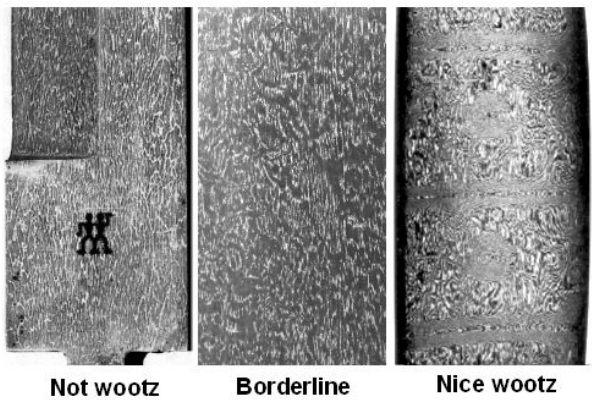
Wootz Patterns

General Remarks

Illustration

There are many wootz blades with well-visible patterns around but there are probably far more that sported a pattern once that now is gone. Letting a blade get old and rusty is one of the (better) reasons for this. Another (and stupid) one is to polish a wootz blade to a mirror sheen. This has been done in several museums.
Wootz patterns can differ. Sword connoisseurs throughout the ages therefore have come up with all kinds of systems supposed to classify wootz patterns and to provide some kind of ranking. It goes without saying that the pattern with the highest marks are automatically found on the very best swords.
That is not true. A clear pattern does testify to well-spheroidized cementite in ultra-high carbon steel (UHCS) and that is a pre-requisite for any UHCS that is not completely brittle. A very complex pattern does indicate that a very experienced smith was at work, and that is certainly a quality mark. But that is just indirect evidence.

- Before I go into the systematics of wootz patterns it is necessary to point out that not every pattern on a UHCS blade is a wootz pattern.
  Only *nice* patterns qualify. Of course, as always with matters of taste, there is no clear borderline between patterns that qualify as "wootz" and those that don't. That's why I chose the very unscientific criteria of "nice" wootz. It is just as hard to define what separates a nice wootz pattern from a run-of-the-mill not-nice one, as it is to define what separates pornography from art. Yet you just know it when you see it. However, patterns on *old* wootz blades are by definition always "nice" wootz.
  Due to the efforts of many, in particular the two research groups around Wadsworth and Verhoeven and (much earlier) Käthe Harnecker, we know hat *any* UHCS steel can be induced to provide for a pattern. Most of those patterns, however, are not why I have termed "nice" wootz patterns.
  Here are examples:



Nice wootz and not wootz

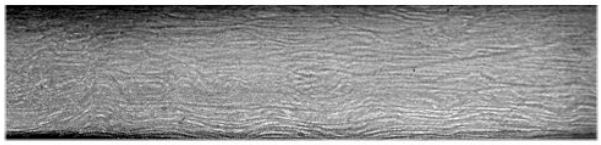
- The "not wootz" pattern on the left is from a knife made by Käthe Harnecker around 1955, the borderline case is from a modern smith (Klaas Remmen[1)]), and the nice wootz is from the present undisputed champion of wootz blade forging, Al Pendray.

A lot of long dead guys from the East and Middle East have remarked about different wootz patterns and how they should be graded. Khorasani presents that in some detail in his marvellous book. However, since dead guys from the West hadn't invented photography by then, a lot of prose in hard-to-understand languages just doesn't help all that much. That is just as true for the systems designed by many Westerners who looked into wootz in the 18th and 19th century.
Of course, **L.S. Figiel** has written almost a whole book[2)] on the subject and I can't compete with that on just a few pages.
We need to start somewhere. The system presented by Manfred Sachse in his landmark book is just as good as any other, so let's start with it.

Manfred Sachse's System

Stripe pattern
"Streifiger Damast"; literally "stripy damask" in Sache's book; also known as "sham" meaning (I hope) "Syria" and thus "Syrian kind of pattern".
Sachse describes it as having "predominantly straight lines".

Sachse



Khorasani, p. 125, 541

Striped pattern

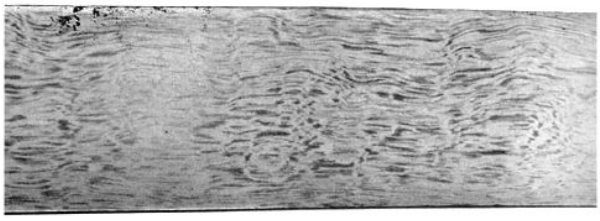
Source: All following pictures, if not otherwise noted, are from Manfred Sachse's or Khorasani's book as noted.

- Khorasani shows many wootz blades in his 750+ page opus but less than a handful with the "sham" pattern. Of these most do not not have a pattern that is clearly recognized on the printed page.

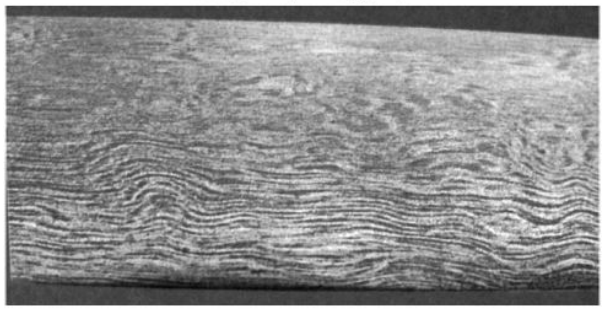
Water pattern

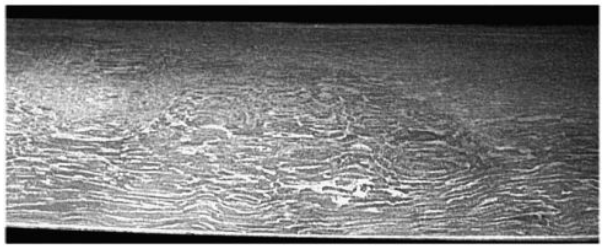
"Gewässerter Damast" literally "watered damask" in Sachse's book; also known as water (damask) pattern
Sachse describes it as: "The straight lines become shorter and are mixed with curved ones".

Sachse



Khorasani p. 478, 540



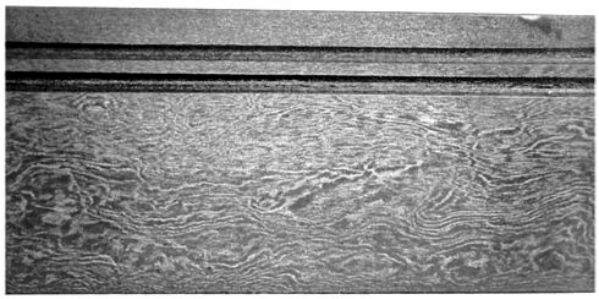


Water pattern

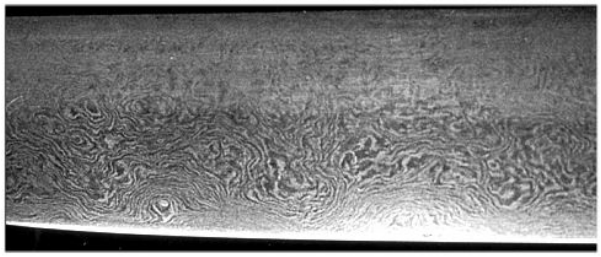
- One can also appreciate from these pictures why "color" was a criterion for some. Are you looking at white lines on a black or greyish background, or is it the other way around? A photography simply cannot do justice to patterns that are very sensitive to illumination conditions and viewing angles. Two eyes plus a brain see something that is different from what a camera records.

Wave pattern
"Wellen Damast" literally "wave damask" in Sachse's book.
Sachse describes it as: "Curved lines become dominant; broken lines and points / dots appear".

Sachse



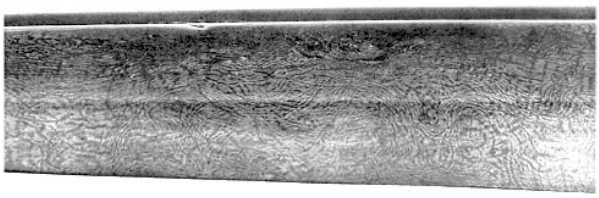
Khorasani p. 509



Wave pattern

Net pattern
"Netz Damast" literally "net damask".
Sachse describes it as: "Broken lines become shorter and end in dots. They appear in bunches, and on occasion run at large angles to the blade, forming net-like pattern".

Sachse

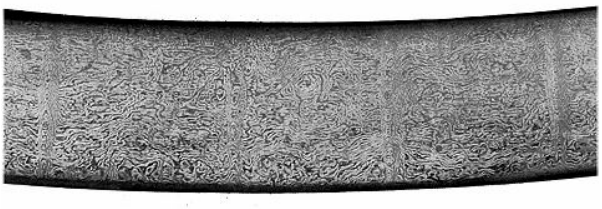


Net pattern

Source: lower picture is form the Net: Fateh Singh: An Introduction to Wootz Crucible Steel, September 3, 2014. The blade was not identified

- Khorasani does not recognize a "net pattern", nor is it very prominent elsewhere. The second picture has not been classified as "net pattern" but at I believe it comes close.

Step pattern
"Stufen Damast" literally "step damask" in Sachse's book.
Sachse describes it a bit circuitously, so I won't translate. Everybody is familiar with the step or **ladder pattern**, also known as **kirk nardeban** or **Mohammed's ladder** anyway.

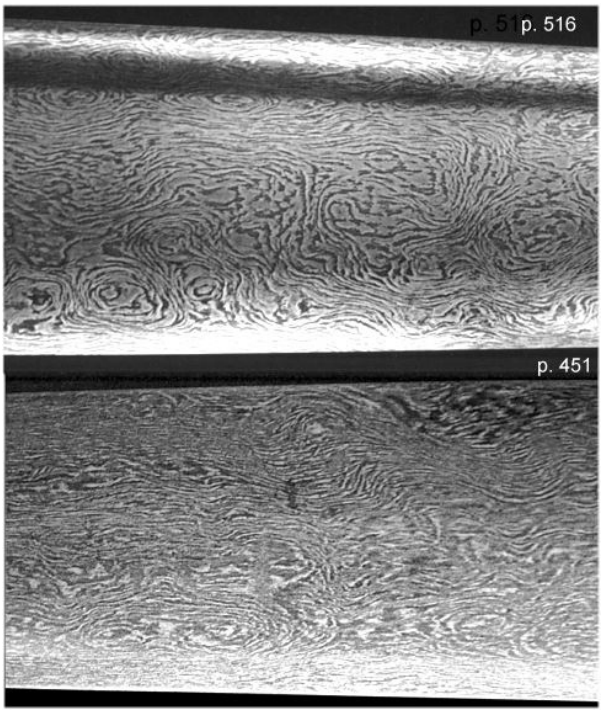


Step pattern

- I have a lot to say about the "step pattern" further down so I won't go into details here.

Beyond Manfred Sachse

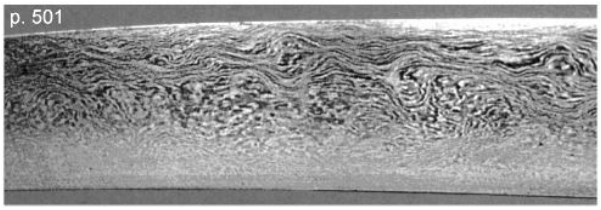
Wood Grain pattern or **Mottled pattern**
While Sachse doesn't list this pattern, it dominates by far in Khorasani's book. Here are a few examples:



Wood grain or mottled pattern

- Well, you see why it is called "wood grain". You might also call it "wavy" or "net" on occasion.
  If you think about true wood grain as seen on wooden boards, you get the pattern because you cut through a system of staggered and buckled but always more or less cylindrical planes with two "colors", resulting from growth "rings" (actually growth cylinders) in the wood. If you now think hard, you realize that growth rings / cylinders in a piece of wood do *never* end somewhere but are closed on itself.
  When you cut through a piece of wood you see a line wherever the growth rings or cylinders intersect with the surface of the cut. If you now think *very* hard (or look below) you realize that these lines can *never* end just so on your cutting plane. They either end a the edge of the cutting plane or they form closed loops. These loops can be so small on occasion that they look like a dot. But you will *never* see an ending line.
  That gives a clue of how the various patterns are formed. I'll come back to this.

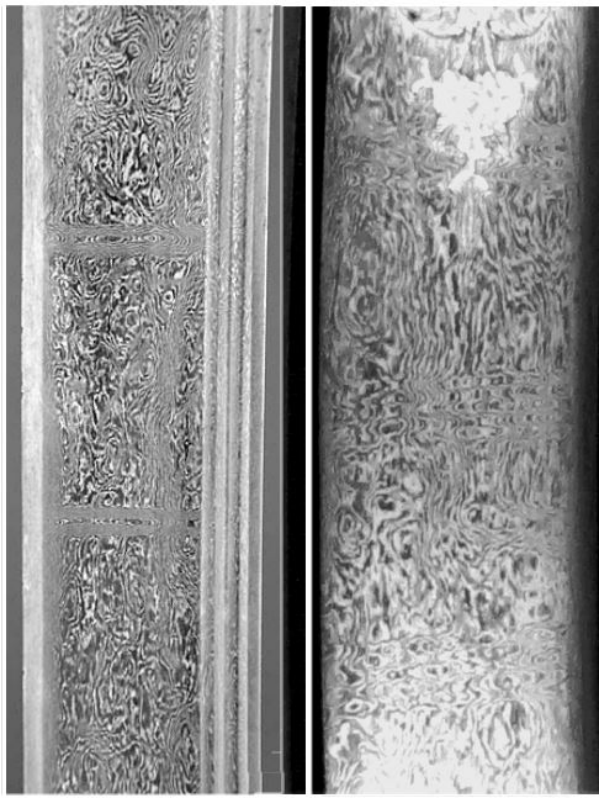
Rose pattern
You know the "ladder and rose pattern" but the rose pattern, while rare, also exists by itself. There are a few examples in Khorasani's book but they are not very convincing. Here is the best:



Rose pattern

Now let's give "**kirk nardeban**" or *Mohammed's ladder* (step pattern) a closer look. Its name comes from the Prophet's ascension to heaven, parts of which are known as "Mi'raj", an Arabic word that literally means “ladder”. On occasion the pattern is also called **Jacob's ladder** since the Old Testament of the Christians (identical to the Hebrew Bible including the Torah) recounts a similar story, featuring Jacob's ascension to heaven (Genesis 28: 12). For some reason the ladder is supposed to have 40 rungs. What one finds is often in the neighborhood of this number

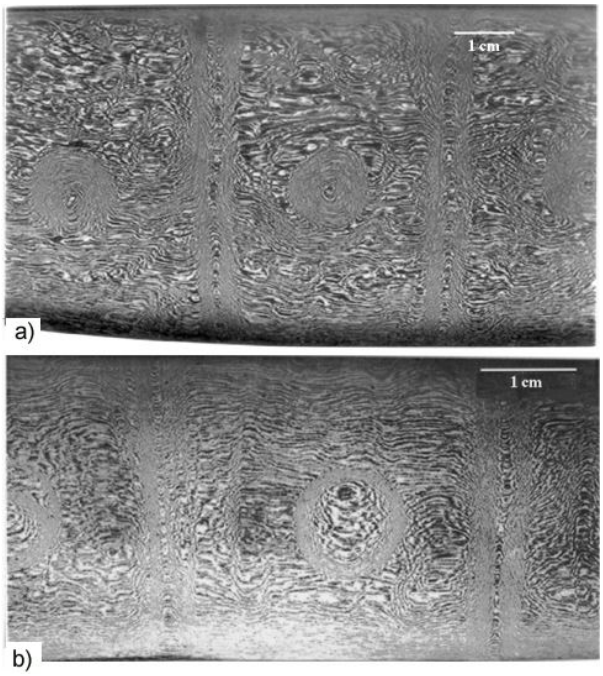
- One might further distinguish kirk nardeban patterns by the way the rungs look. There are single and double rungs (and below I added even a triple rung variety):



Kirk Nardeban ladders with double and triple rungs
Here is large picture

Source:
Left: Indian Tulwar Sword with “Kirk Narduban” Ladder Wootz Blade, from the 18th Century; sold by Akaal Arms in 2014
Right: Photographed in the Metropolitan museum in 2013

- Then there might be a rose between the rungs, making for the most complex antique patterns, the "**kirk nardeban and roses**" or "**ladder and rose**". There seem to be no good pictures of ancient "ladder and rose" patterns around, so I take new ones:



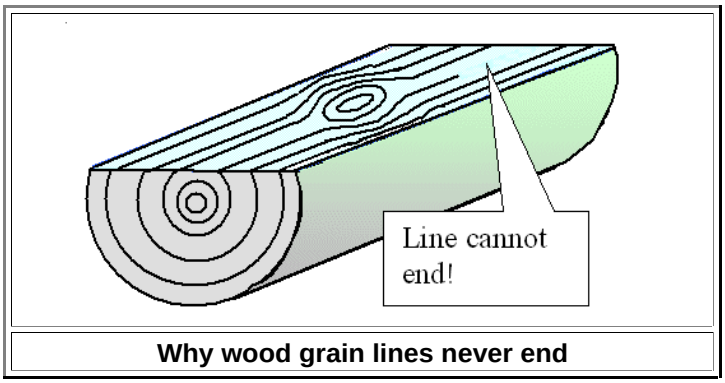
Ladder and rose pattern made by Al Pendray around 1998
The ladder and rose pattern produced by grooves a) *cut* or *b) forged* into the surface of the nearly finished blade.

Source: Verhoeven, A.H. Pendray and W.E. Dauksch

- The patterns shown above cover most of whatever there is. Of course, the assignment of a given pattern to one of the classes above is often a bit arbitrary.
  - There are plenty more names for patterns similar to the ones shown and systems with a finer distinction including also color, for example. This might be of some interest for people with the need to classify everything. For everybody else it is far more interesting to consider what it takes to make a certain pattern. I'll give this a quick look in what follows and a lot of attention in the backbone module.

Making Patterns

- You are the smith in ancient times and about to produce a wootz blade with a certain pattern. How do you go about this?
  - Easy: You go through the necessary steps as your master taught you. You know from experience that this will work most of the time but not all of the time. So you also pray a bit and sacrifice something. If this didn't help and your blade didn't work out, you start a new one. Sooner or later you get what you set out to do.
- You are a modern half-way educated person and you know that wootz pattern result from the blade surface intersecting strings of cementite precipitates. Can you figure out how these precipitates need to be arranged to produce on of those patterns from above and, after you figured it out, how to make it? At least in principle?
  I gave you a hint right above. Let's start from there.
  - Hint: If you want to make a wood grain pattern, arrange sheets of cementite particles just like the growth rings / cylinders of wood. Make sure that those sheets do not end inside the blade but extent all the way through the blade. Wherever they come to the surface of the blade you see a line of the wootz pattern. And this line doesn't end!
    Look at this very primitive model to see why:



Why wood grain lines never end

But lines of some patterns do end. So we can't only have sheets that extend all the way through the blade. What else might be there? It's a short list:

- Planes or sheets of cementite precipitates that end in the blade. Pack a suitcase with randomly distributed handkerchiefs or small towels and you get the idea.
- Strings of precipitates going all the way through the material.
- Strings of precipitates with finite length (like here)
- Randomly distributed clusters of precipitates but with varying density on a 50 µm scale (like here)

That's about it. Now think what kind of pattern you would get cutting through one of the arrangements in the list above. We assume that the size of the precipitates and the general geometry provides the scales needed for visibility as discussed before.

It's not that difficult. Try as you might but cutting through an arrangement of lines always gives dots. The only exception would be lines running almost parallel to each other and a cut along the lines.

We can draw a major conclusion: If you want to make a nice pattern, you should:

1. Make sure that you have a system of parallel planes or sheets of cementite precipitates that extend through most of the blade.
2. Buckle and bend that system of planes in such way that they cut through the blade surfaces in such a way that the pattern wanted is produced.

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1) Klaas Remmen: "Experimental research of crucible steel: a new insight and historical refllections", http://ceroart.revues.org/2557.

2) L.S. Figiel: "On Damascus Steel" , Atlantas, FL: Atlantas Arts Press (1991)