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MATERIAL EVIDENCES FOR WOOTZ STEEL PRODUCTION IN NORTHERN TELANGANA

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Iron and wootz steel industry was an important industrial activity of Telengana region, especially during the pre-modern period. A detailed survey of the villages in the region was conducted in order to obtain material and physical evidences that indicated the widespread nature of this industry. During the course of the survey, several material and physical evidences were collected. These evidences confirm that iron and wootz steel manufacture was a large scale activity in this region, before wootz steel was officially banned by the British in the middle of the 19th century. In particular, the large heaps of slag, which in several cases spreads over miles of land, point to the large scale nature of the iron and steel industry. In addition, remains of iron smelting furnaces have been unearthed in the forests of Adilabad district and this has been brought to light for the first time in this communication. With specific reference to wootz steel, a large number of crucibles and different types of crucible remains have been recorded at several villages and these evidences confirm that these villages were centers of wootz steel production in the medieval period. The large varieties of wootz crucibles indicate the multifaceted dimension and application of wootz steel ingots for the fabrication of a wide variety of cutting objects, in addition to confirming the relatively large-scale production of wootz ingots from this region. Apart from these direct evidences, several indirect evidences in the form of materials wrought out of wootz steel (knives, blades and swords) have been also collected. Apart from serving the requirement for conducting a detailed scientific analysis, these material evidences offer direct proof of the important role of the Telangana region in the manufacture of wootz steel during the medieval period.

Keywords: Andhra Pradesh, Furnace, Iron extraction, Iron slag, Medieval period, Survey; Telangana, Wootz crucibles, Wootz steel implements, Wootz steel manufacture.

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Introduction

The Telangana region of Andhra Pradesh was a world-famous centre for wootz steel production for a long period in history. European crusaders received a fright when they encountered swords wrought out of wootz steel in action. A swinging blow with such a sword made of "*telingānā*" steel could cut a man in two even if he was protected with the best European armor. Crusader helmets were of no use against these swords. Remarkably, the swords never shattered or broke even with very rough use. And the best part was, the swords retained the sharp edge even after continuous use. These famed stories of the blades wrought out of wootz steel have been so much quoted in the literature. This is also attested by glowing references to "*teling*" steel by Persian authors and by eye-witness account of European visitors to this region during the late medieval period[1]. Wootz steel from Telangana was exported in large quantities to west Asia and Europe as late as the 19th century, as confirmed by eye-witness accounts[2] and marine trade records[3]. These medieval Persian and European trade accounts confirm the great demand for wootz from Telangana region and the high premium placed on the material.

A large scale industry connected with iron smelting also existed in this region due to the availability of rich iron ore deposits on the surface[4]. This region was particularly famous for wootz steel production, as attested by Persian and European visitors[1]. It is important to study the wootz steel industry of Telangana region in order to place the industry (that has long disappeared due to Industrial Revolution in the west as well as specific laws enacted by the Imperial British government in the middle of the 19th century that banned the production of wootz steel and objects wrought out of wootz steel) in proper perspective. In view of this aim, a detailed survey of a large number of villages in Northern Telangana was conducted recently[5]. Of the 1100 villages surveyed, evidences related to iron smelting and wootz steel making were confirmed in more than 425 villages[5]. During the course of this survey, several evidences were unearthed and these pointed to the large scale nature of the iron and wootz steel industry in this region. These material evidences have been recorded in this communication. A secondary aim of this paper is to show that a large variety of wootz steel crucibles shapes and sizes indicates that wootz steel ingots possessing different shapes and probably

physical properties were manufactured, with the end use determining the king of wootz ingot used for fabricating the product. The paper will first address iron ore deposits in the region, followed by remains of iron making furnaces and finally discuss wootz steel making evidences supplemented with wootz steel materials.

Evidences for Iron Ore Mining

The major minerals found presently in this region are those of copper and iron, in addition to plentiful supply of coal[6]. The common ores of iron found in this region are hematite (Fe_2O_3), magnetite (Fe_3O_4), goethite (FeOOH) and limonite [$FeO(OH)_nH_2O$]. Iron ore deposits are richly distributed in the Deccan and this facilitated easy mining, iron smelting and establishment of number of manufacturing centers. In fact, the iron industry was brisk till the middle of the nineteenth century.

On interacting with the communities that earlier used to practice iron making in this region, it was found out that people used to collect iron ore in the shape of stones or granules or the sand on the surface of the earth. In particular, they did not dig mines to extract the ore. This is also attested by Thevenot, who states that "the mines are mere holes at a depth of a man" (see ref. 1 for a full account of description). This certainly implies that ore was collected from the surface and not from the deep mines. This was aided by plentiful availability of rich ore deposits on the surface.

Iron ore deposits are found in the form of branded magnetic quartzite in Chandoli, Yerabali and in Jagtial *tāluks* of the Karimnagar district. In Karimnagar district, near Amberpet in Jagtial *tāluk*, a large reserve of magnetite-quartz rocks is located. Minor deposits of iron ore are found near Medipalli, Koratla, Kurnipet, Venkatapuram, Tadipalli, Tumbaraopeta, Vemulagundu and Gorapalle in Jagtial *tāluk* and Poligutta, Peeralabaru, Parkalammapeta and Peddagutta in Karimnagar *tāluk*. Iron ore in the form of banded magnetite hematite-quartzite occurs in the Dharwar band at Yerabali in Huzurabad taluk. Historical records reveal that Gorrepalle in Jagtial *tāluk* and Yerabali in Huzurabad were prominent prospect areas of iron ore mining in the medieval period[1].

The Persian manuscript *Tārikh-i-Qutb Shāhī* comments that "during 16th and 17th centuries mining and manufacturing work was very brisk. It

also mentions that iron mines were located at "Indur, Nirmal, Nagalvanca, Machilipatnam, Ramayapatnam, Bhimunipatnam, Mootapalli and Singarayakonda."[7] Many of these places have also been mentioned by Daniel Havart[8], a Dutch traveler who visited Golconda between 1672 and 1685 AD. He noted that "abundance of good quality of iron ore at Golconda region on the surface level was one of the reasons for the presence of good number of mines and manufacturers." He also observed that "the mines here are mere holes through the thin grainitic soil, from which the one is detached by means of small iron crowbars."

Interestingly, most of the villages in the areas surrounding the iron ore deposits were famous for iron ore mining, smelting and iron forge welding. Generally, iron ore was mined and smelted alongside. In almost every village where ever iron smelting was carried out, the village is located near hillocks containing sufficient quantities of iron ore deposits. An example of an iron ore hillock near Shekall in Karimnagar district is seen in Fig. 1. The iron ore deposits in this region are available on the surface as cap-type deposits on hillocks (see Fig. 2) and in the shape of big stone boulders on the hills.

In early times, a stream by the side of the village was a source for the collection of fine quality of iron ore in the shape of black sand in rainy season. A typical stream near Kalleda in Adilabad district is seen in Fig. 3

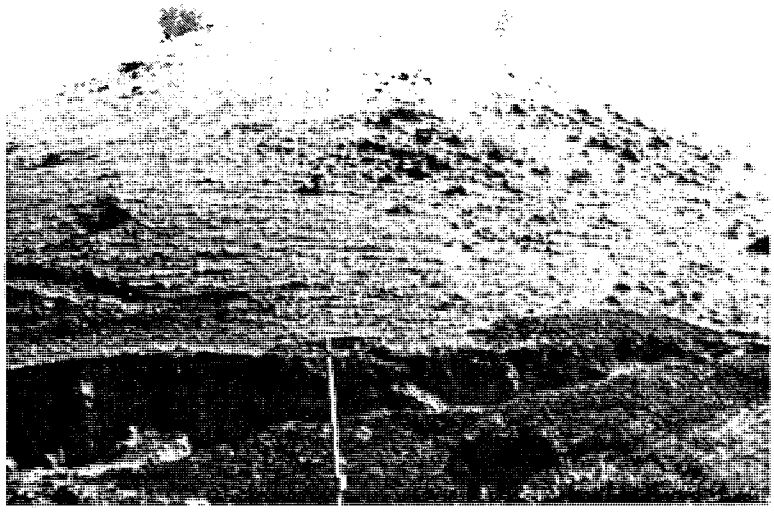


Fig. 1. An example of an iron ore hillock near Shekall village in Karimnagar district.

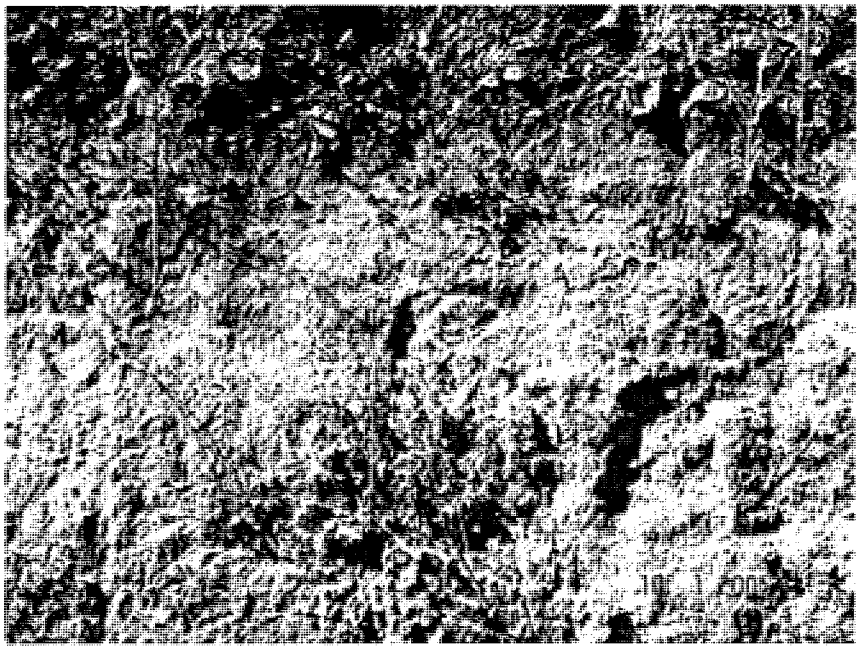


Fig. 2. Cap type iron ore deposits at Neralla village in Karimnagar district.

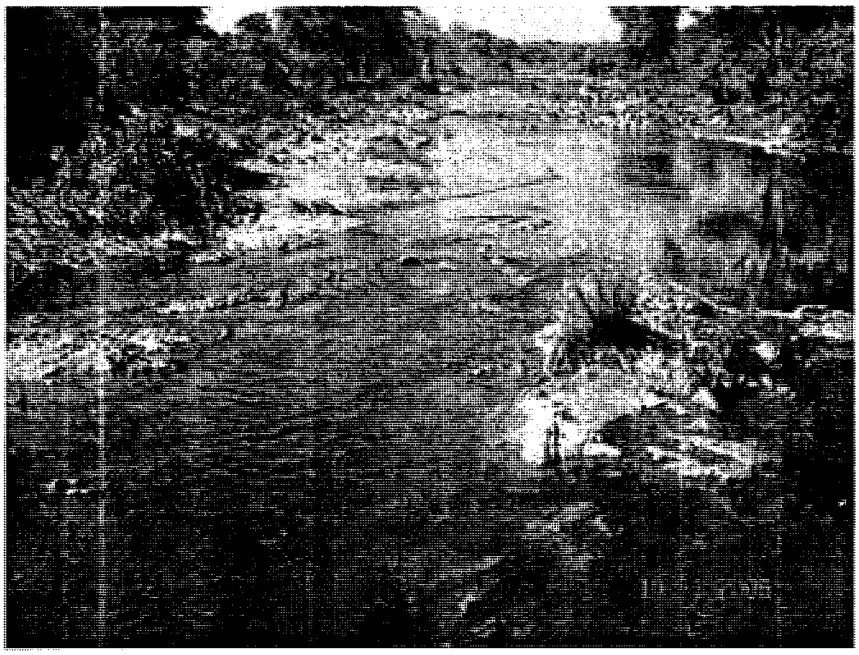


Fig. 3. A black sand stream near Kalleda village in Adilabad district.

and the black sand of the stream is quite evident. It is interesting to note the statements made by members of the iron smelting community called *Muḍḍākāmmāri*, at Dasthurabad village in Adilabad district. They note, "the iron sand collected from stream beds, contains pure iron ore, without any clay or sand particles. It was considered important and used to obtain very fine metal."

Iron was particularly produced by smelting black sand obtained from channels in hills. Remains of these specially-constructed channels in the hills and hillocks can be seen in some places even today. An example from the hill adjacent to the Kalleda village in *Kadem Mandal* is seen in Fig. 4. Several local persons mentioned that they have seen several such constructions in the hills surrounding the villages, but, unfortunately, they are not aware of the significance of these constructions. They incorrectly suspect that these may be the remains of iron smelting '*bhaṭṭies*', which is certainly not the case.

Fig. 4. Remains of specially-designed channel seen on the hills adjacent to Kalleda village in *Kadem Mandal.*

The iron ore deposits are widespread in this region, in the shape of 'cap type deposits'. The iron ore deposits available on surface at a depth of three to six feet. This can be seen on the top of the hills and hillocks every where in the region. The iron ore deposits spread over several miles in this region. As mentioned earlier the iron ore was available on the surface in shape of sand or small stones and big boulders.

Several hillocks containing iron ore deposits (in the form of sand, small stones and large boulders) were identified in the survey. These locations include *Inuparallā guṭṭā* at Medaram village in Dharmaram Mandal, *Usiguṭṭā* in Chekalla village, *Inupaguṭṭā* in Chandoli village in Gollapally Mandal, *Śirikoṇḍāguṭṭā* in Śirikoṇḍā village in Dharmapuri Mandal, *Rajulaguṭṭā* near Choppadandi Mandal, *Erraguṭṭā* in Errapur village, *Warasakoṇḍāguṭṭā* and *Dabbaguṭṭā* in Ibrahimpatnam Mandal, *Koppuguṭṭā* near Rebbanapalli, *Inupa Borlu* at Nambala in Luxittipet Mandal, *Jaṇḍāguṭṭā* and *Āgariguṭṭā* in Bejjur Mandal, *Lohāguṭṭā* in Dehagaon Mandal, *Gangāpur Guṭṭalu* in Gangapur village in Kadem Mandal, *Kalledaguṭṭalu* near Kalleda village in Kadem Mandal, *Jaṇḍāguttā* at Lohā village in Dohagam Mandal in Adilabad, hillocks in and around Ārnakondā and Mallapur villages in Choppadandi Mandal, Endapally and Jagdevepur villages in Velgatoor Mandal, hillocks at Korutla Mandal in Karimnagar district are some examples. It may be noted that, in addition, there are hundreds of hills and hillocks with surface iron ore deposits in the region. The iron content varies from 20% to 70%. The State Mineral Development Corporation has not yet conducted a proper survey of these iron ore deposits in these areas. It is important to do so in order to establish primacy of iron industry in Telangana region.

Some feedback was also received regarding the trade in iron ore during the past days. The iron smelters in ancient and medieval periods empirically knew the iron content based on experience. The miners supplied the ore to the smelters on a regular basis. The payments were made on weakly or monthly or annual basis, at a fixed rate. The ore was also sold in the weekly markets, big bāzārs, and *Aurangs* in medieval cities and towns. Itinerant traders used to sell the ore in the villages. Some ideas of the rates of the iron ore are available from medieval market records[9,10]. This subject has not been researched in much detail and the economic aspects of iron and wootz steel trade in Deccan requires a detailed study. The smelters generally

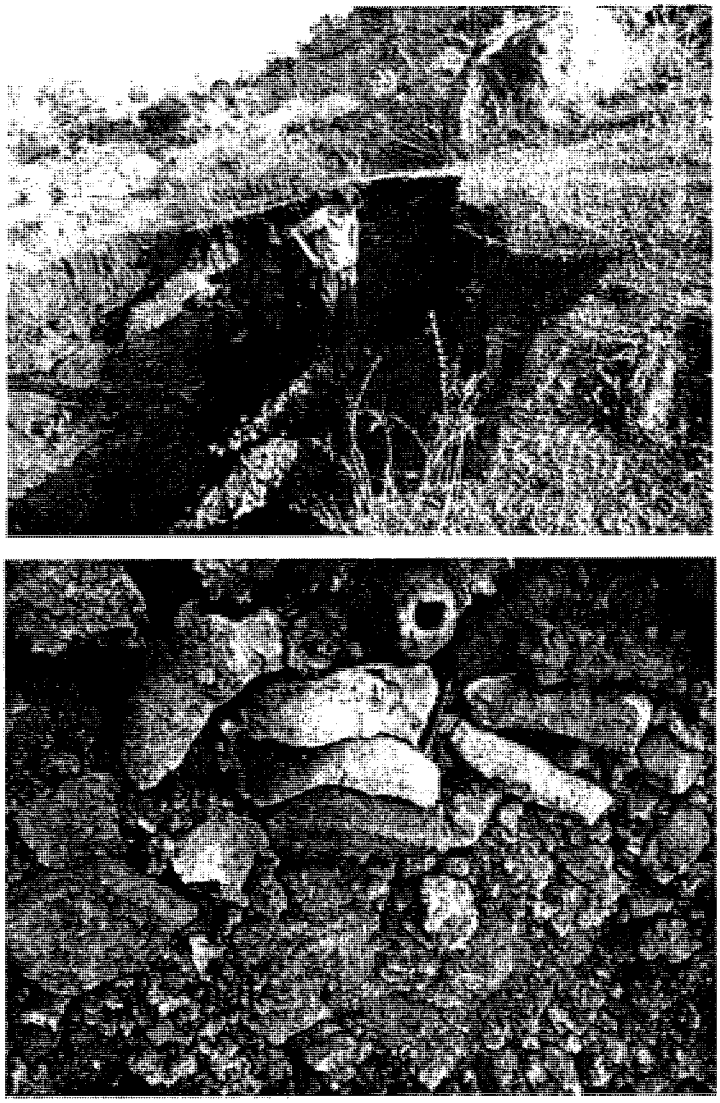
stayed close to the forests, to smelt the ore, because of easy availability of wood in the forests to make charcoal. The use of mined coal was not known and all iron smelting was practiced using charcoal. Charcoal was generally made using bamboo wood, rose wood ('*Gittregī* ' tree), and '*Mahuā* ' wood or '*Ippā* ' tree ('Bessie latifolia').

Evidences for Iron Smelting

The basic design of iron smelting furnace remained fairly constant during a long period in the history of the Indian subcontinent as it was produced primarily by the direct reduction method, i.e. reduction of iron ore in a small shaft furnace using charcoal. Some regional varieties have been reviewed by Tripathi[11]. Remnants of slag and furnace parts were discovered at Ranamkota, in Dharmapuri Mandal in Karimnagar district (see Fig. 5). A furnace was also unearthed at this place which was not found in other sites. Moreover, the slag found here is different from the slag from other sites of the region. Jake Keen[12], who visited this site on the third of December 2006, commented that this site could be at least 2000 years old.

The observations and findings in the survey indicate that the furnaces were generally constructed with clay, based on its easy availability. Different types of clays are available and the iron smith was particular in choosing the right clay for the right application[13]. For example, the clay used for making wootz steel crucible was different from that used for making iron smelting furnace. This traditional knowledge was handed through generations of practise and this knowledge now appears to have been temporarily lost since the traditional iron and steel industry in this region has disappeared. Remains of different types of furnaces were found in all the districts of Telangana.

There are two general methods by which the slag resulting from iron smelting was tapped from the furnace. In the first type, slag was tapped by piercing a hole on the lower side wall of the furnace, which resulted in the slag flowing out of the furnace (i.e. slag tapped furnace). Later the iron bloom was removed from the furnace and consolidated by hammering, so as to remove the remaining entrapped liquid slag as well as to compact the bloom. In another type of furnace construction, the slag was allowed to settle in the bottom of the furnace such that it remained in the furnace (i.e. plano convex bottom furnace). The iron bloom was removed as usual and



(a)

(b)

Fig. 5. (a) Old slag site at at Ranamkota, and (b) debris of furnace discovered among the slag.

consolidated. When the furnace cooled down and the solidified slag at the bottom was removed, it was in the shape of a circular disc with a plano convex bottom. A good number of such slag pieces in the intact condition were discovered in several places in Adilabad and Karimnagar districts. An example of a slag piece with a plano convex bottom obtained from Kalleda

village is seen in Fig. 6 while the remains of iron making furnaces (most probably plano convex bottom type) discovered at Kalleda forest in Adilabad district are seen in Fig. 7.

Fig. 6. A typical plano convex bottom slag piece obtained from Kalleda village.

Fig. 7. Remains of iron making furnaces at Kalleda forest in Adilabad district.

Using either the slag tapped furnace or the plano convex bottom furnace, the end result was an iron bloom. This iron was not obtained in the melted state but in the solid reduced state. It was generally shaped like a cauliflower. One example of a partially consolidated iron bloom is shown in Fig. 8. After consolidation of the bloom, different shapes could be produced. Generally, the blooms were the products of the iron smelter which was traded. The blacksmiths who purchased this utilized the blooms for making a wide variety of objects. An example of a relatively large consolidated iron bloom collected from Agaram village in Adilabad District is seen in Fig. 9.

Evidences for Wootz Steel Making

The specific term for wootz steel in local Telugu language is '*wokku*' or '*ukku*'. The literal meaning of '*ukku*' is '*ayassaramu*' or 'essence of iron'. Another meaning of the term '*ukku*' in Telugu is "strength". The term '*Telaga ukku*' was used for similar material, but one that was very tough. Similar to the usage in English where the adjective 'iron' is used to indicate a tough or courageous person (for example, 'Iron man' or 'Iron lady'), the word '*Ukku*' is used in Telugu to denote toughness or courage or strength, like for example '*ukku manisī*' (Iron man) or '*ukku-tunaka*' (a brave, sharp or active man).

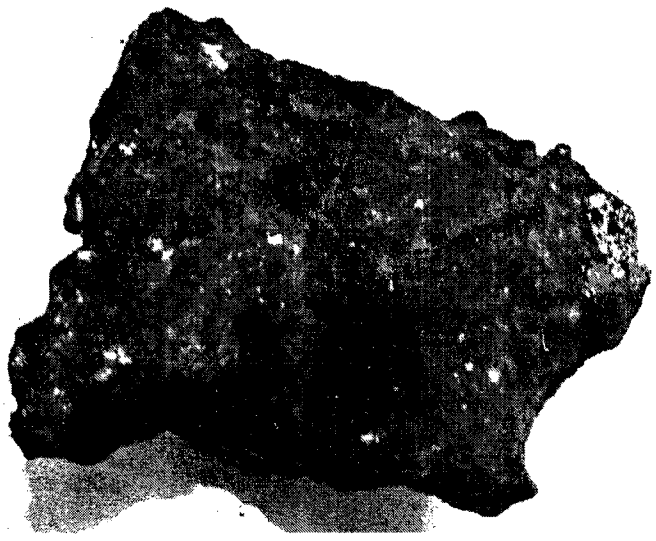


Fig. 8. A partially consolidated iron bloom collected from the Telangana region.

Fig. 9. A consolidated iron bloom collected from Agaram village in Adilabad District.

Wootz steel was a wonderful creation of ancient Indians. This was high carbon steel that was specially worked in order to produce tough cutting objects. The primacy of Deccani wootz (dating to times prior to 300 BC) has been established from historical records[14].

It is clear that wootz steel was manufactured in refractory crucibles and different shapes of crucibles have been mentioned in the literature[15]. Although differences have been made out in the wootz making crucibles of Indian subcontinent (i.e. Hyderabad type, South India type, etc.)[16], a careful survey of wootz crucible remains from the Telangana region has revealed that a wide variety of crucible sizes appear to have been used. The crucibles that were collected from the Telangana region are subjected to a proper technical analysis and the results of the study will be presented in the next issue.

It is understandable and reasonable that wootz steel ingots of different sizes were manufactured because the size of the ingot was based on the end application of the ingot. For making small blades, the ingots were smaller compared to larger ingots used for making larger blades. In fact, physical evidences for the use of different size ingots have been obtained. However, the common feature noted was the cylindrical shape of the crucible, which gradually reduced in diameter from the bottom or to the top, and the provision of a lid on the top in the shape of pine cone.

The wootz making crucibles were called '*Konam pavulu*' or '*Wukku pavulu*' in the Telangana region. Based on feedback received from the local people, the following information was gathered first hand. In each refractory crucible, two pieces of iron and one wood piece were placed. The wood pieces were of '*Thengādu*' or '*Paidī Thengādu*'. At some locations, the crucibles were filled with leaves locally known as '*pulayīlauk*'. The top of the crucibles were closed with clay. The number of crucibles that were placed in the furnace depended upon the size of the ingots that were to be produced. This also leads us to an important conclusion that wootz steel ingots of different sizes were produced with the aim being that different sized objects could be produced using wootz ingots of different sizes. For example, a small ingot would suffice for producing a small blade but will not be sufficient for fabricating a long sword.

Generally, about three to four dozens (36 to 48 numbers) of crucibles were kept in the furnace, which was called as '*bhaṭṭi*'. Interviews[13] with senior blacksmiths indicated that the number of crucibles may be as high as 64. The furnace was constructed with local made bricks and plastered with clay. The furnaces were charged with charcoal continuously and air blown into the furnace by using tuyeres. There are several intricacies regarding wootz steel making furnace construction and this has been described in detail, elsewhere[17].

The base of the wootz crucible was always made a little concave. These were called, in local language, as '*konam pavulu*' or '*wukku pavulu*'. Interestingly, the villages Konasamudram and Konapuram etymologically recollect their association with wootz crucible and wootz making. Another feature that was noted in the survey was that there are several villages in the Telengana region with the name 'Konasamudram' or 'Konapuram', and in most of these villages iron (and wootz steel) was produced in the medieval period.

The presence of remains of crucibles was recorded from several places (see Fig. 10). In villages like Konasamudram, we can notice large number of crucibles even in the by-lanes of the village.

A survey of the traditional wootz steel making centres of northern Telangana[5] indicated that the best varieties of wootz steel ingots were produced at Ibrahimpatnam (present *Maṇḍal* headquarters in Karimnagar district, quite

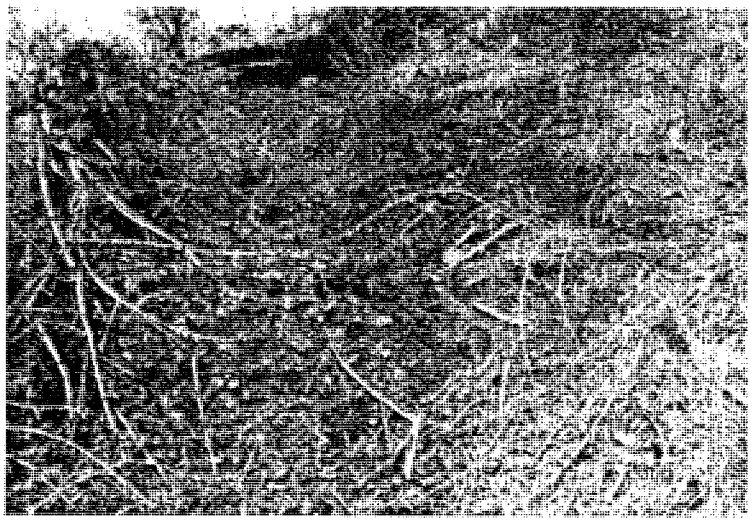


Fig. 10. A heap of crucibles seen among debris at Konapuram in Nizamabad district.

near to the famous wootz steel centre of Konasamudram), Nandi Medaram in Dharmaram *Maṇḍal*, Jagtial and Kalleda in Jagtial *Maṇḍal*, all in Karimnagar District; Konapuram, Basheerabad, Dindurthy and Konasamudram in Nizamabad district and Nirmal, Kalleda and Rebbanapally in Adilabad district.

An interesting sight at Ibrahimpatnam village is information about a huge heap of crucible slag. Mattela Gangaram, aged about 86 years, the most senior blacksmith in the village, narrated the following on 26 January 2006: "All the roads, ditches and streets are filled with this remains of crucible slag. This '*citeapu peṇṭā*' or '*citeapukuppā*' (slag heap) has been now reduced to ground level." At present two big protected water supply tanks have been constructed on this heap of crucible slag, as this place is located at high elevation in the village. It is possible to collect used crucibles from several locations in Konasamudram. Craddock[18] narrates hut walls in Konasamudram village that were constructed out of used crucibles.

A large number of remains of crucibles were collected from several locations in the Telangana region (Fig. 11). It was found that the thickness of the crucibles was not constant and there were differences noted. It is also certain that there was much difference in the sizes and shapes of the wootz steel ingots. The weights of the wootz ingots produced here ranged from half

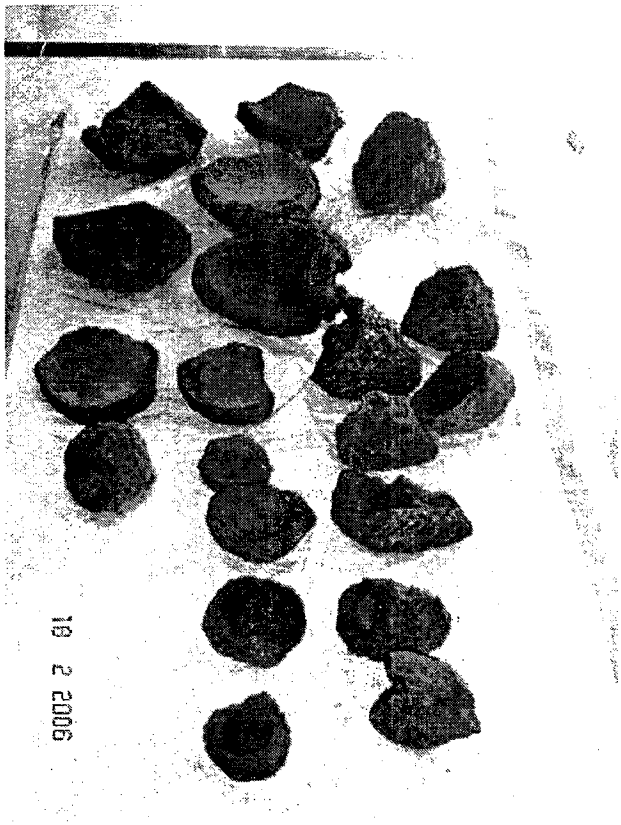


Fig. 11. Wootz crucibles collected from several different sites in Telangana.

kilogram to several kilograms and it appears that the ingots possessed a concave bottom. Fortunately, we were able to collect two wootz ingots from the region and these are shown in Fig. 12. In the case of the larger ingot, it was also possible to match the bottom of the ingot with a crucible base found in the same region, thereby additionally confirming that the ingot did indeed originate from Telengana. The larger one is approximately 11 cm in diameter and 2.5 cm in thickness in the thickest portion, while the smaller ingot is approximately 6.5 cm in diameter and 2 cm in thickness at the thickest portion. The larger wootz ingot was obtained from Konapuram village in Nizamabad district of Andhra Pradesh and its weight is 1.5905 kg. The smaller wootz ingot was also from Konapuram village in Kammarpalli Mandal of Nizamabad district of Andhra Pradesh and it weighs 0.4254 kg. These two wootz ingots are now in IIT Kanpur undergoing a detailed non-destructive

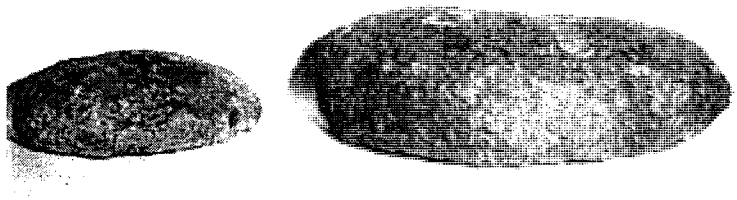


Fig. 12. Wootz steel ingots discovered in Konapuram village Nizamabad district of Andhra Pradesh. The larger wootz ingot weighs 1.5905 kg while the smaller ingot weighs 0.4254 kg.

study and these wootz ingots will be deposited with the National Museum, New Delhi, once the studies are over.

Another interesting aspect of wootz steel usage was the availability of several implements, still used by the local population that had been wrought out from wootz steel. There was much demand for this wootz steel within the region from local buyers. Generally, the implements of artisans would always have been made with wootz steel. Even to this day, wootz steel implements are very much in use and also in demand. Some examples are discussed below.

One use of wootz steel was that it was used for covering anvil in order to provide a tough and hard surface. Locally, the anvils are called *'Dakhalī'* and in Hindi as '*Nihāi*'. Some of the smiths anvils are to be found implanted with wootz plate on the surface. Some of the smiths are still using anvils, which they inherited from their ancestors and these anvils are quite old. One example of a smith's anvil in which wootz steel plate has been used on the surface is shown in Fig. 13. The sharpening of the wootz implements is now done by all the blacksmiths on their common iron anvil. They use specially made surfaces of the anvil. Surface of the anvil is forged with nine wootz spike pieces for handling the sharp implements.

Some other examples of objects wrought out of wootz steel are shown in Fig. 14. These include toddy taper wootz knives from Jagtial and *khater* (or *kitār* or *pañcakātārī)* from Jagtial, *Khanjer* from Konasamudram. These are living examples of the wide-spread popularity of wootz in this region.

Currently, it is interesting to note that, in these villages, there are a good number of smiths working with their old ancestral implements made

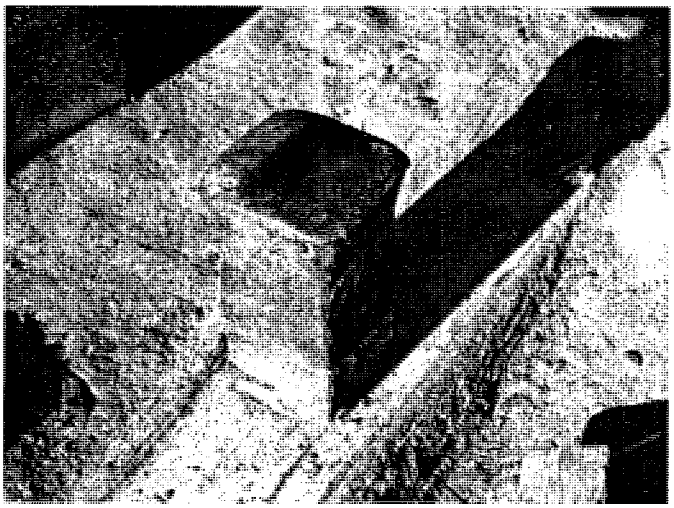


Fig. 13. One example of a smith's anvil in which wootz steel plate has been used on the surface. This is from Ibrahimpatnam in Karimnagar District.

up of iron and wootz steel. The tools of the traditional blacksmiths of this region need to be carefully studied and catalogued. Surprisingly, the local occupational groups, particularly the toddy toppers and butchers express their displeasure and discomfort in using modern steel implements. Similarly, other artisans like blacksmiths, carpenters and woodcutters, prefer to use the implements made with traditional wootz steel. Some of the tools used by the local artisans that are wrought out of wootz steel are seen in Fig 14. In addition, the people in this region traditionally possess swords and other warfare objects from the medieval period, some examples of which are seen in Fig. 15. This is generally handed down as family heirlooms. Unfortunately, the people are not aware of the value of these objects and the rare swords and other objects usually are sold off to middle men, who in turn sell them to valued customers both in India and abroad. There is a dire and urgent need to catalogue the wootz-based objects that are still with the people of this region.

There are several numbers of villages in the region that were involved in wootz steel production which are not properly identified[5]. Some of these village sites appear to have been active sites in different period of history like ancient, medieval and early modern periods. The authors found several remains of unexcavated furnaces in Adilabad forests. It needs careful study

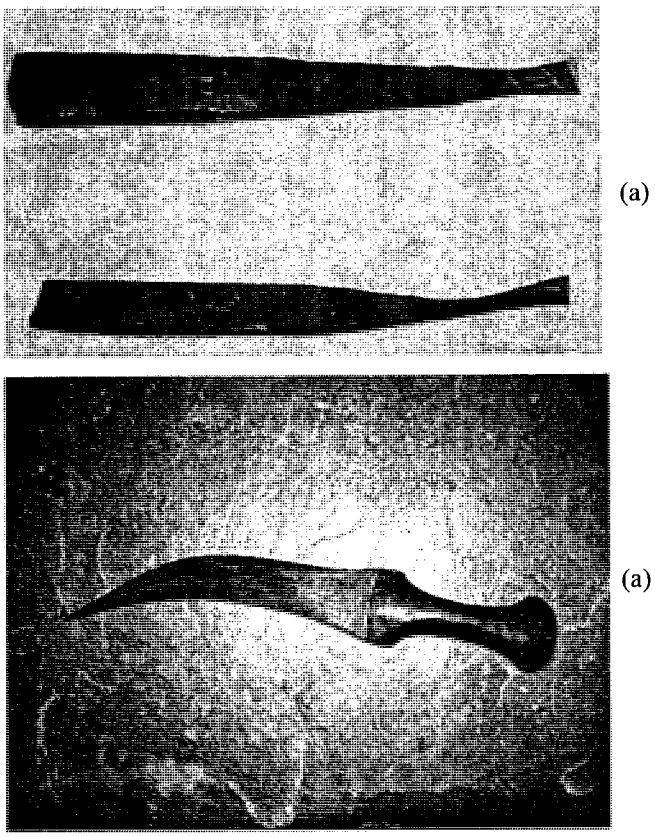


Fig. 14. Some wootz steel implements used by local artisans of Telangana: (a) toddy taper wootz knives from Jagtial, and (c) *Khanjer* from Konasamudram.

to record more information and dating tests have to be done in this regard. Looking at the slag spread sites and remains of wootz crucibles one can assess the grand scale production activity of this region. However, at present it is not known to the people who are living in the same villages. Even most of the blacksmiths who are living now in the villages in and around the slag fields, do not know anything about the smelting of iron, iron ore or processing of the wootz steel.

Epilogue

It is very clear that the making and processing of wootz steel was in vogue in many villages in northern Telangana districts, in the medieval period. The region was not only famous for the iron and wootz steel but also

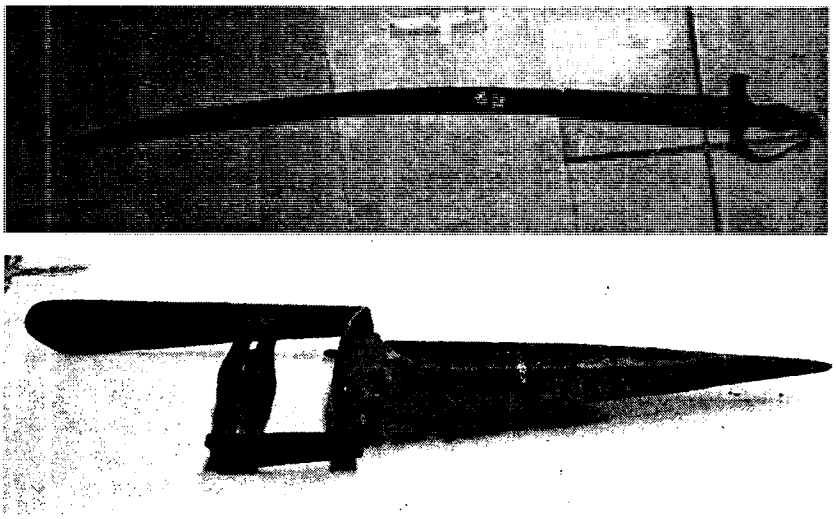


Fig. 15. Some wootz steel objects that were found from the region: (a) sword (broken) and (b) *Khater* (or *kitar* or *pañcakāṭārī*) from Jagtial.

famous for making tools for the occupational groups, arms and artillery production. There were several thousands of people working in manufacturing units in the medieval period. Kodimayal, Lingapur and Dammannapet were famous for cannons and matchlock gun barrels, Poodur and Kodimayal were best cutlery and arms producing centers. Elgandal, Jagtial, Konasamudram and Kathalapur were famous for sword production and arms industry in the medieval period. Kodimayal was producing forge welded cannons. Till today this village is distinguished for making the best of tailor scissors and bronze-ware products. It is encouraging to note that the people in this region continued to excel in the workmanship and handling of the wootz steel implements till to this date. Historical case study and archaeometallurgical studies would go a long way in probing the quality and extent of wootz steel making and processing in this region. It would further help in understanding the local talent available for making world class wootz steel again in India.

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