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Wootz: Erroneous Transliteration of Sanskrit "*Utsa*" used for Indian Crucible Steel

R.K. DUBE[1,2]

1.—Department of Materials Science and Engineering, Indian Institute of Technology, Kanpur 208016, India. 2.—e-mail: rkd@iitk.ac.in

The terminology Wootz for the legendary Indian crucible steel was first introduced by Helenus Scott in his letter to Joseph Banks, the then President of the Royal Society, London, in 1794. He stated several salient features of this steel in his letter. During the period 1794–1796, Banks received approximately 200 lbs. of this steel from Scott. Banks assigned several professionals to carry out experimental work on Indian crucible steel. One such important person was the famous surgical instrument maker, cutler and metallurgist of his time, James Stodart. Stodart experimented extensively with the Indian crucible steel, and was its great admirer. It has been shown, along with corroborative documentary evidence, that the original word for this steel was Sanskrit word "*utsa*". This was erroneously transliterated in Roman script as Wootz by Scott in his letter to Banks. It was James Stodart, who preserved the Sanskrit word "*utsa*" written in Devanāgarī script on his trade card for future generation. The reason for using this word for the Indian crucible steel has also been discussed.

INTRODUCTION

Indian crucible/cast steel made via the liquid metallurgy route (henceforth called simply Indian crucible steel) has a very long and interesting history. The origin of this steel in India dates back many centuries prior to Christian era. Some of the early documentary evidence of the Indian crucible steel can be found in the Great Epic Mahābhārata, Kautilya's Arthaśāstra and Pāli Jātaka texts. Indian crucible steel came to be known in Western Europe in the beginning of the medieval period. It is widely believed that during Crusade times European crusaders discovered that the steel swords of the Muslim soldiers in Damascus were superior to their own steel swords. European crusaders brought the story of "Damascus steel blades" back home.

The origin of the Damascus steel blade has been discussed by Smith,[1] Wadsworth and Sherby,[2] and Verhoeven.[3] The name Damascus steel/blade is a misnomer, in the sense that it was not manufactured in Damascus. In fact, India was the original place, where this type of steel, and subsequently blades from it, was first manufactured. These commodities were exported to several parts of the world throughout the ages. Elgood[4] discussed the Damascus steel sword manufacture and stated that:

> in the Islamic period prior to the sixteenth century there was a considerable import of Indian swords and steel into the Arab lands of Egypt and Syria. ... There is nothing to suggest that Damascus held any pre-eminent position as a sword manufacture in the Arab world.

Thus, Europeans became acquainted with Indian crucible steel by the name of Damascus steel.

INTRODUCTION OF THE TERMINOLOGY "WOOTZ" FOR INDIAN CRUCIBLE STEEL IN WESTERN EUROPE AND THE PROBLEM OF ITS ETYMOLOGY

The year 1794 A.D. was a turning point in the history of Indian crucible steel when a new Indian word transliterated in Roman script as "Wootz" by

The author wishes to dedicate this paper to the memory of Mr James Stodart, F.R.S. (1760–1823 AD), who preserved the original nomenclature of the legendary Indian crucible steel in the Devanāgarī script for future generations, upon which this paper is heavily based.

R.K. Dube is Retired Professor and Head, Department of Materials and Metallurgical Engineering, and Advanced Centre for Materials Science, Indian Institute of Technology, Kanpur 208016, India.

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Helenus Scott, of Bombay (now called Mumbai), was introduced to Western Europe through his letter, dated January 8, 1794, addressed to Joseph Banks, President, Royal Society, London.* Scott sent a specimen of a kind of steel, which was called by the term "Wootz", as transliterated by him in Roman script, in the Mumbai area of India along with his above letter to Banks. Since Scott was stationed in Mumbai, it is reasonable to assume that this Indian nomenclature for crucible steel was prevalent in the Mumbai and its surrounding area, and also probably in the area where this steel was manufactured. Scott stated some of the important characteristics/features of this steel in his above letter to Banks. There were two important characteristics of the Wootz steel, as mentioned by Scott, which are of relevance in the present context. Firstly, the steel has a "harder temper (hardness) than any thing we are acquainted with". He also stated the various applications of wootz steel in India, which was due to its excellent hardness. He stated that "it is employed for covering that part of gun-locks which the flint strikes, that it is used for cutting iron on a lathe; and for chissels (chisels) for cutting stones; for files and saws; and for every purpose where excessive hardness is necessary". Scott informed Banks that this type of steel is in "high esteem among the Indians".

The second important characteristics of the wootz steel, as stated by Scott, was that: "it cannot bear anything beyond a very slight red heat, which makes its working very tedious to the blacksmiths". Scott further elaborated this problem and stated that "when the heat is a little raised above a slight red heat part of the mass seems to run and the whole (mass) is lost, as if the substance consisted of metals of different degree of fusibility". As a result of this characteristic, there was a separate class of blacksmiths, who specialise in the hot forging of wootz steel. Scott also requested Banks to send his opinion on the quality and composition of the wootz steel.

The terminology wootz came into the print media first through the paper by George Pearson, in 1795. The findings of Pearson are discussed later.

In his memorandum on the Indian crucible steel to His Excellency the Governor of Madras, Puckle** stated that, in the area where Canarese (Kannada language) is spoken, there is a tradition of using the adjective ucha (uchcha) for denoting the superior variety of the articles in daily use, e.g. ucha batte (for superior cloth), ucha tuppa (for superior clarified butter), etc. The word ucha is derived from Sanskrit *uchcha*, meaning superior. He opined that Heyne adopted the terminology wootz on the ground that "the pieces or lumps of steel he inspected were "ucha kabbina" or superior iron". It is not clear as to which reference of Heyne he referred to. In his classical account of Indian steel manufacture in Mysore,[5] published in 1814, Heyne did not mention the term "ucha kabbina". Unless it is mentioned in some other document written by Heyne, it is reasonable to assume that this explanation of the origin of wootz is of Puckle himself. It appears to be a too far stretched philological argument to trace the origin of the word wootz from Sanskrit *uchcha*.†

Beck[6] transliterated the legendary Indian crucible steel as "Wutz (Wootz-Wuz)", as follows:

> Wutz (Wootz-Wuz) ist der Name, den das Product in der Guzeratsprache fuhrt, angeblich von dem Sanskritworte Vajra, —

Clearly, he was not fully content with the transliteration of the Indian crucible steel as wootz. He was of the view that the word Wutz/Wootz/Wuz is derived from the Sanskrit *vajra*. Monier-Williams defined *vajra* as 'the hard or mighty one', and also as a thunderbolt (especially that of Indra, said to have formed out of the bones of the Ṛiṣi (Saint) Dadhīci).[7] *Vajra* has been used metaphorically to denote diamond, and steel, because of its high hardness.[7,8] Although the usage of the word *vajra* for steel is tenable metaphorically, it is not reasonable to assume that the Sanskrit *vajra* was either transliterated as wootz in Roman script, or was the word from which the "wootz" was derived.

INTRODUCTION OF THE TERMINOLOGY "*UTSA*" IN DEVANĀGARĪ SCRIPT BY JAMES STODART

Soon after Banks received a specimen of the Indian crucible steel wootz from Scott in 1794, he approached Pearson to carry out experiments on wootz steel for investigating its physical and mechanical properties. His paper, which was perhaps the first paper on the scientific aspect of wootz steel, was published in Philosophical Transactions of the Royal Society, London in 1795.[9] Several professionals assisted Pearson in his investigation on wootz steel. One such person was James Stodart. He was an extraordinary professional having excellent combination of scientific bent of mind and practical skill. Stodart was an expert of steel forging and was a maker of surgical instruments and razors. He had his workshop in the Strand area of London. Banks requested Stodart to forge the wootz steel, which he did successfully. Pearson has described this event along with his high opinion about Stodart, as follows.[10]

> That ingenious artist, Stodart, forged a piece of wootz, at the desire of the President (Sir Joseph), for a penknife, at the temperature of ignition in the dark. It received the requisite temper ("At the temperature of 450° of Fahrenheit's scale"—

*Dr. Helenus Scott's Letter sent to Sir Joseph Banks, President, Royal Society, London (Dated January 8, 1794).

**J. Puckle's Letter sent to His Excellency the Governor of Madras (Dated October 31, 1863).

†A more appropriate transliteration of the Sanskrit word *uchcha*, according to the standard rule, would be *ucca*.

> Mr. Stodart's letter to the President). The edge was as fine, and cut as well as the best steel knife.

It has been stated earlier that Scott mentioned that it is very difficult to forge wootz steel in his letter to Banks. This shows the technical skill and ingenuity of Stodart. Perhaps this was the first successful attempt to hot forge wootz steel in Great Britain. Pearson further stated that "Notwithstanding the difficulty and labour in forging, Stodart from this trial was of opinion, that wootz is superior for many purposes to any steel used in this country".[10]

After the initial experiments carried out by Pearson and his associates, which gave first-hand knowledge of the superior properties of the wootz steel to the people of England, there was an increasing demand for this material over there. Scott sent a consignment of 183 lb of wootz steel to Banks on January 19, 1796.[11]

Stodart was actively involved with wootz steel during the successive years and was an important supplier of the products made from this steel in England. He was a great admirer of wootz steel on the basis of his rich experience in the manufacture of products from this material in England.

After receiving more wootz steel cakes from Scott, Banks assigned work to David Mushet to get further insight into the wootz steel. His paper was published in the *Philosophical Transactions of the Royal Society*, London in 1805.[12] Although the work of Pearson and Mushet gave very important information about wootz steel, the mystery of this material could not be unravelled at that point of time.

Stodart and Michael Faraday were engaged in their efforts in the laboratory of the Royal Institution to imitate the wootz steel. In this context, Faraday carried out the chemical analysis of the wootz steel and published his findings in 1819.[13] He concluded that the excellent properties of the wootz steel were due to the presence of alumine (alumina) and silex (silica). Stodart and Faraday were also involved with the work on the alloys of steel and used both English steel and Indian steel wootz in their experimental study. Their findings were published during the period 1820–1822.[14,15] An interesting feature was that they used Indian crucible steel obtained both from Bombay and Bengal, which were designated as Wootz (Bombay) and Wootz (Bengal) respectively.[16]

Stodart was so much overwhelmed with the excellent quality of the wootz steel that he mentioned in his trade card the fact that the wootz steel is to be preferred over the best steel in Europe, which reads as shown in Fig. 1. A photograph of the original trade card is shown in Fig. 2. An important point to note in the present context is that Stodart wrote the name of the Indian crucible steel in Devanāgarī script (which is used to write texts in Sanskrit and Hindi languages) with its transliteration in Roman script as "wootz" in parentheses on his trade card. This helps in understanding the origin of the word wootz. It appears that this word in Devanāgarī script was engraved/imprinted on the Indian crucible steel cakes sent to Banks, and Stodart reproduced the same textual matter on his trade card.

J. Stodart

No. 401, Strand, London.

Surgeons Instruments, Razors & other

fine Cutlery, made from उत्स (Wootz), a Steel

from India, preferred by Mr. S. to the best

Steel of Europe, after years of comparative trial.

Fig. 1. Text of the trade card of James Stodart.

Fig. 2. Photograph of the original trade card of James Stodart. © The Trustee of the British Museum. All rights reserved. This photograph cannot be reproduced in any form without the permission of the Trustees of the British Museum, London.

DISCUSSION

Monier-Williams provided the English equivalents of the Devanāgarī letters in his famous *Sanskrit-English Dictionary* published in 1899.[17] This is the standard practice used by the scholars for the transliteration of Sanskrit and Hindi words in English. According to this standard practice, the word written by Stodart in Devanāgarī script on his trade card should be transliterated as "*utsa*" in Roman script. Monier-Williams transliterated this particular word in this manner in his dictionary.[18]

It is understandable that there was no standard convention adopted by the officials of the East India Company deputed in India for the transliteration of Sanskrit and Hindi words in Roman script in the late eighteenth and early nineteenth century. It was a common practice by the English people stationed in India in colonial times to use long sounds for certain vowels of Sanskrit and Hindi words. This practice continued even in the late nineteenth century. Some examples are: Hindoo (for Hindu), Bengāl (for Bangāl), Bareilly (for Barelī), Balliā/Ballia (for Baliyā), Cāwnpore (for Kānpur), Bunārus/Benāres (for Banāras), etc. In the background of this fact, it is apparent that Scott made an error in the transliteration of the Sanskrit word *utsa* for the Indian crucible steel, and he erroneously transliterated it as "wootz" in Roman script. It must be said that it was an unintentional error on the part of Scott, but it led to an erroneous, and sometimes wild, explanation of its etymology by the researchers in the later period.

An important question that arises is as to what is the meaning of Sanskrit *utsa*. Does the meaning of *utsa* conform to the characteristic of the Indian crucible steel. It is well known that the Indian crucible steel was ultra high carbon type. Typically the carbon content of the Indian crucible steel was about 1.5–2.0 wt.%.[19]

Utsa is a Sanskrit word, and has a very ancient origin. It has been referred to a number of times in the oldest Vedic literature *Ṛgveda*. The most common meaning of *utsa* is a spring or fountain. It is also used for a watery place. It is also metaphorically applied to denote clouds. In *Ṛgveda* (2.24.4, 5.32.1, etc.), *utsa* has been used in the sense of clouds.[20] *Śabdakalpadruma*, a Sanskrit lexicon composed somewhere around 1835 A.D. by Rādhā Kānta Deva, has referred to the statement of Kokkāṭa, which is as follows:[21]

> *Ajasraṁ mandavegena sravajjale. Iti Kokkāṭaḥ.*
> [English translation: According to Kokkāṭa, the place from where water continuously comes out very slowly, i.e. oozes out, is called *utsa*.]

The above reference has used the Sanskrit *jala* for water. Thus, the place from where water oozes out is also known as *utsa*.

Before finding out the reason for using the word *utsa* for the Indian crucible steel, it is necessary to discuss some of the characteristics of this steel.

As stated earlier, Pearson carried out experiments on wootz steel on the request of Banks. He presented his findings before the Royal Society on June 11, 1795. One of his experiments is very relevant for the present discussion, and it would be discussed here.[22] Pearson heated a piece of wootz steel, weighing approximately 500 grains, in a closed vessel for above 1 h to "a pretty considerable fire". The temperature of the fire was equivalent to 140° measured by Wedgwood's pyrometer. On cooling, Pearson observed that the specimen of wootz retained its form. An interesting observation made by Pearson was that "many round particles as large as pins heads adhered to its surface, as if matter had oozed out by melting." This clearly shows that a liquid phase was formed in the wootz specimen, when it was heated to the chosen temperature of the fire used in the investigation. The nature of the low melting point phase present in the wootz steel cake, used by Pearson in his experiment, cannot be indentified due to lack of its chemical analysis.

It is well known that wootz steel was also used for making sword blades exhibiting different types of patterns on its surface, both in India and abroad. Smith stated that Damascus blades were forged from the legendary wootz steel, originating from India.[23] Thus, an insight into the formation of low melting point phase present in wootz steel can be obtained from the available chemical composition of wootz steel cakes, and also of the semi-finished and finished products manufactured from it.

Chemical composition of several Indian wootz steel cakes and forged bars is shown in Table I[24–27] It can be seen that most of the specimens had relatively higher amounts of phosphorus than that found in modern steels. On the other hand, only one specimen had higher amounts of sulphur, of the order of 0.17–0.18 wt.%. Verhoeven and Jones reported the average composition of Damascus steel blades, based on the chemical analyses of several blades, as follows:[28]

$$\mathrm{C} = 1.60, \mathrm{Si} = 0.043, \mathrm{Mn} = 0.056, \mathrm{P} = 0.107, \\ \text{and } S = 0.02\,(\mathrm{wt.\%})$$

It is apparent that a relatively high amount of phosphorus was also a characteristic of Damascus steel blades.

It is well known that sulphur and phosphorus are important elements forming low-melting point phases in ferrous materials. Sulphur forms Fe-FeS eutectic in steels, which causes hot shortness. Fe-FeS eutectic has a melting point of 988°C.[29] Verhoeven and Jones carried out a series of experiments on the role of impurity elements present in wootz/Damasus steels on the origin of cementite particles present in it.[30] They prepared chill cast Fe-1.7 C-0.1 P-0.015 S (wt.%), which was subsequently remelted, and crucible castings were either air-cooled or furnace-cooled. The above composition was used to simulate the chemical composition of a typical wootz steel cake. Figure 3 shows the microstructure of the remelted and furnace-cooled Fe-1.7 C-0.1 P-0.013 S-0.06 Mn-0.05 Si (wt.%) alloy (Alloy 4). An interesting observation, relevant to the present discussion, was that a different microconstituent, steadite, was

Table I. Chemical composition of Indian crucible steel ingots and forged bars

S. No.	Details	Composition, wt.%							Remark	Ref.
		Fe	C	Si	Mn	S	P	As		
1	Truncated cone shape steel ingot from Gattihosahalli, Chittaldroog District, India, Date: NA	98.314	0.963	0.127	0.097	0.02	0.007	–	(a)	24
2.	Truncated cone shape steel ingot of unknown origin, supplied by the Director, Geology & Mines, Mysore State, India, Date: NA	–	0.45	0.14	–	0.01	0.27	–	(b)	25
3.	Forged wootz bar from India, supplied by Lewis Humbort, Military Deptt., India House, London	98.092,98.100	1.333,1.340	0.045,0.042	–	0.181,0.170	–	0.087, 0.086	(c)	26
4.	Forged wootz steel bar (1 cm × 5 cm × 29 cm size) from Alwar Armory, India, bought from R. Charlton, USA, having well defined damasked pattern in the central region, Date: app. 1700 AD, Bar 1, Piece 1, Location A (rim region)	–	0.66	0.09	<0.01	0.006	0.092	–		27
5.	Do, Bar 1, Piece 1, Location B (central region)	–	1.48	0.09	<0.01	0.007	0.104	–		27
6.	Do, Bar 1, Piece 2	–	1.47	0.10	<0.01	0.007	0.100	–		27
7.	Forged wootz steel bar (1.3 cm × 3.2 cm × 58 cm size) from Alwar Armory, India, obtained from Oriental-Arms Ltd, Haifa, Israel, central portion showing Damascus pattern, analysis was carried out at the central region	–	1.24	0.04	0.05	0.001	0.066	–		27

Remarks
(a) wt.% C reported is the total carbon
(b) Average analysis by collecting samples from different places of the ingot
(c) Silicon was stated as "Silicium" in the concerned reference

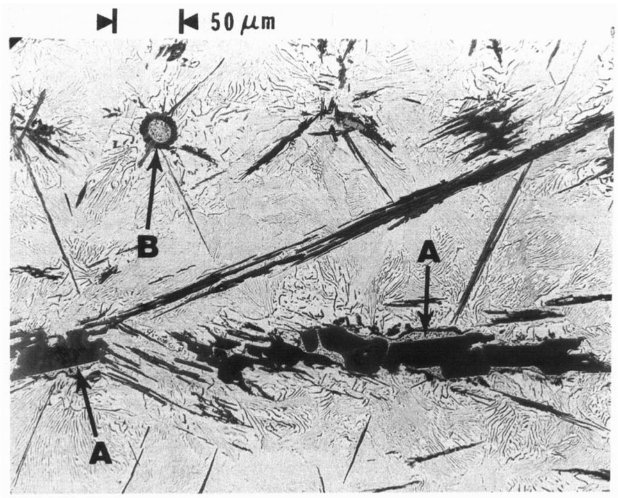

Fig. 3. Microstructure of the as cast crucible steel ingot (Alloy 4).[30] Cementite etch. A = Steadite on faceted dendrite, B = Steadite sphere.

present along with cementite. Steadite is a ternary Fe_3P-Fe_3C-Fe eutectic having melting point of 950° C.[31]

Thus, it can be said that the temperature corresponding to "a pretty considerable fire", as used by Pearson in his experiments on wootz steel described earlier, was just sufficient to melt some low-melting point phase present near the outer surface and on the grain boundary of the wootz steel specimen. The molten low melting point phase oozed out on the outer surface of the specimen, and solidified in the form of pinheads. Thus, the oozing out of liquid at moderate temperatures was an important characteristic of the wootz steel.

The meaning of the Sanskrit word *utsa,* together with its definition according to Kokkāṭa has been discussed earlier. The behaviour of wootz steel of oozing out of low melting point liquid phase when heated at moderate temperatures has similarity to that of the oozing out of water as mentioned in the definition of Sanskrit *utsa* according to Kokkāṭa. It is interesting to note that Sanskrit *jala* also means any fluid or liquid.[32,33] In the background of the above, it is apparent that the usage of the Sanskrit word *utsa* was extended to ultra high carbon steel, which has the characteristic of oozing out of low melting point liquid phase when heated to moderate temperatures. A similar case in point is the usage of the Sanskrit word *vajra*, which has been used for three different type of materials, such as diamond, a kind of hard mortar or cement, and a kind of hard iron or steel.[34] Such a usage is due to the fact that there is a common factor of the relatively high hardness of these three materials in their respective material category.

To be fair to Dr. Scott, it must be said that he had all the intention of conveying the exact pronunciation of the Sanskrit word for the legendary Indian crucible steel to his people in England, but due to lack of the availability of the standard procedures or rules for the transliteration of Sanskrit words into Roman script, he erroneously transliterated Sanskrit *utsa* as "wootz" in Roman script. This created confusion in establishing its etymology. In view of the fact that there is now a standard rule for the transliteration of Sanskrit words written in Devanāgarī script into Roman script, it is our duty to use the Sanskrit word used for the world-famous Indian crucible steel as "*utsa*" in Roman script. I appeal to all to do the same.

SUMMARY AND CONCLUDING REMARKS

In the last decade of the eighteenth century, the Sanskrit word *utsa* was used for Indian crucible steel in the Mumbai region of India. Due to its excellent hardness, this steel was held in high esteem amongst Indians. Helenus Scott erroneously transliterated it in Roman script as Wootz in a letter addressed to Joseph Banks in 1794. Since then, this terminology has been in usage for Indian crucible steel in technical literature throughout the world.

One of the greatest admirers of Indian crucible steel was James Stodart, the famous surgical instrument maker, cutler and metallurgist of his time in England. He carried out extensive experimental work on this steel. Stodart was so much overwhelmed with the excellent quality of the *utsa* steel that he mentioned on his trade card the fact that the *utsa* steel is to be preferred over the best steel in Europe. An important point is that Stodart wrote the name of Indian crucible steel *utsa* in Devanāgarī script (which is used to write texts in Sanskrit and Hindi languages) along with its transliteration in Roman script as "wootz" in bracket on his trade card. In this manner, Stodart preserved the original Sanskrit nomenclature *utsa* used for Indian crucible steel in print for future generations, for which the metallurgical community would remain grateful to him.

In one of the experiments carried out by Pearson, it was found that when *utsa* steel was heated at "a pretty considerable fire", and cooled, "many round particles as large as pins heads adhered to its surface, as if matter had oozed out by melting." This clearly shows that a liquid phase was formed in the *utsa* specimen, when it was heated to the chosen temperature. One of the meanings of the Sanskrit word *utsa* is the place from where water oozes out. It is apparent that the usage of the Sanskrit word *utsa* was extended to Indian crucible steel, which had the characteristic of oozing out of low melting point liquid phase when heated to moderate temperatures.

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