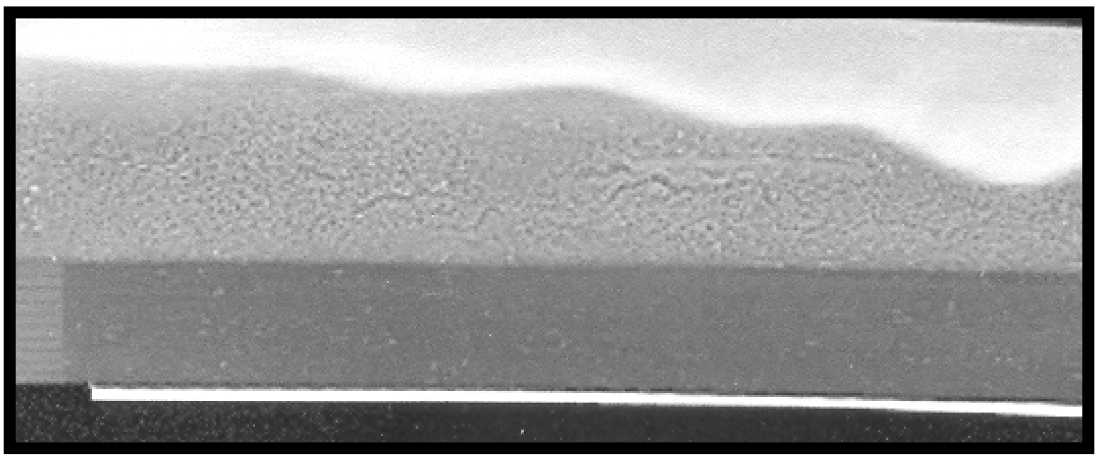

Figure 8

Figure 8 shows an example of Osaka *hada* in a blade by the Naka Kunisuke

Matsukawa hada was done this way in *koto* times by Norishige with spectacular effects. In Shinto times, Hankei also mixed steels with different carbon content to try to imitate Norishige. Figure 9 shows the *matsukawa hada* of Norishige.

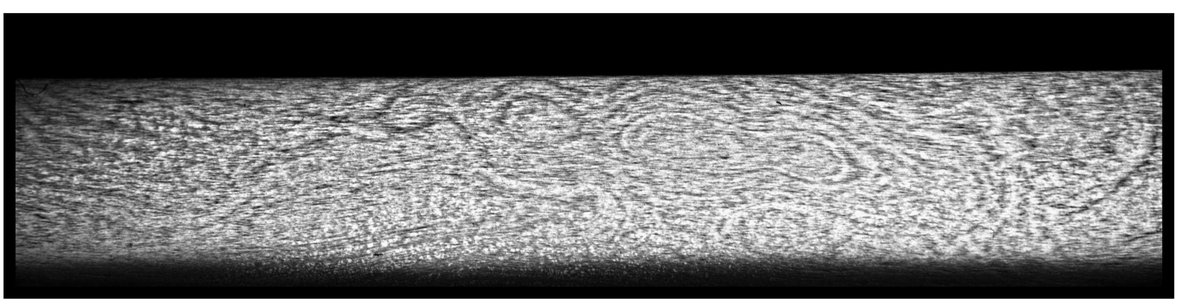

Figure 9

Figure 9 shows the *matsukawa hada* of Norishige.

Some *Shinshinto* smiths mixed steels with different carbon content in their blades to form what is known as *hada-mono*. This is so exaggerated that it is not beautiful at all.

In Shinto times *nanban tetsu* (steel) was used. It can be argued that it was steel made from the Indian *wootz* cakes that the Dutch brought to Japan from India. This opinion is shared by both Tanobe Michihiro [6] and by Sakakibara Kozan in an old book on armor [7]. In this old book, *nanban tetsu* is described as being imported by the Dutch in the form of gourd-shaped masses (*hyotan*). These would be *wootz* cakes described in the previous article in this series.

Figure 10 shows the *nanban tetsu* pattern in a sword by Yasutsugu (3rd generation Edo).

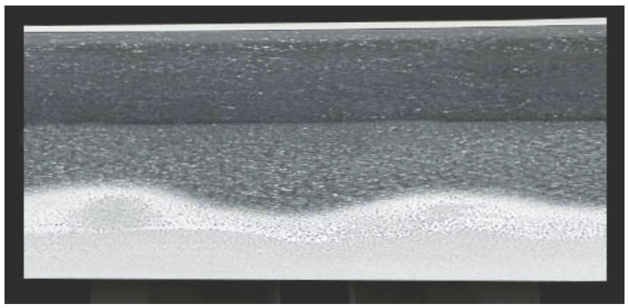

Figure 10

Figure 10 shows the *hada* of a Yasutsugu (3rd generation Edo) blade made with *nanban tetsu.*

Finally the other types of *hada* commonly found in Japanese swords should now be considered. These are *mokume hada, ayasugi hada* and some other special patterns. As described by Kapp [8], those are made by drilling a hole in the steel and then forging it. This is very similar to **mechanical *damascus*** found in Indo-Persian swords.

Figure 11A, Figure 11B and Figure 11C below show examples of **mechanical *damascus*** of an Indo-Persian blade compared with *mokume hada* of a Japanese blade.

Figure 11 A

Figure 11B

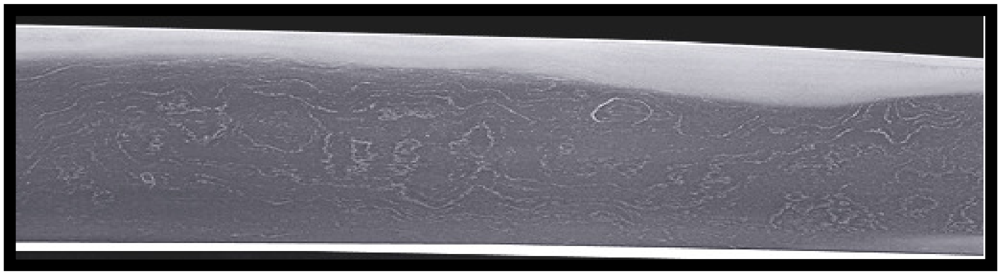

Figure 11 C

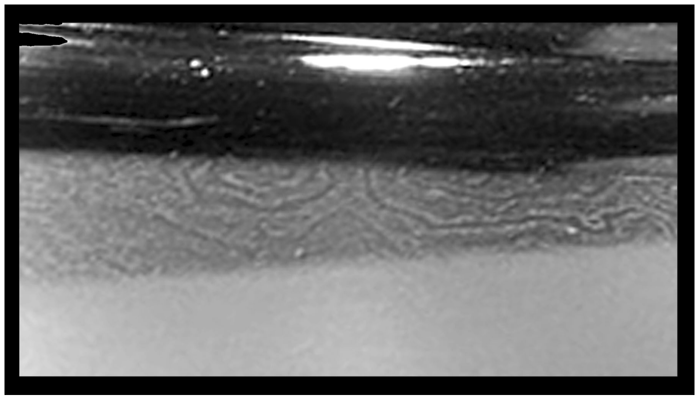

Figure 11D

Figure 11 A shows an Indo-Persian sword which was heavily treated with acid. Figure 11 B shows the same blade, with some of the acid etch removed. Careful inspection of this blade shows a *mokume*-like grain. Figure 11 C and 11D shows a Japanese blade with *mokume hada*. Note in figure 611D the tree-ring like pattern.

The steel which becomes the *yakiba* usually has the highest carbon content. It is the most finely-forged steel. Layering of clay over the steel, before heating and quenching, influence the quenching velocity. Unequal quenching velocity causes stresses that make the blade very tough and able to hold an incredibly sharp edge. (see Weins and Bleed [3]).

This combination of steel and care in sword manufacture resulted in the best sword ever produced by any culture in the history of mankind - the Japanese sword.

Acknowledgment - I would like to thank Iracene A. Boccia for much help in preparing this and the other articles in this series. I would also like to thank Barry Hennick for carefully reviewing this article.

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