Flowers in Steel

Introduction:
For many years I have talked about the importance of shape when assessing a Japanese sword. Following Dr. Walter Compton's view that it is the first thing you should study and you shouldn't progress to looking at anything else on a blade until you had learned all you can from the shape.
By way of a change I thought I would move on to my next obsession, hada or more specifically activity within the hada.
I need to start with an apology, I am neither an engineer nor metallurgist and my chemistry is over thirty years out of practice. So in approaching what is an extremely technical subject I have the handicap and also benefit of having little preconceived idea of how activity within hada is created. As a result I have had to rely on those sources of reference available to me and, I hope, some logical assessment of what is being described. I don't doubt there are many errors in the following notes, it is not meant to be a definitive article on how various types of activity are formed. It is aimed primarily at stimulating thought and discussion.
The most obvious unique feature of a Japanese sword is the presence of the hamon.
(Note: Over recent years hamon has become increasingly used to describe the hardened edge as a whole. This is technically incorrect, the term for the hardened edge is Yakiba and the hamon refers to the border between the Yakiba and ji-hada. However as the reference works mentioned in the following notes follow the modern convention I have used the same terminology when quoting these sources to prevent possible confusion.)

No other edged weapon that I am aware of has this feature. However the swordsmiths ability to produce a hamon is not purely dependent on applying clay to the sword blank heating and cooling it rapidly. It also depends on the raw material and the ability of the smith to manipulate that material when forging the steel.
I have recently finished reading "The new generation of Japanese swordsmiths" by Tamio Tsuchiko. Many of the Smiths interviewed stress the importance of raw material and forging in producing a blade capable of withstanding yakiire (water quenching) and developing hataraki (activity) both in the Hamon and the Ji-hada.
Somewhat surprisingly (at least to me) Yoshihara Yoshikazu goes even further stating that the creation of a Bizen Choji hamon with all its inherent activity is as dependent on the assembly of the pieces of Tamahagane in the initial block as it is on the application of clay prior to quenching.
Many Smiths believe so strongly that they can only achieve the activity they require with the right material, they smelt ore to produce their own raw material.

The living National Treasure Smith Amata Akitsugu best summarised the importance of hada when he said **"Jigane is the essence of the Japanese Sword"**
Not only is it the essential component in creating an unsurpassed cutting weapon it also encapsulates all of the features, in both Jihada and hamon that students so appreciate as the intrinsic beauty of Nihon-To.

1. **What is Nie and what is meant by activity?**
As any new student will discover there are many, many terms which describe activity in both the hamon and the hada between the hamon and the shinogi. The majority of this activity is the result of the formation of various forms of steel structure known within industry as

Martensite, cementite, austenite etc but somewhat more poetically within the study of Nihonto as Nie or Nioi.

Chemically Nie and Nioi are the same, they are forms of Martensite. The difference is in the size of the martensite granules. Nie is large enough to be seen by the naked eye as small independent dots of clear bright steel which turn black as you re-orientate the blade in a single light source. Amata Akitsugu comments in Modern Japanese Swordsmiths that the Kanji for Nie is constructed from two Chinese characters Kane meaning Iron and Hana meaning flower; a poetic description of the phenomenon. Others describe Nie crystals as resembling bright stars in a night sky.

Nioi forms much smaller grains which are not visible singly but appear as a misty cloud along the hamon, continuing the astronomical theme nioi has been described as resembling the Milky Way.

Other activity such as Inazuma, Kinsuji and Sunagashi in the hamon and Chikei in the Ji-Hada are formed by groups of nie merging to form continuous lines within the blade's surface.

2. **How is Nie formed?**

Tamahagane's physical structure changes as it is heated. To quote L. Kapp from "The craft of the Japanese Sword" "When steel with a carbon content of approximately 0.7% is heated above 750C it enters the Austenite phase. Austenite has a crystal structure which "opens" to allow carbon atoms to combine with the iron".

The longer the blade is held at that temperature the larger the crystals grow. When it is allowed to cool slowly Austenite loses its trapped carbon and the crystals gradually decompose. If the steel is cooled rapidly, as occurs when the blade is quenched, its structure changes again to another crystalline form, Martensite (Nie).

However the higher the temperature you heat to and the more rapidly you cool a blade from that temperature the greater the stress you introduce to the blade and the greater the likelihood of it cracking during the yakiire process.

There is therefore a fine balance between using sufficient heat to enable the austenite to combine iron and carbon atoms and being able to cool it quickly enough to form Martensite but at the same time maintaining the structure without damaging the blade.

One of the comments often made about Soshu blades and Masamune in particular was that he worked his steel at higher temperatures than other smiths allowing the formation of superb Nie and activity in both hamon and hada. The fact he was able to do this was believed to be a result of his excellent forging techniques which enabled the blade to withstand the stresses the hardening process inflicted on them. The resulting Ji-hada is alive with activity with profuse Ji-nie and Chikei clearly visible as bright/dark (depending on orientation) lines throughout the Ji-gane. This combines beautifully with the nie forming the hamon which is full of Inazuma and Kinsuji.

There are other factors which appear to influence the production of Nie. A number of sources quote the purity of the steel, or the Iron ore used to produce the steel as being an important factor. It is documented that traditional Japanese steel has far fewer impurities than western steel. It was suggested some years ago during an event at the Liverpool museum that the lack of contaminants makes it easier to produce nie when using traditionally produced Japanese steel. However at the start of the Edo period many highly regarded smiths such as Yasutsugu

incorporated foreign steel in to their blades and these were not noted as lacking activity, quite the contrary.

From this point however we can assume that the composition of the steel (and in particular its carbon content) can and does affect the ability to produce nie in the quenching process. This view is to some extent supported by the fact that you find different levels of activity in the different traditions of the Koto period. At this time Tamahagane was produced locally from the ore that was most readily to hand. This is believed to account for the colour variations in the steel identified between different traditions and locations. Could it also explain to some degree why, for example, Yamato blades had a predominance of Nie where Bizen blades of the same period were almost exclusively Nioi? Was it just down to the working temperatures used in each school or did the local material in one area lend itself more readily to crystallisation than the other?

Activity in the Ji-hada

As mentioned earlier one of the most admired features of the prominent schools is the Ji-hada whether it is the beautiful Chirumen hada of the Awataguchi smiths, the subtle combination of itame and Mokume of Bizen or the combination of Itame and Nagare in Soshu. Without exception, when a Japanese authority is describing the beauty of hada they comment on the presence of Ji-Nie and Chikei. Some of the blades of Rai Kunitoshi are described as having a sheet of very fine Ko-nie covering the Jigane. Unfortunately Ji-nie and Chikei are not the easiest features of a sword to see, particularly in swords in less than perfect polish. It takes time practice and effort to identify these characteristics in a sword. It must also be said that sometimes ambition overtakes reality and we think we see them because we want them to be there!
However when you do see them they strike your eye and yes I think it is really like looking into the depths of a dark pool and seeing ice crystals shining through (Inoue Shinkai) or stars shining across heaven (Awataguchi) or any other description one can think of for something that captures a serene beauty in a hard and unforgiving object.

One question however is how do smiths achieve this activity in the hada between the hamon and the shinogi? One of the Smiths interviewed in Modern Japanese Swords said that Chikei was independent of hada, i.e. it does not follow the weld lines of the hada and is not related to the construction of the Jigane. If this is the case how is Ji-Nie which is the foundation for all this activity created?
As mentioned above if steel cools slowly the crystal structure decomposes so the crystals get smaller and then disappear. The Ji-Hada cools more slowly than the hamon does because:
a) It's thicker and therefore retains heat longer, taking longer to cool down
b) It is insulated by the clay so it is likely to take longer to heat up and reach the temperature achieved by the hamon
And
c) It cools down more slowly because the clay insulates it from the cooling effect of the water.
Therefore if the formation of Nie was totally independent of the steel used in construction and the forging technique of the swordsmith, any crystals formed in the hada would have to be smaller than those seen in the hamon.
There are many examples where this is not the case.
Following the logic of this argument through, the ability to produce hatarake in the Ji-gane must be influenced by the materials used in the forging process. This is supported by

Yoshihara Yoshikazu's earlier mentioned comment concerning the construction of the block affecting the ability to produce activity within the choji hamon of Bizen blades.
It would also again explain the regional differences in the production of Hatarake during the koto period which are considerably reduced in the Shinto period as raw material became more uniform.
The view that the formation of Nie in the Ji-hada is influenced by the forging process was further confirmed in the July issue of the NBTHK journal. Tanobe Sensei was describing a blade made jointly between Sukehiro and Inoue Shinkai. He describes the hamon as being the unmistakable work of Sukehiro. But he then goes on to say that the Ji-nie and Chikei present in the hada suggests the forging was carried out by Inoue Shinkai
I believe this confirms conclusively that the activity seen in the hada is equally if not more dependant forging technique as it is on subsequent hardening

In summary Activity seen in the Ji-gane is a result of the formation of nie crystals either singly or formed into continuously joined threads to form Chikei. The ability of the Hada to form these crystals is the result of a combination of factors which include the chemical structure of the raw material, the way different variants of that raw material is combined and ultimately the way the blade is quenched to form the hardened edge.

The belief that such activity is directly related to a combination of the iron ore used and the forging techniques employed is supported by the regional variations seen in swords made in the Koto period where particular types of activity became associated with specific schools.

This leads on to the final topic of this discussion. This is perhaps the most often talked about form of activity in the hada, Utsuri. Utsuri has become almost synonymous with the swords of the Bizen Schools. However it is not exclusive to Bizen. Swords of Yamashiro and Mino also exhibited Utsuri in one form or another. It is true that it is seen more often and more clearly in the work of some, not all, of the Bizen schools. How clearly it is seen varies considerably. At its most prominent it can be seen from across a room at its least obvious the viewer has to work hard to see it. As a very rough rule of thumb Utsuri shows more clearly on blades with tighter hada. So for example in the work of the Osafune School which makes a tight Ko-Itame hada, Utsuri is said to stand out. In the work of the Ichimonji schools where the hada is coarser Utsuri is described as less prominent.

What is Utsuri?
Many references tell the reader what Utsuri looks like few actually say what it is. There is equal controversy as to how it is achieved and whether it was intentional or appeared accidentally as a by- product of the quenching process. Within the aforementioned Modern Swordsmith volume the two extreme views expressed were:

1) "The appearance of Utsuri was purely accidental"
2) "Utsuri was created to strengthen swords and reduce the likelihood of them bending in combat".

Utsuri is translated as "Reflection". It describes a misty whitish line which follows the hamon. The area of the Ji-hada between the hamon and Utsuri can appear dark and this is sometimes described as "Antei".
As with everything else in sword terminology there are many different types of Utsuri described. The two most common are midare and Bo- Utsuri. However there is also Jifu, Shirrake and Nie-Utsuri. The clue to what Utsuri is I think in the last one. Nie Utsuri is most

commonly seen in swords of the Yamashiro tradition and is mentioned as a key kantei point for the works of the early Rai smiths. Nie utsuri is seen when Ji-nie follows the hamon in a line between hamon and shinogi.
Is it possible that the finer utsuri seen in Bizen blades is in fact a form of nioi? Again formed between hamon and shinogi. If this is the case then the introduction of this harder material in this area might explain the earlier comment about Utsuri preventing blades bending. If Utsuri is martensite but with very fine crystal structure it would also explain why it is more easily visible on tighter or finer hada. On coarser Jigane such as that found in the Ichimonji School the fine grains of nioi would be lost in the structure of the steel.

Conclusion

At the beginning of this piece I quoted Amata Akitsugu saying that Jigane was the essence of the Japanese sword. In the notes above I have concentrated almost exclusively on activity within the Ji-hada and almost totally ignored the pattern of the welded steel. This is in its self a subject for a separate paper. However in looking at the subject of activity and some of the claims (often contradictory) in various reference works I believe it is possible to draw the following conclusions

1. The activity described in the Ji-hada is a result of the formation of hard crystalline structures within the steel. While chemically identical these structures may appear in a number of physical forms and are given the names; Nie, and nioi, chikei utsuri. etc

2. The creation of activity in the Ji-hada is caused by combination of a number of factors which include: the quality of the raw material, the way that material is combined in the forging of the Jigane and the final quenching process.

3. While the final appearance of such activity may be to some extent “accidental” the fact that it is present is the result of deliberate and highly skilled crafting by the smith.

There is no doubt that activity in the Ji-hada of a Japanese sword can be extremely beautiful. At its best as for example in the works of Inoue Shinkai, it can create the illusion of depth and translucency in what is a flat opaque surface. It can also create a landscape of flowing structure which is beautiful to see and lifts the Japanese sword far above its utilitarian purpose in to an object of great art. While the shape can define the immediate beauty of the sword the hada presents a view into its spirit, or at least the spirit of the man who made it.