CHAPTER III: History of Researches and Literary Sources
History of Researches:

While going through the researches devoted to various aspects related to the antecedence and subsequent use of iron in the Indian subcontinent, the eastern Indian perspective has obviously come to the fore. Several archaeological endeavours along with a major thrust on pre-industrial iron working process have meaningfully explored various issues on the chrono-cultural contexts of iron, methods of its (iron) production etc. Retrieval of primary data (Buchanan, 1807, 1930; Heyne 1814; Voysey, 1832: 245-247; Percy 1864; Ball, 1880 and others) has ultimately resulted in the reconstruction of historical realities associated with the use of iron and in such reconstruction, eastern Indian contexts have often been mentioned as mere references. One must keep in mind that the growing interest among the scholars regarding various issues of the use of iron is not only because of unfurling of new data on the old iron workings/ metal workings and the references to iron found in several literary sources. It is essentially due to the precise evidence of metal objects or tools found in different chrono-cultural contexts mostly associated with other archaeological assemblages (retrieved from the different parts of the subcontinent) that encouraged one to hypothesize, contradict and raise the debates on the history of the use of iron (Hadfield, 1912: 94-100; Bhandarkar, 1913-14: 186-226; Neogi, 1914; Banerjee, 1965 and others). The reconstructed history of the use of metals is thus primarily based on the studies of the distribution of old workings, available data in several literary sources and archaeological contexts of the particular metal. The presence of metal and its extensive use in a settlement are separate issues and the evolution of such historical process i.e., from the mere presence of metal, its limited use, proliferated use and finally to its extensive use has different manifestations in cultural reconstruction. One may also visualize the evolution of metal extraction and smelting activities as the part of this historical process. Thus, venturing into different aspects of such manifestations form the basis of historical reconstruction. The fundamental understandings found in the works of P.C Ray (Ray, 1903) probably signify the formative phase of research on the use of Indian iron. P.C Ray in his work on Hindu Chemistry opined that “Since the days of Sir W. Jones, Sanskrit literature, in almost every department, has been zealously ransacked by scholars, both European and Indian. As the results of their labours we are now in possession of ample facts and data, which enable us to from some idea of the knowledge of the Hindus of old in the fields of Philosophy and Mathematics including Astronomy,
Arithmetic, Algebra, Trigonometry and Geometry. Even Medicine has received some share of attention” (Ray 1903: 1). Thus, in his works mainly based on literatures, use of iron was discussed in the context of alchemy. However, his works laid the foundations of such researches which mainly dealt with the delineation of the nature of the use of metal in different aspects of a society, particularly medicine. His attempt subsequently paved the way for considering archaeological sources as one of the significant contributors for such historical reconstruction. The genesis of such research interest is essentially evident from the works of P. Neogi (Neogi, 1914). His work, though mainly meant for searching the origin of iron, has explored a substantial amount of archaeological database. The work of N.R. Banerjee (Banerjee, 1965), in all probability gives new insights on the settlement history related to early/ initial use of iron based on excavated and explored data along with literary sources that referred to the concerned subject. Contributions of Dilip K. Chakrabarti (1974, 1976, 1977a, 1977b, 1979, 1985, 1985-86, 1992) and in subsequent years Vibha Tripathi (2001, 2008) and others on various issues of the use of iron have opened up new avenues of researches and certainly gave a fresh outlook on the existing debates. In their works, archaeological data and metallurgical analysis have been extensively exercised. Their systematic synthesis of database gives us a new theoretical understanding about the concerned subject. The present work does not ignore the importance of the discoveries of archaeological and metallurgical sources along with ethnographic study evidence made since the 17th century CE onwards which were responsible to form the basis of such historical reconstruction on the use of iron.

The present section seeks to review the researches carried out till date on the history of the use of iron. It is however, necessary to state, as a prelude that, here an attempt has been made to categorize the pioneering works based on different themes of the concerned subject like ethnographic, metallurgical, socio-economic aspect etc. Since the researchers have dealt with multiple issues, it is difficult to organize their works in water tight compartments of themes.

If the researches can be put forth chronologically, it can be said that the first phase has been dedicated to understand the properties and manufacturing processes of pre-industrial Indian steel. During the 18th -19th century CE the British administrators intended to obtain Indian iron, specifically wootz which had a great demand worldwide. Wootz is a variety of steel characterized by a pattern of bands or sheets of micro carbides within a tempered martensite or pearlite matrix. The term wootz may have been a
mistranscription of *wook*, an anglicized version of *urukke*, the word for melting in Tamil and Malayalam or *urukku*, the word for steel in Kannada, Telugu and many other southern Indian languages. The legends associated with the excellent properties of the wootz steel and the sophisticated patterns on Damascus blades impelled the Europeans to know its metallographic details.

It was in 1774, the Swedish chemist Torbern Bergman (cited in Smith, 1960) unravelled the mysteries of wootz for the first time and realized that the inclusion of carbon at various degrees ultimately resulted in the production of diverse categories of iron compounds viz. wrought, cast and steel. The first significant work on the method of wootz production was done by Pearson in 1795 (Pearson, 1795: 322-346). According to him, wootz was directly made from ore and his conception that it has never been in the state of wrought iron was subsequently proved wrong. However, Mushet based on reports of European travellers and in light of his own research suggested that wootz steel was never formed directly from the ore but by fusion of fragments of small bars of malleable iron in a crucible with woody carbonaceous matter (Mushet, 1805: 163-175).

Michael Faraday (Faraday, 1819: 319-330) along with the cutler Stodart (Stodart, 1818: 570-571), attempted to make steel by alloying nickel and noble metals like platinum and silver and indeed Faraday’s studies did show that that the addition of noble metals hardens steel. Stodart reported that wootz steel had a very fine cutting edge and also highlighted its utility in making surgical instruments. Further researches in this regard were made by Bréant (Bréant, 1823: 222-227), Wilkinson (Wilkinson, 1837: 187-193), Abbott (Abbott, 1847a: 417-423; 1847b: 666-667) etc.

This genre of research paved the way for the dawn of *ethnographic study* on the indigenous iron smelters. This was aimed at recording the details of the manufacturing process of wootz and other types of iron at different parts of the subcontinent. So far as wootz is concerned, significant contributions were made by Francis Buchanan (Buchanan, 1807, 1930), Benjamin Heyne (Heyne, 1814) and E.H. Voysey (Voysey, 1832: 245-247) who documented the said process in different parts of south India, viz. Karnataka, Kerala, Andhra Pradesh.

W. Cracroft’s description of smelting in the Kasya (Khasia) Hills in 1832 (Cracroft, 1832: 150-151), J.M Heath’s account of the south Indian process in 1832 (Heath, 1832: 253-255) and 1839 (Heath, 1839: 390-397), Legrand Jacob’s report on Kathiawar in 1843 (Jacob, 1843: 98-104), Lt Yule’s report on the Khasia hills in 1842 (Yule, 1843:

So far as eastern India is concerned, Buchanan should be accredited for recording the iron smelting activities of the Kols near the village of Pahiridihi on the bank of the river Urni during his ethnographic survey in the Bhagalpur district in 1810-11 (Buchanan 1930: 15-17). The large scale distribution of iron production centre situated in the north-western parts of the district of Birbhum has found its necessary mention in the contemporary reports of the British administrators. Jackson in his report for the first time mentioned about the use of argillaceous iron ore in the smelting activities at Balia Narayanpur. According to him an iron-ore matrix with brown haematite and small crystalline nodules of magnetite iron ore were used in the said smelting (Jackson, 1845: 754-756). In a note on a specimen of iron object from Ballia-Narayanpur, Torrens gave an explicit description of the site and the methodology for performing iron working activities (Torrens, 1850: 77-78). That in 1852, there were about seventy furnaces in operation at four sites of the region i.e., at Deocha, there were thirty furnaces, about thirty at Ballia-Narayanpur, at Damra four, at Ganpur, about six was first highlighted by Oldham (Oldham, 1852: 7). Besides, he also stressed on the geological contexts of iron ore of the region. Sherwill must be credited for specifically identifying the then existing iron mines of Birbhum which were situated in the western and north-eastern parts of the district, particularly in Tappeh Sarhet-Deoghar, Parganas Nooni, Mallarpur and Mayureswar (Sherwill 1855: 25, 26, 30). Piddington’s assumption of using *kunkur* (Kanakar nodules) as flux in iron smelting gives enough clue regarding the interest of British administrators in establishing iron industry here since the use of flux in iron smelting was not in vogue at least in this part of the country (Piddington, 1856: 212-215).

Robert Rose’s account on the process of iron making at Amdeah near Sambalpur in 1831 and H.F. Blanford’s (as cited in Percy, 1864: 261-262; Oldham 1859: 1-32) description on the nature of iron smelting activities, practiced in the village of Kunkerai of Orissa were significant contributions in this regard.
Such study was further consolidated and acted as one of the sources of information for setting up of iron industry in the subcontinent. Three noteworthy works which summarized the plethora of data (till then collected) on the said subject and organized them are those of John Percy (Percy, 1864), Thomas Turner (Turner, 1895) and George watt (Watt, 1890). John Percy in 1864 not only accumulated the data thus far published in the Records and Memoirs of the Geological Survey of India and other district manuals and various government records but also classified the then existing iron smelting furnaces into three basic types (Percy, 1864: 257-263). He was followed by another metallurgist Thomas Turner (1895) who also gave a précis on the small blast furnaces of India. In 1890, a concise summary of the available evidence both on the distribution of ores and the pre-industrial smelting practices was published in the fourth volume of George Watt’s *A Dictionary of the Economic Products of India* under the heading of ‘iron’ (Watt, 1890: 499-513).

In 1880 the works Valentine Ball need special consideration as he has dealt with both the geological contexts of iron ore and also the ethnographic data related to iron working methods of the Agarias of the Palamau region of Jharkhand (Ball, 1880/ 1985: 666-669). Ball also gave enough insights on the iron works of the Birbhum region. In 1877, on his report on the geology of the Rajmahal hills (published in the Memoirs of the Geological Survey of India in 1877) he referred to the principal works on Birbhum iron smelting activities while describing the economic resources of the region (Ball, 1877: 87-94). These were by T. Oldham, on ‘examination of the districts in the Damoodah valley and Beerbhoom producing iron ore’ in 1852 (Oldham, 1852), by J. Barratt in 1857 (Barratt James 1857. *Report on the Iron Works: Iron, Copper, Lead, Ores, Coal and Lime of Beerbhoom*), by W.T. Blanford in 1860 (Blanford W.T. 1860. *Report on the Beerbhoom Iron Works*) and by Sowerby (the Manager of the Kumaon iron-works), also reported upon Beerbhoom iron. Some illustrations made by Oldham of such furnaces, used in the Birbhum district have also been reproduced in the said volume of the Memoirs of the Geological Survey of India. However, incorporation of such illustrations (published in same volume) on the refining and forging activities of iron smelting of the region should be counted as one of the unparalleled contributions in such study. This gave a complete demonstration of the said works. Another interesting work in this regard, which deserves special mention, was made by E.R. Watson (Watson, 1907). He not only discussed on east Indian iron smelting of the nineteenth century but on the blacksmith’s craft at the
village level - the different iron objects used by them and the methods of their manufacture. A synoptic account of the east Indian iron industry as a whole with considerable emphasis on the pre-industrial practice was given by Charles Ritter Von Schwarz in 1901 (cited in Chakrabarti, 1992: 8; Schwarz, 1901: 209-211, 277-283, 337-341, 391-399). Axel Sahlins also pointed out the potentialities of Indian iron and described the Tata Iron and Steel Works (cited in Chakrabarti, 1992: 8; Sahlins, 1913: 50-72). Unabatedly, such research interest continued till the 1920s.

In 1920, the work of Andrew McWilliam on the manufacture of iron implements and iron at Mirjati gave a new dimension in this line of research as it was for the first time amply testified to the fact that ancient iron smelting techniques evolved enough to give rise to the surviving pre-industrial process. However, his assertion on the continuity of iron smelting process was based on the comparative analysis of the Mirjati iron and the composition of iron of Delhi Pillar assignable to the 4th century CE as studied by Robert Hadfield (McWilliam, 1920: 159-170). In 1922-23, Harold Harris summarized the methods of ‘native manufacture of wrought iron in small blast furnaces of India’ with special reference to Rajdoha in the Chhotanagpur plateau (Harris, 1923: 42-62).

After Ball, the iron smelting process of the Agarias of the Palamau region was meticulously documented by Verrier Elwin in 1942 during his anthropological study on the Agarias (Elwin, 1942).

There is no doubt that during 17th-18th century the Europeans traders reached Indian shores in search of lucrative trade in spice and other products. Of these, iron especially wootz, was a significant one. At the outset their objectives were definitely to gather knowledge on the composition of Indian iron and metallurgical details in its production. After seizing a firm foothold in the Indian economy and of course administrative system (at least partially), they tried to establish iron industry here. Large scale iron production was also necessitated for the inception of railway tracks for easy transport of tradable products besides other utilitarian objects. Therefore, the rationale behind the ethnographic study of the indigenous iron smelters is that the British administrators were seriously intending to gain access to the widespread economic resources of the subcontinent apart from their quest to acquaint themselves with the Indian soil.

In the post-independent era, the initiatives and progress in this line of research was undertaken by several Indian metallurgists and archaeologists. So far as the eastern India is concerned, the endeavour made by the Birla Industrial and Technological Museum,
Calcutta in 1960 under the supervision of S.K. Bagchi to organize a demonstration programme on the primitive iron smelting in a village near Baipariguda in Jeypore subdivision of Koraput district is worth noting (cited in Srinivasan, 1998: 229, 239-240). The anthropological study on the Asuras of Netarhat plateau by K.K. Leuva in 1963 also carefully referred to their iron smelting techniques (Leuva, 1963). The study of S.B. Das Gupta (Das Gupta, 1978: 48-52) on the said tribe (Asur-Birjhia) in 1978 also added substantial information on the same. M.K. Ghosh (Ghosh, 1964: 132-135), National Metallurgical Laboratory, Jamshedpur studied the process of traditional iron workings and types of furnaces being operated in the villages of Kamarjoda (Bihar), Chinglebecha and Jiragora in Orissa. Srinivasan in 1990 recorded the minutiae on the iron smelting practice at Bangurkela, a village located about 20 km from Rourkela (Srinivasan, 1998: 229). Mohanta et al. (Mohanta et al., 2003: 81-90) recently surveyed the Mayurbhanj and Keonjhar districts extensively and discovered ancient remnants of iron objects, iron smelting furnaces, ingots etc.

One of the most dubious issues on which researches have been carried out is regarding the **origin of the use of iron**. While exploring the proximate cause of the ‘Iron Age’, the scholars were keen to ascribe the eastern Mediterranean as the earliest producers of iron. According to them, iron made its earliest appearance around c. 5000-4000 BCE in West Asia (Grave A at Samarra, Tepe Sialk in Iran). However, whether it was meteoritic in origin or an accidental by-product of smelting of some other mixed ore is a subject of assumptions (Moorey, 1994: 279). During the subsequent period, the number of iron objects increases though not in profusion. Mitannians and Hittites appear to hold the key to iron production initially. Maxwell-Hyslop opined that the primary cause of the Hittite attack on the Mitanni by Suppilulimus (1380-1346 BCE) and his subsequent control over Aleppo and Alakh may have been related to the need to control the routes leading to the Mitannian sources of iron. Thus, there were wars for possession of mineral rich territories particularly iron ore bearing zones (Maxwell-Hyslop, 1974). The correspondence between the kings of Hittites and the Assyrian king and that of the Mitannian king with the Egyptian Pharaoh for buying, selling and ordering of iron objects during 3rd -2nd millennium BCE (as evident from literary sources) also attests to the fact that iron production was even scarce and it had a cultic or ritualistic significance. The presence of a linguistic group speaking a dialect subsequently used by the Indo-Aryans amongst the Mittannians has been noticed. Boghazkoi inscription also aptly testifies to the presence of
a group of people in the Asia Minor worshipping the same gods as the Indo-Iranians and Indo-Aryans did. The archaeological data (similar cultural materials found from excavations at different sites) coupled with philological evidence suggests a cultural interactions among central Asiatic, Iranian and South Asian borderlands. The similarity of grey pottery in the Swat region and those found from the Iranian and central Asian counterparts also gave enough impetus to the diffusion theory of cultural elements, traditions, language etc. Regarding the origin of iron, this diffusion theory has been vehemently applied.

So far as the study on the origin of Indian iron is concerned, the first and foremost contradiction of the above hypothesis comes from the works of Heath. In a letter addressed to the Secretary of the Royal Asiatic Society of Great Britain and Ireland on ‘Indian Iron and Steel’ in 1839 (Heath, 1839: 390-397) states an interesting fact about Indian iron “the antiquity of the Indian process is no less astonishing than its ingenuity. We can hardly doubt that the tools with which the Egyptians covered their obelisks and temples of porphyry and syenite with hieroglyphics were made of Indian steel”. According to him, “we know that a maritime intercourse was maintained from the remotest antiquity between the Malabar coast, the Persian Gulf, the country about the mouths of the Indus and the Red Sea ; and it appears reasonable to conclude that the steel of the South of India found its way by these routes to the country of Porus, to the nations of Europe, and to Egypt” (Heath, 1839: 395).

Hawkshaw in his presidential address, given in the forty-fifth meeting of the British Association for the Advancement of Science held at Bristol in August 1875, accredited Indians for their expertise in making steel. According to him “…there is no great secret in making steel, the natives of India now make excellent steel in the most primitive way, which they have practised from time immemorial”. “The supply of iron in India as early as the fourth and fifth centuries seems to have been unlimited”. His study on Delhi iron pillar and iron beams of the Konark temple at Orissa led him to conclude that “India well repaid any advantage which she may have derived from the early civilized communities of the West if she were the first to supply them with iron and steel” (Hawkshaw, 1876: Ixviii-c)

John Percy (1864: 254) suggested that “the large accumulations of slag which occur in various localities in India” evidently confirms the extensive production of iron through the ages. Crawfurd in his work on Stone, Bronze and Iron Ages of Society supported the
indigenous origin of iron in India. According to him, “Iron and steel, although not cast-
iron, appear to have been known to the Hindus beyond the reach of all record…the
inventions of both iron and steel were made in India at several independent points of
time” (Crawfurd 1864: 316).

After a period of more than a decade, Swank in 1892 agreed to his opinion and stated that
the Indians acquainted themselves with the use of iron in a much early period (Swank,
1892: 8).

Thomas Turner on the other hand completely refuted such opinion and while discussing
on the use of iron in West Asia during 1100 BCE, suggested that “Probably about this
time the art of iron-making was carried eastward into India”. According to him “…the
inhabitants of that part of the world were well versed in the manufacture of iron centuries
before the Christian era. The famous iron pillar at Kutub, near Delhi, stands 22 feet above
the ground, and its weight is estimated to exceed 6 tons. It consists of malleable iron of
great purity, and was probably made about A.D. 400, by welding together discs of metal.
So great a forging at this period indicates a remarkable skill among the early iron workers
of India which has not survived to the present day.” (Turner, 1895: 4)

During 1907-1910, Belck (cited in Chakrabarti, 1992: 12) in his papers on the origin of
the use of iron has quoted some passages from Bible to prove that the Philistines had the
knowledge of iron and steel and they were the earliest users of the same. However, he
believed that the Philistines may have derived the knowledge of iron smelting from Crete
and used to bring their iron objects to India for barter. He also asserted that excavations at
the old port sites of India would produce Philistines iron and steel articles.

Smith is of opinion that the knowledge of producing workable iron in India must owe its
origin to New Babylonia from where the same must have spread to India via traders
(Smith, 1912: 183-184).

An American metallurgist George Brinton Phillips in 1924 strongly negated the above
suggestion and after considering the works of Hadfield in some way suggested multiple
origin of iron and stated that if the tools used in Egypt were obtained from India, they
may have been of case hardened iron not of the simple wrought iron (Phillips, 1924: 175-
183). However, more sound and rational observation was made by J. Newton Friend in
1926 who strongly recommended the simultaneous and independent origin of iron and
considered India as definitely one of them. He opined that, “The question has been raised
as to whence India derived her knowledge of iron….Babylon is suggested…..Others
suggest that the Hindoos discovered iron themselves...This is very reasonable...There is
of course no need to attempt to trace back the discovery of iron to one source. Just as the
present time discoveries are not infrequently made simultaneously in different parts of the
world, so it reasonable to suppose that in early days, when means of communication were
slow and primitive, different nations or tribes may have simultaneously unravelled certain
of nature’s secrets quite independently” (Cited in Chakrabarti, 1992: 12; Friend, 1926:
150).

Disagreement to this statement came from the works of Harold Peake, who stated in 1933
that “How and when iron reached India is uncertain. It was unknown to the people of the
Indus civilization...... but iron is mentioned several times in the Atharvaveda, the
latest of the four Vedas, composed, it is believed, between 1200 and 1000 B.C. Thus the knowledge of ironworking must have reached the peninsula not very long after
the downfall of the Hittite Empire and possibly through Persia, where extensive
remains of iron working of an early but uncertain date have been found in the
neighbourhood of Parpa, between Kerman and Shiraz, as well as in the Karadagh
district in the north” (Peake, 1933: 649-650).

Thomas T. Read in 1934 while discussing on the history of early casting of iron
suggested that “Though the metallurgists of India did not develop the casting of iron,
they were the first to hit on the making of true steel by what is known in modern
parlance as the crucible-steel method” (Read, 1934: 552).

“Our present knowledge of the history of cast iron tends to refute rather than support
the general belief of archaeologists that the reduction of iron from its ores was invented
by the Hittites and its practice spread from that point of origin over the ancient world”
(Read, 1934: 553).

Albert Neuburger based on Indo-philological evidences propounded that the history of
the use of iron in India can be dated back to 2500 BCE. He assumed that Sanskrit word
ajas is undoubtedly related to the old Gothic ais which later led to the German eisen and
this according to him proved that the Indo-Germanic races must have been familiar with
iron before they separated (cited in Chakrabarti, 1992: 12; Neuburger, 1930: 20-21).

In the light of literary data, Schoff have put forward many valuable information on Indian
iron and steel. He in 1915 suggested that the Seric iron of the classical writers came from
India and not from China. In his words, “Something of the relative value and extent
of distribution of Chinese iron may be gathered from Professor Hirth's Chau Ju Kua
in which it appears that traders from Chinese ports to foreign countries took iron to Sumatra, the Malay Peninsula, Java, the Philippine Islands, Hainan and Formosa; but this iron consisted apparently of pots, censers, tripods, coarse needles and utensils, whereas particular reference is made in that very text to the excellence of the iron swords and other weapons produced in India, which apparently found their way to the same markets that took the coarse utensils of Chinese iron” (Schoff, 1915: 226-227).

“For the importation into the Roman world from some Eastern source of the finest grade of steel then known, there is ample evidence, and it all points toward central India and not China. Ferrum Indicum appears in the list of articles subject to duty at Alexandria. Indian iron and steel appears in the Periplus among the imports into Abyssinia, and from this text, as I have elsewhere pointed out, we get a curious indication of a long-standing trade monopoly, under which certain products of India in large demand in the Mediterranean world were handled only by South Arabian merchants and were not offered to ships of Roman registry which succeeded in finding their way to India” (Schoff, 1915: 230).

P. Neogi in 1914 suggests that the ‘use of iron was perfectly known to the first ‘Aryan settlers’ of India (Neogi, 1914: 3). As regards archaeological evidence, ancient specimens of iron are so abundant in India that an enumeration of these alone will convince any one that India has always been a rich iron producing country.

Apart from his views on the origin of iron, the work of Neogi is acclaimed for his endeavour to organize the volume of researchers on the history of iron till then carried out in India. Being an expert in chemistry he has competently dealt with different aspects of ancient Indian metallurgy. He, for the first time, drew the attention of scholars to the lesser known architectural masterpieces of iron i.e., the pillars at Dhar and Mount Abu. Besides, he also presumed that high phosphorus, low sulphur and manganese have contributed to the capacity of iron of Delhi iron pillar in resisting the rusting influence of rain and wind. The work has also dealt with chemical and metallographic analysis, tensile strength estimate, the varieties of Indian iron deduced from Sanskrit texts, the forging and corrosion resistance of early beams and pillars etc. However, his work must also be applauded for probing the nature of use of iron in several architectural grandeurs assignable to different chrono-cultural time frames. Indeed, his study on clamps, beams, drills used in the temples of the historical period is quite interesting as such studies on the
use of iron in the historical period are hardly attempted nowadays. In fact, it seems that this phenomenal use of iron during the historical period has failed to evoke its due appreciation from the present day scholarly world. The significance of such study i.e., looking into the nature of the extensive use of iron in temples, monasteries etc. of the early medieval period has been largely shrouded by a pre-conceived notion of delineating the monumental settlement dynamics of the concerned period based on its politico-religious paradigms (Neogi, 1914).

In summarizing the significant research works on the origin of iron, another work should found its respective place which in some way contributed to the same. The work of M. N. Banerjee based on literary data tried to corroborate the fact that during the composition of Rigveda iron was in existence. He inferred that ayas which is a hard metal, tenacious, tough, malleable, ductile was not of course bronze. Banerjee by citing one of the passages from the Rigveda, which reads as “with dried faggots of trees as fuel and fans of wings of birds and clear and bright stones, the karmar or the smith (engaged in making arrows) desires a rich person (to buy them)” tried to interpret it as an activity associated with steel making. According to him, with dried medicinal plants which in his opinion could be cassiaauriculata a plant used by makers of wootz steel for adding carbon in crucible steel and with wings of birds (Parnebhih Sakunanam) and bright stone (ores or anvils translated variously) the smith waits for a wealthy customer. Besides, he was also in favour of identifying Ksura, Khadi and asi or svadhiti with razor, quoit rings and axe respectively and according to him all of these were made of iron (Banerjee, 1927: 121-133, 793-802; 1929, 432-450; 1932, 364-366).

D. H. Gordon in 1950, on the basis of archaeological data stated that iron was supposedly introduced in India around 600-700 BCE. In his words, “It seems likely then that some time between 700 and 500 B.C. this iron-using people who buried their dead in cairns was spreading from the area just south of Kerman eastward through Makran into Baluchistahan, and moreover that their cairns will be found throughout Las Bela into southern Sind. Apart from these two peoples, those who practised megalithic tomb burial in the South and those who practised cairn burial in the North-West, we have no material edience yet of the use of iron by anyone in India or Pakistan prior to 250 B.C” (Gordon, 1950: 67).

Mortimer Wheeler postulated that Indians learned the use and preparation of iron only from the Achaemenids. According to him, “There is at present no clear evidence for
the systematic use of iron anywhere in the (Indian) sub-continent before (the VIth century BC) unless sporadically in the north-western region. Attempts to equip the Vedic Aryans in the middle of the second millennium BC, or their successors of the Brahmana period, with iron have no solid substance. The earliest unequivocal literary evidence for the use of iron by Indians are the well-known references by Herodotos and Ktesias (Vth century BC); and the earliest firm archaeological evidence for the normal use of iron within the subcontinent is provided by the First Taxila (Bhir Mound) for which Sir John Marshall's initial date of c. 500 BC is unlikely to be varied significantly. It is reasonable in the present state of knowledge to associate this developed use of iron with the imposition of Achaemenid suzerainty first upon Gandhdra and then upon the Indus region by Cyrus (558-530 BC) and/or Darius (521-485 BC), with the consequent quickening of trade and civic life in the north-west” (Wheeler, 1962: 33-34).

In 1965, the works carried out by N.R. Banerjee (Banerjee, 1965) is colossal in its approach as it has handled substantial data on the use of iron and tried to explain the nature of their use by identifying their archaeological contexts. He also tried to identify the folks responsible for the introduction of iron in India and suggested that the earliest occurrence of iron in India has been traced in the cultural remains associated with Painted Grey Ware. He further opined that Aryans should be credited for imbibing this new metal and its technology in the indigenous cultural traits. The work also focussed on the occurrence of iron in west Asia and its postulated link with the spread of Indo-European language speaking population groups. It is quite evident that with this approach, he has raised the debate on the non-indigenous origin of iron afresh. However, the work has given enough consideration to enquire that whether megalithic culture of India in anyway was interlaced with the cairn-burial folks of Baluchistan, Persia and Baluch Makran or their Aryan compatriots.

Radomir Pleiner in 1971 based on the literary sources suggests that ‘iron penetrated into India after the arrival of the Aryans’…. ‘the period of penetration of iron into the material culture of India is that of about 800-500 BC’.. ‘the gradually increasing importance of iron was conditioned since the sixth century B.C. by continuing technical influence coming from western neighbours, from Persia and Media and later from the Greek world ’.. ‘the developed and prospering iron age flourished only since 300 B.C.’ (Pleiner, 1971: 5-36).
**Megalithism and use of iron:**

The issues on the Megalithic culture of Peninsular India and its association with the use of iron deserved a special consideration while looking into different avenues of researches on the origin of iron. The large scale presence of iron artefacts found during the excavations and explorations at different megalithic sites of south India confirmed the phenomenal consumption of this metal in the ‘protohistoric’ society of south India. The nature of artefacts i.e., the actual findings do not betray the technological evolution of such tools. Rather the concerned findings suggest the use of highly sophisticated tool types whose antecedent stages are not discernible from the concerned data. A debate comes to the forefront which may be argued in two ways i.e., 1. the involvement of indigenous methods of iron workings 2. The procurement of sophisticated tool types through the mobile groups of the Megalithic folks. Besides, there are other cultural traits which rarely have any antecedent counterparts. This naturally raises question about their origin. Scholars from the pre-independent era onwards have devoted much to understand the same.

The evidence unearthed during a series of excavations at the cairn burial sites of Persian and Baluch Makran and Baluchistan by Aurel Stein (1929, 1931, 1937) gave a welcome light on the issue of evolution of megalithism in the region and its subsequent spread in the Indian peninsula. However, the presence of iron objects amidst the tombs led him to ascribe the evidence to the early centuries of the Christian era. He made this assessment on the basis of the finding of a pot with impressed Hellenistic motif at Moghal Ghundai cairn together with a bezel ring of bronze with an intaglio. Gordon suggested that the makers of the Londo ware found in several sites including Alizai, near Surab in North Baluchistan, in the Baghwana valley of Jhalawan in Baluchistan by Beatrice de Cardi (De Cardi, 1951: 63-75), named after the type site and those of the pottery found in the cairn-burials were at least contemporaneous, if not identical (Gordon, 1958: 156). The Londo ware is dated by De Cardi, on account of its affinities with the pottery from Sialk VI B to circa 1200-1000 BCE (De Cardi, 1951: 63).

It is important to note that both Moghul Ghundai and Nad-i-Ali have yielded specimens of the trilobite iron arrowhead, which is absent at Sialk VI B, but occurs in the Iron Age levels at Boghazkeui and Alisar Huyuk in Asia Minor. This has led to the suggestion of a post-Sialk VI B date for the cairn burial sites (De Cardi, 1951:71).
According to De Cardi “On general stylistic grounds it is suggested that the Londo ware should be ascribed to the early rather than the late phase of Cemetery B, and the case for dating it to about 1100 or later is supported by analogies with motifs on Kassite boundary stones dated by inscription to 1145-1123. The impact of Sialk VI B ideas can also be recognized in pottery and grave goods from cairn-burials in Baluchistan. There is, however, no resemblance between the Londo ware and the pottery from the cairns and in view of its affinities with late Luristan, it is suggested that the latter ware should be ascribed to a slightly later date than Londo ware” (De Cardi, 1951: 72).

According to N.R. Banerjee if a link can be established between the megalithic builders of south India and those associated with cairn burials, there is no doubt that the former acquired the knowledge of iron from the latter. In his words, “the difference in cultural repertoire among the cairn burial zone of Iran and the Pakistan border and the megalithic zone of South India related mainly to the ceramics. In so far as the iron objects themselves are concerned, the arrowheads and spearheads show similarity in form to those from the megaliths in general, and a comparison of tool types shows several parallels viz. barbed arrowheads, swords, daggers, knife and hook.” (Banerjee, 1965: 49)

In doing so, Banerjee also briefly summarized the nature of cultural materials found from the megalithic sites of eastern India, northern India and central India. He said that the southern megalithic monuments are sepulchral and belong to the Iron Age whereas, the eastern Indian megalithic culture is commemorative and are Neolithic in origin (Banerjee, 1965: 49-54).

Now, the question arises, if such cultural contacts can be ascertained, via which routes these has been spread. Gordon is of opinion that the megalithic idea may have been travelled across the sea through Arabia (Gordon, 1958: 18). Wheeler has considered Karachi as the springboard of the megalithic idea for entry into south India (Wheeler, 1959: 168). Heine-Geldern suggested that the occurrence of straggling megaliths, even beyond the northernmost latitudes bearing the cairn burials can be explained by the existence of more than one strain of megalithic concept entering into India. The occurrence of bronze and iron artefacts in the cist like graves of the Leh Valley at Ladakh probably shows the incorporation of the megalithic monuments already within the Iron age (cited in Banerjee, 1965: 55-56; Heine-Geldern, 1959: 179). Walter Ruben on the other hand opined that the megalithic traits came into India from Palestine via Persia. According to him, one strain proceeded to the south and other towards the east till the
land of Mundas was reached. Wheeler held that megalithic mode of disposal of dead in south India was associated with the Dravidian speaking groups who appear to have entered into South India considerably earlier than Asoka (Cited in Banerjee, 1965: Ruben, 1939: 154-158).

Christoph von Fürer-Haimendorf sought to connect the introduction of megaliths in south India to a distinctive linguistic group in India. The distribution zone of megaliths in south India covers exactly the Dravidian speaking area which according to him, substantially prove the immigration of a Dravidian speaking folk into the landmass. Archaeologically this is evident from the ‘sequential position of the megaliths following, with an overlap, immediately upon the very primitive Neolithic agriculturists’ (Fürer-Haimendorf, 1943: 149-178).

However, the discovery and subsequent excavations at several new sites of Peninsular India has substantially revealed the occupational contexts of the megalithic appendages. Extensive evidence of iron workings from the same region successfully proved the indigenous origin of the objects in question. Therefore, cultural contacts, if had any between the megalithic builders of south India and that of Persian and Baluch Makran and Baluchistan is essentially through the exchange of cultural traits and is a subject of further investigation. This has a little scope to be dealt here and definitely has a merit for an altogether separate study.

The **metallographic study** of iron objects introduced an important chapter in the researches on Indian iron, which also lit the way of archaeological study and initiated a trend of considering **archaeological assemblages as the main source of history reconstruction**. The pioneering work of Robert Hadfield on the metallographic examination of three specimens of Sri Lankan iron objects, two (chisel and nail) from Sigiriya of the fifth century CE besides a undated specimen from Kandy broadened the scope for historians to reconstruct various issues related to the Indian iron (Hadfield, 1912: 94-100).

He stated that some of these implements of ancient Sinhalese iron were subjected to a standard physical test, microscopic examination and chemical analysis giving interesting results and it indicates the indigenous metallurgical knowledge of iron.

“The transverse section shows that this chisel has been carbonised, the section showing the carbonised areas to be on two sides…. The presence of martensite and hardenite suggests the important fact that the chisel has been quenched….this is the first time there
has been put on record evidence that the art of cementation must have been known 1500 to 2000 years ago....” (Hadfield, 1912:97).

Subsequent analysis of Delhi iron pillar and a wedge found from the foundation of the Heliodorus pillar at Besnagar also brought forth some interesting results (Hadfield, 1912: 94; Bhandarkar, 1913-14: 186-226). However, Cunningham’s report approximately four decades ago also furnished positive evidence of Delhi iron pillar being of iron. He sent a bit from the rough lower part of the pillar to Murray Thompson, who informed that the metal was ‘pure malleable iron of 7.66 specific gravity’ (Cunningham, 1871).

Among other works on metallurgical study on Indian iron, mention may be made those of Day (Day, 1877: 177), Swank (Swank, 1892: 68), Lester (Lester, 1912: 6) etc.

Archaeological excavations conducted by the Archaeological Survey of India (henceforth ASI) especially at Taxila under the supervision of John Marshall (Marshall, 1951), that at Adichanallur, Perumbair by Alexander Rea (Rea, 1902-03:111-140; 1915), D.R. Bhandarkar’s excavations (Bhandarkar, 1913-14) in the first quarter of the 20th century have yielded plethora of iron objects. Unfortunately, proper attention was hardly given to the nature of its use in the ancient settlements and little was made to reconstruct several issues of settlement dynamics based on the same. Chakrabarti rightly pointed out that “Hundreds of iron objects must have been excavated from these sites over this period but all that one gets in most of the reports is just a casual reference to ‘iron objects’ ”. (Chakrabarti, 1992: 13).

A major thrust in archaeological studies came during the post-independence era. As a result, considerable number of excavation programmes at different sites by the ASI, archaeological departments of various state governments, universities, museums has resulted in the discovery of an array of iron objects. Specific mention must be made of the excavations at Takalghat Khappa (Munshi and Sarin, 1970: 78-79), Prakash (Athavale, 1965: 131-139), Kausambi (Sharma, 1960, 1969), Hastinapur (Lal, 1954-55: 97-99) from which substantial iron objects were yielded. Subsequent metallurgical studies were also undertaken.

In 1970’s the first significant work, deserve to be mentioned here is that of K.T.M. Hegde. His analysis on iron specimens found from the early historical site of Dhatwa is quite interesting as it for the first time tried to follow an ethno-archaeological approach. He intended to search for the location of the source of ore, study the composition of the ore, methods of ore preparation besides to investigate the fuel for smelting, the
composition of the slag, the composition of the metal extracted, the methods used in fabrication of objects and finally reconstruct the metallurgical technique. While studying the concerned iron smelting practices, he also put forward some parallels as recorded from the contemporary Ghadi Loharia near Vadodara city (Hegde, 1973: 416-421).

Besides this pioneering attempt, the work of H.C. Bharadwaj is also worth noting in this context, as it has dealt with metallurgical minutiae of a few finished specimens and slag of iron found from the early historic phase of Rajghat (Bharadwaj, 1973: 391-400).

An enduring urge for investigating the metallurgical specifications of the Delhi iron pillar has resulted in the discovery of a few interesting observations during 60’s and 70’s. In this context, the works of Bardget and Stanners (1963: 24-30), Ghosh (1963: 31-45), Lahiri et.al. (1963: 46-54) etc. on the technique of production, corrosion resistance of the concerned iron specimen were worth-mentioning.

In the subsequent phase, discovery of iron objects from different excavations and metallurgical analysis of the specimens especially from the initial iron beating phases found during these excavations went concurrently.

On the early use of iron in India, the works of Dilip K. Chakrabarti (Chakrabarti, 1974: 345-356; 1976: 114-124; 1992) brought forth a new genre of research as he for the first time made it clear that there were six early iron-using centres in the subcontinent: the Northwest, the Indo-Gangetic divide and the upper Gangetic Valley, eastern India, Malwa, Berar in central India and the megalithic south India. The archaeological evidence was put in the background of the history of research, the distribution of iron ores suitable for pre-industrial smelting, the data on pre-industrial iron, the literary data and some recent observations on the history of the origin and use of iron outside India. His successive publications on the aforementioned issues related to iron not only contributed to the comprehensive understanding of the subject but also his ideas on independent and indigenous origin of iron in India marked distinct break from the bewildering state of researches on the origin of iron in India. He strongly refused the diffusionist hypothesis and according to him, the post-Chalcolithic iron bearing level of central Indian sites like Nagda etc. should be considered as the earliest iron bearing level of India. He challenged the view of a western origin, stating “there is no logical basis to connect the beginning of iron in India with any diffusion from the west, from Iran and beyond”, and further (1976: 122) “that India was a separate and possibly independent centre of manufacture of early iron.” His book on the use of iron in India also offers a
comprehensive synthesis of the geological, archaeological, metallographical, literary and ethnographic data.

Another significant work on a similar aspect was made by Vibha Tripathi. She visualizes that iron technology had a constructive impact on the economy. She tries to identify the period in which iron technology had reached such a level of efficiency that it could gainfully contribute to the contemporary society and the areas where such influence were most discernible. She identified the period beginning from 5th-4th centuries BCE as witnessing a positive impact of iron on the contemporary socio-economic developments. She preferred to categorize three distinct stages i.e., 1) from the beginning to 7th-6th century BCE; 2) 7th-6th century BCE to 2nd-1st century BCE and 3) 2nd-1st century BCE to the historical period, discernible in the growth of iron technology in ancient India. Besides, several ethnographic works have also been done by her (Tripathi, 1986: 75-79, 1990, 2001).

T. N. Roy in his work emphasizes that the term ‘Iron Age’ represents basically a technological change which heralded many new things unknown to the preceding ‘Chalcolithic’ cultures. The assemblages of iron recorded from Painted Grey Ware and Northern Black Polished Ware (henceforth NBPW) bearing cultural phases do not necessarily shows that the metal had its impact on the socio-economic of the people during this period and led to a considerable degree of cultural homogeneity all over the country during the late phase of the NBPW. He thus suggests considering the settlement dynamics associated with the NBPW and Painted Grey Ware cultural phases or precisely “the Ganges civilization” under the rubric Iron Age. (Roy, 1983)


D.P. Agrawal has done extensive work on archaeometallurgy of the Harappa Culture, the Copper Hoards Culture, and also in the Central Himalayan region. He has also specialized in the use of scientific techniques for archaeological research. His work with
Tripathi on early iron technology- Himalayan contacts and Gangetic civilization is quite noteworthy (1999: 53-58, 2000).

The work of Arun Kumar Biswas is also worth-mentioning here. Being a specialist in archaeo-metallurgy and history of science, he has contributed enough in Indian archaeology by summarizing relevant data on Indian metals and minerals, their production and application in ancient and medieval India. His interest in Indian literatures also resulted in bringing forth different aspects of the history of mineral extraction and its use in ancient India. His work on *rasa ratna samuccaya* is quite an interesting as it has tried to correlate the literary data with the archaeological ones. His study on the iron smelting activities of the pre-colonial India is also worth-noting (1987: 29-46; 1996, 2001).

However, this budding archaeological approach of addressing various issues of the use of iron has aroused the scholars for searching for an early antiquity of iron. In this context, the work of Gim J. Shaffer is the most significant one (Shaffer, 1984: 41-62). He for the first time, pointed out the existence of iron artefacts and nodules in the ‘Bronze Age’ contexts at Mundigak, Deh Morasi Ghundai and Said Qala Tepe in South Afghanistan. The iron found at these sites has been categorized into two types 1) distinct and 2) indistinct objects. Category 1 has ‘well defined articles’. The second group ‘comprises only natural iron ore nodules having an extremely high iron content’. Rationale behind ascribing these nodules as ‘artefacts’, according to Shaffer is ‘principally because their location in an exclusively cultural context eliminates any possibility of a natural occurrence’. He also drew attention to the presence of lollingite nodules in Mohenjadaro and the location of a Harappan pot in a deposit at Pirak, which also contained iron artefacts. He also firmly established the indigenous origin for iron in India.

However, this genre of research of finding the nascent stage of the use of iron in the ‘Chalcolithic’context got its proper shape with the works of Chakrabarti and Lahiri (1994: 12-32). On the basis of metal objects found from Lothal, they argued on the presence of iron in later phases of the Harappan culture. They tried to show the difference and similarity in percentage of Fe content present in the copper objects from Lothal and other Chalcolithic, Copper Hoard sites and the later levels of the Harappan sites. Based on the said report, they postulated that at Lothal, the technology of iron exploitation was known since the late Harappan phases.
Tripathi contradicted the viewpoint that was postulated by Chakrabarti and Lahiri and suggested for the reclassification of the list of objects (demonstrated by Chakrabarti and Lahiri) in view of the fact that 'slags, fragments or lumps and finished objects have all been incorporated in it without any discrimination'. She cited the works of K.T.M. Hegde (Hegde, 1969: 225-228), who after studying the composition of metal objects from Ahar inferred that such high percentage of FeO in slags proves use of chalcopyrite, an ore with a high percentage of iron oxide that is up to 48 per cent in an otherwise copper ore. While smelting of copper, the iron content goes into the slag as a waste material of copper smelting. So far as the lumps or fragments of iron are concerned, she questions that “could such pieces show the nature of metal? Or could they be described as deliberately smelted iron? Or where they discarded bits of copper smelting activity, rejected by the coppersmiths? She after considering the spectrophotometric analysis of metal objects from Lothal by Nautiyal, Agrawal and Krishnamurti (1981: 48-51) suggested that “the master artisans of mature levels of Harappan culture successfully eliminated iron oxide from copper, while those from Chalcolithic level or Copper Hoard family and even later levels of Indus Civilization, do not seem to possess that good control or manipulation of temperature or smelting process.”(Tripathi, 2001: 67) She further argued that in this context, one should not rule out the possibility of iron as a by-product of copper smelting. There is always a possibility of an accidental smelting of a high percentage iron containing copper object especially while working with iron rich copper ores or when iron was involved as a flux in smelting siliceous ores. To prove this point, she referred to the works of Wertime and Smith at Anjileh near Yazd in a traditional furnace. In this work they showed that for 6 kg cerussite ore, 150 gm of haemetite was being used as flux. Another possibility is that iron oxide gets reduced by solid carbon or carbon monoxide gas before it reacts with silica and forms fayalite and gets added to molten copper metal. Tylecote has also reported many magnetic copper objects showing the presence of iron therein. His comments on the appearance of iron in Early Iron Age (British) bronze artifacts are following- “Substantial quantities of iron are now appearing. This may be the result of using chalcopyrite ores, or it may have arisen from the accumulation of iron due to remelting many times and using iron stirring rods or by the accidental incorporation of pieces of scrap iron” (Tylecote, 1962: 51). Wertime referred to the production of iron “bears” in the traditional Iranian lead smelting operations, as a result of overdriving (excess charcoal and a high volume air blast) (Wertime, 1964: 1262; See also Strathmore and Aschenbrenner, 1975: 251-266). In view
of the above Tripathi suggested that “…it may not be possible especially on the basis of a solitary example of a metallic piece of above 50% iron out of 1500 objects to attribute a knowledge of iron smelting to the copper smiths of Lothal” (Tripathi, 2001: 71).

The work of M.D.N. Sahi (Sahi, 1979: 365-366) could be recorded as a new contribution on the origin and chronology of the use of iron. He pointed at the anomalies in the report of Ahar. According to the original report of Ahar, iron was said to have started with NBPW (Period IIA) around 600 BCE in this part of Rajasthan. Period I having three subdivisions IA, IB and IC belonged to the Chalcolitic cultural horizon. Iron, as was noticed by Sahi during his re-examination of excavated materials occurred in Period I itself. Two iron objects were found according to Sahi in Period IB and ten objects in IC. Period IC at Ahar has been dated by C14 between 1550 and 1270 BCE. Sahi, on this reckoning stated “that the date of beginning of iron smelting in India may well be placed as early as sixteenth century BC”. (Sahi, 1979: 366). This antiquity of iron at Ahar has challenged the earlier theories of beginning of iron in India. No categorical refutations have come though some explanations have been offered.

In regard to the origin and antiquity of iron in India, the work of B. Allchin and F.R. Allchin is worth mentioning. They placed the first period of the use of iron in the subcontinent as between 1300 and 1000 BCE though preferred to correlate the spread of iron in the subcontinent with ‘the secondary spread of the Indo-Aryans’. They further opined that ‘this need in no way conflict with the indigenous population’s beginning to exploit local sources of ore to smelt their own ore’ (Allchin and Allchin, 1982).

All these studies got shaken with coming across a crucially important evidence of the occurrence of iron in black-and-red ware (henceforth BRW) associated ‘Chalcolithic horizon’ of the Karmanasa valley (from Mirzapur-Sonbhadra Chandauli districts). Radiocarbon dates from the sites like Raja Nal Ka Tila and Malhar take the antiquity of iron in the mid-Ganga plains at least to the middle of the second millennium BCE (1400-1300 BCE or perhaps even earlier). Based on the radiocarbon dates of charcoal samples collected from the initial iron bearing cultural phases at Atranjikhera in Uttar Pradesh and Hallur in Karnataka, and stratigraphic position of iron in the lower levels mainly at Kausambi near Allahabad, Jakhera in district Etah in the Ganga valley, and Nagda and Eran in central India, the initial iron bearing cultural phases has so far been dated to 1000 BCE (Subramanyam, 1964: 349-359; Banarjee, 1965; Chakrabarti, 1974: 345-356; Nagarajarao, 1974: 357-362). Tewari, (2003: 536-545) who must be credited for the...
discovery of such new evidences, opined that “Taking all this evidence together it may be concluded that knowledge of iron smelting and manufacturing of iron artefacts was well known in the Eastern Vindhyas and iron had been in use in the Central Ganga Plain, at least from the early second millennium BC. The quantity and types of iron artefacts, and the level of technical advancement indicate that the introduction of iron working took place even earlier. The beginning of the use of iron has been traditionally associated with the eastward migration of the later Vedic people…. The new finds and their dates suggest that a fresh review is needed. Further, the evidence corroborates the early use of iron in other areas of the country, and attests that India was indeed an independent centre for the development of the working of iron”. (Tewari, 2003: 543-544).

 Besides debates on the origin and antiquity of iron, another aspect of the Iron Age in India received enormous attention and generated animated debates among archaeologists and historians since 1960’s i.e., the so called **Iron Age and social change**. It was started from the ‘thought provoking observations’ of Kosambi linking the emergence of peasant societies, settlements and states in northern India in the middle of the first millennium BCE to the introduction of iron tools (Kosambi, 1952: 180-213, 1963: 309-318, 2006: 35-41). The advocates of such theorization explained the term ‘Iron Age’ as a chrono-cultural phase in which iron was used essentially in productive purposes. Propagation of Buddhism and spread of iron technology was according to them instrumental in bringing forth a change in social stratum, expansion of trade routes and the rise of Magadha i.e., ‘an absolute universal monarchy’.

Kosambi posited that spread of iron technology in the Gangetic heartland during the 1st millennium BCE had facilitated in the development of plough agriculture, clearance of forested plains of the Ganga valley ultimately leading to assured supply of food and the resultant surplus. This has meaningfully contributed to the contemporary socio-economic conditions of the region. He stated that “the first land clearing in this region ran along the Himalayan foothills, as beginning of the transition from pastoralism to agriculture…The Gangetic plain is alluvial, and, in its original state, must have been forested, swampy in many places, and certainly devoid of heavy settlement till the age of metals, specifically the age of iron, had set in” (Kosambi, 2006: 37). He surmised that Buddhism aided in the consolidation of a society in which ‘trade had gained a new importance’. However, to propagate trading activities, freedom from robbers that infested the forest, freedom from irregular and excessive tolls charged by petty rulers or tribal oligarchs and opening of
new trade routes were required. This was the time when Magadha rose as a new kingdom. Kosambi believed that iron had to play a decisive role in the above development. Regarding the significance of Rajagriha he asserted that the settlement must owe its ‘original importance’ due to the extensive presence of minerals, in particular iron, ‘which is found as easily smelted surface deposits in Dharwar outcrops, of which the hills about Rajgir consist’. Moreover, Kosambi was the opinion that “…the great demand and logical outlet for metals would be towards the fertile but heavily forested plain of the Ganges, with its great and increasing population. Of course, India’s greatest deposits of iron as well as of copper occur in Singhbhum and Dhalbhum. The location of Rajgir is due also to its straddling this trade-route for metals, northwest of Uttar Pradesh” (Kosambi, 2006: 39).

R.S. Sharma seems to have absorbed Kosambi’s formulations entirely (Sharma, 1983; 1993; 2006: 42-48). He argued that during 700 BCE, the use of iron made a profound impact on the contemporary economy and society of the region comprising the eastern parts of the present state of Uttar Pradesh and that of Bihar. It was the spread of its use, which has enabled in the growth of plough agriculture, spread of settlements, surplus generation and the evolvement of towns. This in all probability culminated in a new milieu of trading activities, money lending, economic inequalities. Such developments led to the rise of a new ideology i.e., Buddhism which propagated against the slaughter of animals. This in other way prepared a foundation for nurturing an agrarian society. Sharma opined that “This was certainly a revolutionary teaching at a time when the non-Aryans slaughter cattle for food and the Aryans for religion”. “The Buddhist emphasis on non-injury to animals assumes a new significance in the context of the needs of new agriculture”. (Sharma, 2006: 43)

Romila Thapar (Thapar, 1984; Sahu ed., 2006: 4-5) recognized the significant role of technology in the process of acculturation, especially the horse and iron in the spread of Indo-Aryan language. According to her, iron signified a qualitative improvement in the existing typology and not necessarily the addition of new implements. She is of opinion that, Iron socketed axe compared to hafted copper axe is more efficient in clearing heavily forested regions and the iron hoe makes a marked difference in rice cultivation. Besides iron, surplus generation, specialization of crafts, use of *dasa-bhrtaka* labour and thrive in trade and commerce collaterally contributed to the dawn of second urbanization.
However, she stressed on the fact that iron was not a sole but one of the contributors in ushering a ‘change’ in early historic society.

D.P. Agarwal (Agarwal, 1967-68: 17-23; 2006: 49-59) in the light of ecological factors of the doab and the middle Gangetic plains, suggested that copper technology could not satisfactorily addressed the task of land clearance which must had been solved by the invention of iron technology. He also pointed out that, in spite of the initial use of iron during the Painted Grey Ware bearing cultural phases, ‘the Iron Age in a true sense’ can be pertained to the NBPW bearing cultural phases. However, wider acceptance of this metal in the society (as evident from its conspicuous presence in the NBPW cultural phases of different sites/ settlements) is not due to its hardness but due to its abundance and cheapness. In his words “…growth of cities coincides with the emergence of NBPW. To us this evidence suggests that use of Bihar iron ores alone could make the use of iron on a mass-scale feasible for complete urbanization of the Doab which gave rise to the first cities.” (Agarwal, 2006: 55)

In 1970’s, the works of A. Ghosh (Ghosh, 1973, 2006: 100-113) was first to highlight that, land clearance can also be done without using substantial number of iron tools. To corroborate his assertion, he cited the examples from the pre-Harappan levels at Kalibangan. Furrow marks at the concerned phase suggest the practice of plough cultivation. By drawing inference from the Videgha-Mathava legend of the Satapatha Brahmana he tried to show that burning of forests could have been produced similar results as iron in respect to land clearance. However, he raised no doubt regarding the significant role played by iron by stating “Iron is expected to have introduced revolutionary changes in the economy of the people- in agriculture, transport and trade and in the promotion of civic life” (Ghosh, 2006: 103). At the same time, he did not quite comply to the notion that iron was a sole signifier in ‘change’ of early historical society. He pointed out that, “No doubt, in a slow moving society the impact of iron was slow” (Ghosh, 2006: 105). He further questioned that, why the megalithic builders with substantial knowledge of iron technology (as evident from the remarkable collection of iron artefacts found from their graves) and organization of labour in the construction of sepulchral monuments could not produce cities or towns. His explanation was that “..the mere possession of technology does not lead to its application to all spheres unless it is encouraged by social institutions which can take advantage of that technology” (Ghosh, 2006: 106).
Contradictions related to the theoretical issues made since 1960’s on the concerned topic also came from the works of Ray (Ray, 1975-76: 132-138; 2006: 121-134). His work is significant as he tried to archaeologically corroborate the above theorizations. He suggested that the iron based agricultural production even during the early NBPW phases as hypothesized by many historians cannot be substantiated by the tool repertoire. There was a conspicuous dearth of agricultural tools and implements as yielded from excavations. At the same time, the presence of considerable number of iron implements and weapons during the concerned period led him to look into the possible role of iron in the process of the formation of territorial states. He stressed on the fact that, ‘right up to the end of the upper NBPW levels which I would date c.320 BC, iron technology was not being made adequate use of for any purpose which could bring out any effective social change, either in terms of the social structure or even in those of traditional living and behaviour patterns’.

Chakrabarti (1973: 329-338; Chakrabarti and Lahiri 1994: 12-32; 2006: 169-178) stated that, the early village farming settlements predate the use of iron. By drawing examples from central India and Deccan, he tried to show that the ‘basic agricultural pattern of Maharashtra was laid down by the Chalcolithic villagers’. He believed that, the introduction of iron must have facilitated the task of agricultural production, though gradually. This did not immediately lead to a perceptible change in the contemporary economy. Chakrabarti while agreeing with Ghosh admits that iron technology may have had a role to play in the intensification of agrarian base but categorically refutes any attempt to link iron with second urbanization.

Makkhan Lal (1986: 83-90; 2006: 137-149) in his discourse suggests that the idea of the extensive use of iron tools and clearance of forests for agriculture is a misnomer. Functionally, it is difficult to relate the proliferation of the use of iron with jungle clearance and agricultural activities during Painted Grey Ware – NBPW bearing cultural phases. It seems that the so called urbanization of the Ganga plains was mainly due to the ‘culmination of social, political and economic factors that were operating over many centuries to channelize the energy, resources, and generate a need and circulation of the surplus’.

Erdosy (Erdosy, 1988, Sahu ed. 2006: 10) recognized an intensified use of iron tools in the archaeological records assignable to 500-200 BCE. By this time state formation had
become deeply entrenched and therefore the iron tool repertoire of the period should be viewed as a response to diverse ‘processes of change and related compulsions’.

In a short but perceptive overview, Shereen Ratnagar refuted the Kosambi’s assertion about the role of iron in the clearance of forests and also questioned that whether the theme like agricultural productivity and use of iron can be so generalized? According to her, regional variations must be taken into considerations while making such statement. Continuation of the use of wooden and bamboo ploughs even in the colonial period at some of parts of the subcontinent can be considered as one of such variations. She highlighted that not only the composition of ploughs but angle of share, its adjustability, alignment of handle and body of the concerned tool have equal merit while discussing such issues. She also shows that use iron must have opened many exchange routes and its role in glass technology cannot be ignored altogether (Ratnagar, 2006: 179-188).

Vibha Tripathi (Tripathi, 2006: 198-209) visualized that iron technology had a constructive impact on the economy. She tried to identify the period in which iron technology had reached such a level of efficiency that it could gainfully contribute to the contemporary society and the areas where such influence were most discernible. She identified the period beginning from 5th-4th centuries BCE as demonstrating a positive impact of iron on the contemporary socio-economic developments.

The above discourse on the debates of iron and social change will be incomplete without referring to the recently editorial works of B.P. Sahu on iron and social change. Here, B.P. Sahu (Sahu ed. 2006) in his editorial note made an attempt to summarize some of the significant aspects related to the various discourses put forward by different scholars. In his note, he tried to emphasize on the fact that how ‘the historians’ concern with the social and economic implications of iron technology has led to exploring of issues of soil type, irrigation, method of cultivation, intricacies of plough technology, crop pattern, settlement history, demography, resource use, interaction sphere, and the introduction of new elements like coinage, glass etc., implying thereby that the use of iron tools created new categories of requirements, artefacts, and social groups, and this broadening of interest needs to be recognized as the most important contribution of the debate’. He further pointed out that delineating the nature of change in early historic society solely on the basis of technological aspects will be too simplified approach, as it distracts attention from the complexities of the society one seeks to explain. ‘The different, even divergent, explanations of change in early historical India between those who focussed on technical
determinism and those emphasizing socio-political factors has been replaced by efforts to see how human history is mediated by the intricate interrelationship between numerous societal processes” (Sahu, ed. 2006: 23).

**Literary Sources:**

At the outset, it must be pointed out that the rationale behind the present work is to investigate the nature of the use of iron in eastern India. My basic database is obviously, archaeological. However, in the present chapter I have gone through some of the major literary sources which refer to or highlight the use of iron in ancient India. However, the present work has not referred to Sangam and other literatures of peninsular India which in their contents and contexts are essentially beyond the scope of the present study area.

Literary sources starting from the Vedic hymns to travellers accounts or some treatise on statecraft, economic policy and military strategy had different identifications of iron and its implications.

**Rigveda:**

In Rigveda, three metals had found its mention viz. ‘Hiranya’ (gold), ‘Rajata’ (silver) and Ayas (?). There is hardly any difficult to identify the first two words though problem arises with the connotations of ayas. It is not possible to deduce anything positive from the Rigvedic references to the term ayas, sometimes translated as “iron” (the following verses have been cited from the Rigveda and its translation by Ralph T.H. Griffith (1896) (from the Sacred Book of the East) and Nooten and Holland, 1995).

Chakrabarti has categorically summarized the contexts in which the term ayas occurs in Rigveda (Chakrabarti, 1979: 22). These are: (i) 6 times (RV 1.52.8, 1.57.3, 1.80.12, 1.121.9, 10.96.3-4, 10.113.5) as an attribute of the thunderbolt of Indra. The verses are

1.052.08c ayachatha bahvor vajram ayasam adharayo divy a suryam. Drse —(Indra’s) thunderbolt of ayas

1.057.03c yasya dhama sravase namendriyam jyotir akari harito nayase—(Indra’s) thunderbolt of ayas

1.080.12c abhy enam vajra ayasahahasrabhrstir ayatarcann anu svarajyam—(Indra’s) thunderbolt of ayas

1.121.09a tvam ayasam prati vartayo gor divo asmanam upanitam rbhva—(Indra’s) thunderbolt of ayas
However, the verses 10.048.03a and 1.081.04c also referred to ayas as an attribute of the thunderbolt of Indra

(ii) The word ayas occurs twice as an attribute of Indra himself (1.56.3, 10.96.8), which has been taken to mean that Indra is clothed in ayas armour;

(iii) 7 times ayas occur (1.58.8, 2.20.8, 4.27.1, 7.3.7, 7.15.14, 7.95.1, 10.101.8) as an attribute of forts.
7.015.14a *adha mahi na ayasy anadhrsto nrpitaye* —Agni be thou a mighty iron fort to us

7.095.01a *pra ksodasa dhayasa sasra esa sarasvati dharunam ayasi puh* —the stream Sarasvati with fostering current comes forth, our sure defence, our fort of iron

10.101.08c *purah krnudhvam ayasir adhrsta ma vah susroc camaso drmhata tam* —cities of ayas

(iv) *Ayas occur* twice (9.1.2, 9.80.2) to denote the *ayas*-fashioned homes of Indra and Soma.

9.001.02a *raksoha visvacarsanir abhi yonim ayohatam* —(Indra) his place, his *ayas*-fashioned home.

9.080.02a *yam tva vajinn aghnya abhy anusatayahatam yonim a rohasi dyuman* —(Soma) his *ayas*-fashioned home

(v) *To denote the *ayas*-pillared chariots of Mitra and Varuna, the term *ayas* occur two times (5.62.7, 5.62.8).*

5.062.07a *hiranyanirnig ayo asya sthuna vi bhrajate divy asvajaniva* —its columns are of *ayas* (chariot of Mitra Varuna)

5.062.08a *hiranyarupam usaso vyustav ayasthunam udita suryasya* —*ayas* pillared (chariot of Mitra Varuna)

(vi) *The term *ayas* occurs twice (1.88.5, 10.87.2) to describe the teeth of Agni and Marut.*

1.088.05c *pasyan hiranyacakran ayodamstran vidhavato varahun* —(Marut) armed with *ayas* weapons

10.087.02a *ayodamstro arcisa yatudhanan upa sprsa jatavedah samiddhah* —(Agni) with the teeth of *ayas*.

(vii) *To describe the jaws of a horse and the sun, *ayas* appears twice (4.37.4, 6.71.4).*

4.037.04a *pivoasvah succadratha hi bhutayahsipra vajinah suniskah* —jaws of *ayas* (context of horse)

6.071.04c *ayohanur yajato mandrajhva a dasuse suvati bhurum hiramaya hanu—Sayana*)—context Indrasomou

(viii) *Ayas occurs once (1.116.5) to describe a thigh.*

1.116.15c *sadojjangham ayasim vispalayai dhane hite sartave praty adhattam* —(Indra)
gave her (Vispala who lost her leg) of ayas

and (ix) once (1.163.9) to describe the feet of a sacrificial horse
1.163.09a hiranya sarnga 'yo asya pada manojava avara indra asit—his feet are of ayas (context of sacrificial horse).

(x) Ayas appears twice (6.3.5, 6.47.10) as an edge and a blade;
6.003.05a sa id asteva prati dhad asisyan chisita tejo 'yaso na dharam —(Agni’s) splendour like the edge of ayas
6.047.10a indra mrla mahyam jivatum icha codaya dhiyam ayaso na dharam—(Indra) sharpen my thought as ‘twere a blade of ayas.

and (xi) a number of times as material of a beak (10.99.8),
10.099.08c upa yat sidad indum sariraih syeno 'yopastir hanti dasyun—beak of ayas.

as point (6.53.5). However, the verse 10.099.06c also occurs to denote the point, made of iron
10.099.06c asya trito nv ojasa vrdhano vipa varaham ayoagraya han—struck down the boar with shaft whose point was iron

Reference to ayas-made arrow and axe occurs in the following verses.
8.101.03c ayahsirsa maderaghuh—ayas-topped

Chakrabarti referred to the verse (10.113.5) as denoting axe made of ayas. However, the verse 10.053.09c also referred to ayas-made axe.
10.053.09c sisite nunam parasum svayasam yena vrsced etaso brahmanas patih—axe of ayas.

The verse 5.030.15 c referred to ayas-made vessel
5.030.15c gharmas cit taptah pravrje ya asid ayasmayas tam v adama viprah (385) —vessel of ayas

The term also occurs to denote knives made of iron
8.029.03a vasim eko bibharti hasta ayasim antar devesu nidhruvih-knife of ayas.

Reference to the shaft having ayas mouth occurs in the following verse
6.075.15a alakta ya rurusirsny atho yasya ayo mukham—(shaft) with ayas mouth

Besides, the verse 4.002.17a describes the smelting of ayas.
The term *ayas* has been variously interpreted by scholars. Vaman Shivaram Apte (Apte, 1957: 210-11) in his work on *Practical Sanskrit English Dictionary* explains the term as ‘iron, steel, gold, a metal in general and aloe wood’. In A *Comparative Dictionary of the Indo-Aryan Languages* by R. L. Turner, *ayas* is listed as ‘metal, iron’ (Turner, 1966:26). Similar explanation has been given in Carl Cappeller’s *A Sanskrit-English Dictionary* (Cappeller, 1891: 39) and Arthur A. Macdonell’s *A Sanskrit-English Dictionary* (Macdonell, 1929: 26, 41). Theodore Benfey categorically interprets *ayas* as iron (Benfey, 1866: 36, 46). Monier Williams in his *A Sanskrit-English Dictionary* indentifies *ayas* as ‘iron, steel, gold, metal’ (Williams, 1899: 85).

Scholars like M.N. Banerjee L. Gopal (1961: 71-86) and N.R. Banerjee (1965) have taken *ayas* as iron.

M. N. Banerjee (1927: 121-133; 1929: 432-436; 1932:364-366) in his works suggests that the term *Ksura* (cf. 1.166.10c *amsesv etah pavisu ksura adhi vayo na paksan vy anu sriyo dhire*, 10.028.09a *sasah ksuram pratyanam. jagaradrim logena vy abhedam arat*), *Khadi* (Banerjee identifies it with *Khadu*) (cf. 6.016.40a *a yam haste na khadinam sisum jatam. na bibhrati*, 2.034.02a *dyavo na strbhis citayanta khadino vy abhriya na dyutayanta vrstayah*, 10.038.01c *yatra gosata dhrsitesu khadisu visvak patanti didyavo nrsahye*) and *asi* or *svadhiti* (cf. 9.096.06c *syeno grdhraman. svadhitir vananam somah pavitram aty eti rebhan*, 3.008.11c *yam tvam ayam svadhitis tejamanah praninaya mahate saubhagaya* (243)), can be identified with razor, quoit rings and axe respectively and according to him all of these were made of iron.

The important references to the metallurgical activities are:

1. 10.81.3. here the term *Samdhamati* (10.081.03c *sam bahubhyam dhamati sam patattrair dyavabhumi janayan deva ekah*) has been explained by Roth and Grassmann (as cited in Banerjee, 1929: 432-436) as *zussamen schweissen* i.e., to weld together whereas *Sayana* suggests that its actual meaning is *Prerayati* or pressing into i.e., joining together (weld- to press or beat into intimate contact and permanent union)

2. 9.112.02a *jaratibhir osadhibhih parnebhih sakunanam*  
   9.112.02c *karmaro asmahir dyubhir hiranyavantam ichatindrayendo pari srava.*
By citing this passage, M.N. Banerjee (1929: 432-436) interprets the same as the evidence of steel manufacture during the Rigvedic period.

3. 10.072.02a *brahmanas patir eta sam karmara ivadhat.* Banerjee identifies *Karmara* of the Rigveda as the works of (performing with bellows) firing, striking and hammering.

4. 4.002.17a *sukarmanah suruco devayanto 'yo na deva janima dhamantah*

Sayanacharya makes the meaning clear. *yatha karmarah ayo bhastrera dhamantti tadvat.* Sayanacharya explains it ‘as the smiths heat metal by the bellows’.

In all probability, *ayas* was a base metal used for making weapons, implements and vessels. As mentioned earlier, *Rigveda* 6.075.15a (*alakta ya rurusirsny atho yasya ayo mukham*) refers to arrows tipped with *ayas*. *RV* 8.029.03 (8.029.03a *vasim eko bhhartir hasta ayasim antar devesu nidhrvih*) informs about the *vasi*, made of *ayas*.

The terms meaning sharp edged weapons like *asi*, *svadhiti*, *parasu*, *pavi* and *kshura* have found its mention in Rigveda. *Rigveda* 10.079.06 (10.079.06c *akrilan krilan harir attave 'dan vi parvasas cakarta gam ivasihi*) refers to *asi* as a sharp weapon used for cutting bull into bits. *Svadhiti* was used for cutting trees whereas *Agni* has been called as *svadhitir vananam* (9.096.06c *syeno grdhranam svadhitir vananam somah pavitram aty eti rebhan*). *Svadhiti* along with *asi* were used in horse sacrifice (1.162.20a *ma tva tapat priya atmapiyantam ma svadhitis tanva a tishhipat te*). These weapons as mentioned in *Rigveda* could kill animal with one stroke. Like *Svadhiti*, *Parasu* was also used for cutting woods and clearing forests (6.003.04c *vijehamanah parasur na jihvam dravir na dravayati daru dhaksat*). *Pavi*, a weapon of *Maruts* has been compared with *Vajra* (1.66.10). It was probably used as a metallic tyre of wheels of the chariots. *Kshura* was also a sharp edged weapon. Indra has been requested to make the intellect of man sharp like *Kshura*, the razor. The epithets such as *ayahsipra* (4.037.04a *pivoasvah sucaadratha hi bhutayahsipra vajina suniskah*), *ayohanuh* (6.071.04c *ayohanur yajato mandrajihva a dasuse suvati bhuri vamam*), *ayahsirsa* (8.101.03c *ayahsirsa maderaghuh*) probably indicate the hardness of *ayas*. Similarly, the sharpness of the metallic objects and weapons is suggested by the expression *ayosa-dhara* (6.047.10a *indra mrla mahyam jivatum icha codaya dhiyam ayaso na dharam*), meaning the sharp blade of the objects made of *ayas*. Such Rigvedic references to the hardness and sharpness of the objects made from *ayas* led N. R. Banerjee (Banerjee, 1965: 158-160) to conclude that it was no other metal but iron. It is interesting to note here that in a hymn of the *Atharvaveda*,...
svadhiti, the axe, has been described as lohita. In the later Vedic literatures lohayasa or lohitayas stands for copper. Thus one can easily conclude that svadhiti described as lohita in Atharvaveda (VI142.2) was a weapon made of copper. Significantly, there is a greater possibility of the use of copper weapons and implements during the Rigvedic period and in that case ayas basically stands for copper (Tripathi, 1998: 346-349). In certain hymns of Rigveda there are allusions about the colour of ayas which may help us in identifying the metal. The Agni has been called as ayodamstra (1.088.05c pasyan hiranyacakran ayodamstran vidhavato varahun). According to Zimmer (cited in Tripathi, 1998: 346-349), it refers to the colour of the flames which resembles ayas. As the colour of the flames is reddish it may be presumed that the ayas was also reddish in colour. Similar information has been also provided by the verse (Rigveda) 10.096.03 (10.096.03a so asya vajro harito ya ayaso harir nikamo harir a gabhastyoh; 10.096.03c dyumn i susipro harimanyusayaka indre ni rupa harita mimiksire). Here, reference is given to a thunderbolt, made of ayas, which is yellow in colour. Interestingly, in Atharvaveda (XT.3.1.7), ayas has been divided into two categories, the Shyama and the lohita. The first is the black-coloured metal and the second is a red-coloured metal. Scholars have identified shyama with iron and lohita with copper. Therefore in Vedic literature, loha, lohayas or lohitayas suggesting a red-coloured metal stands for copper and is distinguished from iron which is black in colour. Now the question arises if ayas stood for copper in Rgvedic times why it was called lohayas during the later Vedic age. It can be well justified that in the early Vedic age metallurgy was in its primitive stage and varieties of baser metals were not known. Furthermore, if the feet of ayas of the sacrificial horse in 1.163.9 (1.163.09a hiranyasrngo 'yo asya pada manojava avara indra asit) suggest horseshoes, which usually are of iron, one may recall the description of the chariot of Mitra-Varuna as ayas-pillared "when the sun is setting" (5.062.08a hiranyarupam usaso vyustav ayasthunam udita suryasya) is also inconclusive because the colour of sunset is reddish and that may suggest any red-hot metal, not necessarily iron. In the verse 1.116.15c (sadyo jangham ayasim vispalayai dhane hite sartave praty adhattam) it has been described that the foot of Vispala (the wife of) Khela was cut off like the wing of a bird, in an engagement by night and immediately you gave her an ayas leg that she might walk. Thus, As’vins provided with an ayas leg to Vis’pala who lost her leg in a conflict. Interesting information regarding surgery and artificial limb is provided by the verse. Difficulty lies in identifying (copper/ iron?) the constituents of that limb. However, iron with its properties may cause poisoning whereas copper with its lighter
weight might be better suited for this purpose (Tripathi, 2001: 60-61). The references to arrow-heads, knives, and axes are equally inconclusive as they may occur in copper, bronze and iron. The references to the iron-walled city (7.015.14a adha mahi na ayasy anadhrsto nrpitaye) quite baffle us as we have hardly met with fortifications of iron or any other metal. Perhaps, it refers to strong walled towns. Similarly, no conclusion can be reached from 6.3.5 where Agni “whets his splendour like the edge of ayas”.

Significantly, references to the metallurgical knowledge of smelting activities are reflected in certain verses (10.072.02a brahmanas patir eta sam karmara ivadhamat). M.N. Banerjee (1929: 432-436) identifies Karmara of the Rigveda as the works of (performing with bellows) firing, striking and hammering, (2.024.07a rtavanah praticaksyanrta punar ata a tastthuh kavayo mahas pathah; 2.024.07c te bahubhyam dhamitam agnim asmani nakih so asty arano jahur hi tam. Stones are being thrown into the fire with both the hands while also fanning the flames. Sayanacharya explains the operation in the following words-‘te bahubhyam dhamitamagnimasmani jahuh hi dagdhham’ i.e., they throw the stones (ores) in the fire flames with both hands), (5.009.05a adha sma yasyarcyah samyak samyanti dhuminah 5.009.05c yad im aha trito divy upa dhmateva dhamati sisite dhmatari yatha. Of whom some emitting, the flames intensely collect then when diffused in the three regions Agni inflates himself in the firmament like the blower of a bellow and sharpens (his flame) as the fire blazes from (the blast) the blower). Such clear references to smelting-forging activities involving the use of bellows perhaps not singularly indicates the methods of iron extraction as such methods are equally applicable for copper-bronze workings. As mentioned earlier, the words like Dham, Dhamati and Samdhamanti which has been interpreted by Banerjee as welding specifically denotes the works associated with blowers and molten metal. Pleiner (Pleiner, 1971: 5-36) suggests that the verse 6.3.4 categorically mentions the word molten metal i.e. dravi-liquified. It is almost certain that melting temperature (so far as iron is concerned) was never attained in early furnaces. Instead, copper was melted during its smelting as well as also during its casting and alloying. Another controversial passage is 9.112.2 (RV, 9.112.02a jaratibhir osadhibhih parnebhih sakunanam; 9.112.02c karmaro asmabhir dyubhir hiranyavantam ichatindrayendo pari srava). Banerjee translated (Banerjee, 1932: 364-366) it as ‘with dried faggots of trees as fuel and fans of wings of birds and clear and bright stones, the karmar or the smith (engaged in making arrows) desires a rich person (to buy them).’ Banerjee interpreted it more literally as ‘jaratibhih
osadhibhih’ with dried medicinal plants which in his opinion could be *cassiauriculata* a plant used by makers of wootz steel for adding carbon in crucible steel and with wings of birds (*Parnebhih Sakunanam*) and bright stone (ores or anvils translated variously) the smith waits for a wealthy customer. Tripathi (Tripathi, 2001: 64) perhaps rightly conjectures that this verse refers to arrow making rather than steel making process. According to her, “The smith must be keeping ready his semi-finished product or the ingots to be precise, to forge the arrow-heads to shape them and finish them as the arrows with wings according to the requirement of his rich customer. To suggest smelting or damascening under such circumstances would be impractical. Smelting and then steeling iron was a lengthy and tedious process. The arrows had to be finished with feathers of birds. The dried up plants or faggots could be used for forging-annealing the copper-bronze arrows” (Tripath, 2001:64). Regarding the sharpness and strength of tools or weapons made of *ayas*, it can be surmised that wrought iron of the post-Chalcolithic phases was sufficiently strong to make weapons or other sharp-edged tools. A good bronze which has undergone through the process of annealing has a strength of 120,000 PSI (per square inch) while a wrought iron (with no carbon content) has only 40,000 PSI. It is well known that early iron found in India, was wrought iron having no carbon in it. Thus, technologically, strong and sharp weapons of Rigvedic people were more likely to be of copper-bronze than of iron (see, Tripathi, 2001: 64).

It should be clear that any controversy regarding the meaning of *ayas* in the Rigveda or the problem of the Rigvedic familiarity or unfamiliarity with iron is yet to be resolved. There is no positive evidence regarding its specific identification (Chakrabarti, 1979: 23). It can mean both copper bronze and iron. Radomir Pleiner concludes after his study on the Rigvedic evidence that “*ayas* . . . served as a term for a copper alloy or metal in a broader sense” (Pleiner, 1971: 9). While fully agreeing with the idea that *ayas* was a generic term, we believe that the term could include iron also.

**Samaveda**

The Samaveda, or Veda of holy songs, third ranks next in sanctity and liturgical importance to the *Rigveda* or Veda of recited praise. Its Samhita, or metrical portion, consists chiefly of hymns to be chanted by the Udgatar priests at the performance of those important sacrifices in which the juice of the Soma plant, clarified and mixed with milk and other ingredients, was offered in libation to various deities (Griffith, 1895). Here, the term *ayas* occur in the verses (Part I) 5.1.4.5 (Great, as his nature is, through power,
terrible, he hath waxed in strength, Lord of bay steeds, strong-jawed, sublime, he in joined hands for glory's sake hath grasped his iron thunderbolt) in the context of thunderbolt and in (Part II) 1.1.15.2 (Fiend-queller, friend of all men, he hath reached his shrine, his dwelling-place, within the iron-hammered vat).

Yajurveda:

In the Taittiriya Samhita recension of the Black Yajurveda, the references to *ayas* occur in the following verses. The verses have been cited from the translation of Keith, Arthur Berriedale of *The Yajur Veda (Taittiriya Samhita)* (Keith, 1914)

**The verse 4-7-5-1 has the reference to *ayas* as one of the important metals.**

4-7-5-1. May I for me the stone, clay, hills, mountains, sand, trees, gold, bronze, lead, tin, iron, copper, fire, water, roots, plants, what grows on ploughed land, what grows on unploughed land, tame and wild cattle prosper through the sacrifice; may for me wealth and gaining wealth, attainment and attaining, riches, dwelling, act, power, aim, strength, moving and going (prosper through the sacrifice).

(Asma ca me mṛttika ca me girayas ca me parvatas ca me sikatas ca me vanaspatayas ca me hiranyam ca me ayas ca me sisam ca me trapus ca me syamam ca me loham ca me gnis ca ma apas ca me virudhas ca ma osadhayas ca me krstapacyam ca.)

**The following verse referred to the citadel of Asuras, made of *ayas*.**

6-2-3-1. The Asuras had three citadels; the lowest was of iron, then there was one of silver, then one of gold. (*tesam asuranam tisrah pura asann ayasmayy avamatha rajatatha harini*)

1-2-11-2. That form of thine, O Agni, which rests in iron, which rests in silver, which rests in gold, the highest, that dwells in the cleft. (*ya te agne yasaya rajasaya harasaya tanur varsistha gahvare stha*).

**The verse 4-2-5-3 referred to bond made of *ayas*.**

4-2-5-3. Loosen ye this bond made of iron (*ayasmayam vi crta bandham etam*).

**The following verses referred to the feet made of *ayas* and the pillars of *ayas* respectively.**

4-6-7-4. Golden his horns, iron his feet (*hiranyakro ayo asya pada manojava avara indra asit*).

1-8-12-3. Gold hued in the glowing of the dawns, Bronze pillared at the rising of the sun,
O Varuna, O Mitra, mount your chariot seat, (ayasthunav udita suryasya rohatam varuna mitra).

Besides, reference to smith working on ayas also appears in the following verse.

4-5-4-2. Homage to you, potters, and to you, smiths, homage! (namah kulalebhyah karmarebhyas ca vo namas).

Of these verses, 4-7-5-1 is significant as it categorically defines different types of metals. These are hiranya, sisa, trapu, ayas, syamam and loham. According to the commentator, syama is black ayas, while loha is bell-metal, copper etc. If the black ayas i.e., syamam stands for iron, the use of this distinctive epithet in one instance makes the word ayas stand for bronze in this case.

In 2.11.05. of the recension known as the Maitrayani Samhita, the relevant words which occur are hiranya, sisa, trapu, syamam, lohitayasam. These words also figure in the Vajasaneyi Samhita (18.13). (Verse cited from the Maitrayani Samhita, translated by Leopold von Schroeder, 1881-86)

(May my stone and my clay, and my hills and my mountains, and my pebbles and my trees, and my gold and my bronze, and my copper and my iron, and my lead and my tin prosper by sacrifice; asma ca me mrttika ca me girayas ca me parvatas ca me sikatas ca me vanaspatayas ca me hiranyam ca me yas ca me syamam ca me loham ca me sisam ca me trapu ca me yajnena kalpantam).

The specific denotation of bronze or copper by colour is found in another recension known as the Kathaka Samhita (18.10) (Leopold von Schroeder, 1900-09). The word Syamenayasa occurs also in the verse 4.2.9 of the Maitrayani Samhita obviously in the sense of iron but in 4.2.13 of the Maitrayani Samhita ayas (ayasi) occurs without any epithet. Therefore, whatever, may be the actual meaning of ayas, one can positively infers that, by the time of Yajurveda, iron was not an unfamiliar metal (Chakrabarti, 1992:101).

Atharvaveda:

There are quite a few references to plain, unqualified ayas in the Atharvaveda (AV). The verses have been cited from the translated version of the Hymns of the Atharva Veda, (translated) by Ralph T.H. Griffith (1895-96)

The reference to teeth made of ayas occurs in the following verse (Griffith, 1895-96 (book 8): a327).
8.3.2: O Jatavedas, armed with teeth of iron, enkindled with thy flame, attack the demons.
Seize with thy tongue the foolish god’s adorers: rend, put with- in thy mouth the raw flesh-eaters.
Halfverse: a ayodamstro arcisa yatudhanan upa sprsa jatavedah samiddhah / 
Halfverse: c a jihvaya muradevan rabhasva kravyado vrstvapi dhatsvasan //2//
Reference to the faces of ayas occurs in the verse 11.10.03 (Griffith, 1895-96 (book 11): 71)
11.10.03: Let those with iron faces, with faces like needles or like combs, flesh-eaters, rapid as the wind, cling closely to our foemen with Trishandhi for their thunderbolt.
Halfverse: a ayomukhah sucimukha atho vikankatimukkah / 
Halfverse: c kravyado vataramhasah a sajantv amitran vajrena trisandhina //
There are also few references which have some philosophical significance and of course some meaningful expression related to the use iron (Griffith, 1895-96 (book 5): a191).
05.28.01: For lengthened life, to last through hundred autumns, they equalize with nine the nine aspirations. Three in gold, three in silver, three in iron by heat are established in their several places.
Halfverse: a nava pranan navabhih sam mimite dirghayutvaya satasaradaya / 
Halfverse: c harite trini rajate triny ayasi trini tapasavisthitani //1//
05.28.05: With gold let earth protect thee, and with iron, accordant, all- sustaining Agni save thee! And in accordance with the plants may silver, regarding thee with favour, grant thee vigour.
Halfverse: a bhumis tva patu haritena visvabhrd agnih pipartv ayasa sajosah / 
Halfverse: c virudbhis te arjunam samvidanam daksam dadhatu sumanasyamanam //5//
05.28.09: The golden guard thee from the sky, the silver guard thee from the air, the iron guard thee from the earth! This man hath reached the forts of Gods.
Halfverse: a divas tva patu haritena madhyat tva patv arjunam / 
Halfverse: c bhumya ayasmayam patu pragad devapura ayam //9//
References to the specific objects made of ayas are found in the following verses.

7. 115 (120).1: Hence. evil fortune! fly away, vanish from this place and from that. We fix thee with an iron hook unto the man who hates us. (Griffith, 1895-96 (book 7): a320)

Halfverse: a *pra patetah papi laksmi nasyetah pramutah pata /
Halfverse: c *ayasmayenankena dvisate tva sajamasi //1//

04.37.08: With those dread hundred iron spears, the darts of Indra, let it pierce (Griffith, 1895-96 (book 4): a147).

Halfverse: a *bhima indrasya hetayah satam rstir ayasmayih /
Halfverse: c *tabhir haviradan gandharvan avakadan vyrsatu //8//

06.63.2: To thee, sharp-pointed Nirriti, be homage! Loose thou the binding fetters wrought of iron. To me, in truth, again doth Yama give thee. To him, to Yama, yea, to death, be homage! (Griffith, 1895-96 (book 6): a229)

Halfverse: a *namo stu te nirrte tigmatejo ayasmany vi ctra bandhapasan /
Halfverse: c *yamo mahyam punar it tvam dadati tasmai yamaya namo astu mrtaye //2//

08.10.22: She rose, approached the Asuras: they called her: their cry was, come, O Maya, come thou hither. Her dear calf was Virochana Prahradi: her milking vessel was a pan of iron. (Griffith, 1895-96 (book 8): a352)

Halfverse: a *sod akramat sasuran agachat tam asura upahvayanta maya ehti /
Halfverse: c *tasya virocanah prahradir vatsa asid ayaspatraṃ patram /
Halfverse: e *tam dvimurdhartyo ‘dhok tam mayam evadhok /
Halfverse: g *tam mayam asura upa jivanty upajivaniyo bhavati ya evam veda //22//

19.66.01: The Asuras with iron nets, magicians, who roam about with hooks and bonds of iron, with wrath I make thy thralls, O Jatavedas. Come as a bolt foe-quelling, thousand pointed. (Griffith, 1895-96 (book 19): 262)

Halfverse: a *ayojala asura mayino ‘yasmayaih pasair ankino ye caranti /
Halfverse: c *tams te randhayami harasa jatavedah sahasrarstih sapatnan pramrnan pahi vajrah //1//
The following verses referring to pillars made of *ayas* have definite connections with philosophical thoughts.

06.63.3: Compassed by death which comes in thousand manners, here art thou fastened to the iron pillar. Unanimous with Yama and the fathers, make this man rise and reach the loftiest heaven. (Griffith, 1895-96 (book 6): a229)

Halfverse: a  *ayasmaye drupade bedhise ihabhihito mṛtyubhir ye sahasram /
Halfverse: c  *yamena tvam pitṛbhih samvidana uttamam nakam adhi rohayemam //3//

06.84.04: Thou hast been fastened to an iron pillar, here compassed with a thousand deaths around thee. In full accord with Yama and the fathers, send this man up-ward to the loftiest heaven. (Griffith, 1895-96 (book 6): a239)

Halfverse: a  *ayasmaye drupade bedhisa ihabhihito mṛtyubhir ye sahasram /
Halfverse: c  *yamena tvam pitṛbhih samvidana uttamam nakam adhi rohayemam //4//

Besides *ayas*, references to the dark coloured metal (*Syamam*) are found in two verses. These are:

11.3.7: Grey iron is its flesh, copper its blood (Griffith, 1895-96 (book 11): 50).

Halfverse: a  *syamam ayo 'syā mamsani lohitam asya lohitam /
9.5.4. Cut up this skin with the grey knife, Dissector! Dividing joint from joint and mangle nothing. Do him no enjury: limb by limb arrange him, and send him up to the third cope of heaven, (Griffith, 1895-96 (book 9): a368)

Halfverse: a  *anuchya syamena tvacam etam visastar yathaparv a1sina mabhi mamsthah /
Halfverse: c  *mabhi druhah parusah kalpayainam trtiye nake adhi vi srayainam //4//

In AV 10.1.20 there may be a reference to the magical property of iron (Griffith, 1895-96 (book 10): 3)

“Within our house are swords of goodly iron. *Kritya*, we know thy joints and all their places. Arise this instant and begone! What, stranger! art thou seeking here?”

Halfverse: a  *svayasa asayah santi no grihe vidma te kṛtye yatidha parumsi /
Halfverse: c  *ut tisthaiva parehito 'jnate kim ihechasi //20// {2}
It is quite interesting to note that during the composition of Atharvaveda, the metal ayas acquired its ritualistic significance.

The reference to smith- karmarah is found in AV 03.05.06. (Griffith, 1895-96 (book 3): a70)

03.05.06: Sagacious builders of the car, cleaver and skilful artisans,—
Make all the men on every side, Parna, obedient to my will
Halfverse: a ye dhivano rathakarah karmara ye manisinah /
Halfverse: c upastin parna mahyam tvam sarvan krv abhito janan //6/

The reference to forging/ smelting is found in the verse 18.03.22. (Griffith, 1895-96 (book 18): 194)

18.03.22: Gods, doing holy acts, devout, resplendent, smelting like ore their human generation,
Brightening Agni and exalting Indra, they came encompassing the stall of cattle.
Halfverse: a sukaranah suruco devayanto ayo na deva janima dhamantah /
Halfverse: c sucanto agnim vavrdhanta indram urvim gavyam parisadam no akran //22/

The references to bows, arrows, swords, axes etc. are found in the following verse.
(Griffith, 1895-96 (book 11): 68)

11.09.01: All arms and every arrow, all the power and might that bows possess,
The warlike weapon, axes, swords, the plan and purpose in the heart,
All this, O Arbudi, make thou visible to our enemies, and let them look on mist and fog.
Halfverse: a ye bahavo ya isavo dhanvanam viryani ca /
Halfverse: c asin parasun ayudham cittakutam ca yad dhrdi /
Halfverse: e sarvam tad arbude tvam amitrebhyo drse kurudarams ca pra darsaya //

Reference to sharp edged weapon is found in the verse 12.05.20. (Griffith, 1895-96 (book 12): 103)

12.05.20: Sharp as a razor when she beholdeth, she thundereth when she belloweth.
Halfverse: a ksurapavir iksamana vasyamanabhi sphurjati //20//
An indirect evidence of the proliferated use of iron seems to be provided by 10.6.2-3. AV 10.06.02 -10.06.03 speak of an amulet born of the ploughshare (Griffith, 1895-96 (book 10): 17). According to Chakrabarti, the necessity of the reference to a smith in the context of the manufacture of an amulet out of a ploughshare seems to suggest unequivocally that the ploughshare was of metal and, considering the fact that iron was positively known in the AV, the metal ploughshare in this case might well have been of iron (Chakrabarti, 1992: 102). The said verses are:

10.06.02: This Amulet of citron-wood shall make for me a trusty shield. Filled with the mingled beverage, with sap and vigour hath it come.

10.06.03: What though the strong-armed carpenter have cleft thee with his hand and axe. Pure animating waters shall cleanse thee and make thee bright again.

Verse: 2
Halfverse: a varma mahyam ayam manih phalaj jatah karisyati /
Halfverse: c purno manthena magamad rasena saha varcasa //2//

Verse: 3
Halfverse: a yat tva sikvah paravadhit taksa hastena vasya /
Halfverse: c apas tva tasmaj jivalah punantu sucayah sucim //3//

Brahmanas: Among the Brahmanas, the Aitareya and the Kausitaki Brahmanas do not specifically refer to ayas though the Taittiriya Brahmana has a few references to ayas (Mitra, 1870:355).

viz. 3.4.10.1. manyave 'yastapam /

Significantly, Satapatha Brahmana has substantial references to ayas which deserve detailed consideration.

General references to ayas are found in the following verses. The verse 3:4:4:3 contains the reference to the castles of Asuras made of ayas

3:4:4:3. Now the gods and the Asuras, both of them sprung from Pragapati, were contending against each other. The Asuras then built themselves castles in these worlds,—an iron one in this world, a silver one in the air, and a golden one in the sky. (Eggeling, 1885 XXVI: 105)
The following three verses mentioned iron (ayas) with lead, silver and gold

12:7:1:7. From his navel his life-breath flowed, and became lead,—not iron, nor silver; from his seed his form flowed, and became gold; from his generative organ his essence flowed, and became parisrut (raw fiery liquor); from his hips his fire flowed, and became surd (matured liquor), the essence of food. (Eggeling, 1900 XLIV: 215)

5.1.2.14: Now when he buys the king (Soma), he at the same time buys for a piece of lead the Parisrut (immature spirituous liquor) from a long-haired man near by towards the south. For a long-haired man is neither man nor woman; for, being a male, he is not a woman; and being long-haired (a eunuch), he is not a man. And that lead is neither iron nor gold; and the Parisrut-liquor is neither Soma nor Sura \: this is why he buys the Parisrut for a piece of lead from a long-haired man. (Eggeling, 1894 XLI: 9)

12.7.2.10: With lead he buys-the malted rice, with (sheep’s) wool the malted barley, with thread the (fried) rice-grain, — that lead is a form of both iron and gold, and the Sautramani is both an ishti-offering and an animal sacrifice, so that he thereby secures both of these. (Eggeling, 1900 XLIV: 219)

In the verses 5.4.1.1-2 copper or bronze is specifically mentioned as lohayasa.

(Eggeling, 1894 XLI: 90)
5:4:1:1. He puts a piece of copper into the mouth of a long-haired man, with (Vâg. S. X, 10), 'Removed by sacrifice are the mordacious.' For verily he who performs the Ragasuya escapes all kinds of death, all murderous blows, and old age alone is his death: hence whatever kind of death, whatever murderous blow there is, past that he now guides him, as past the mordacious ones.

Sentence: a  kesavasya purusasya
Sentence: b  lohayasamasya avidhyatayavesta dassasuka iti sarvanva esa mṛtyunatimuceyate sarvanbadhanyo rajasyena yajate tasya jaraiva mṛtyurbhavati tado mṛtyuryo badhastamevadatinentayati yaddandasuken

5:4:1:2. And as to why it is of a long-haired man,—such a long-haired man is neither woman nor man; for being a male, he is not a woman, and being long haired (a eunuch), he is not a man. And copper (or bronze) is neither iron nor gold; and those mordacious ones (snakes) are neither worms nor non-worms. And as to its being copper--reddish. Eggeling suggest that, *lohayasa*, literally, ‘red metal’, apparently either copper, or an alloy of copper and some other metal.—The eunuch is sitting in the Sadas. (Eggeling, 1894 XLI: 90)

Sentence: a  atha yatkesavasya purusasya
Sentence: b  na va esa stri na pumanyatkesavah puruso yadaha pumastena na stri yadu kesaavasteno na pumannaitadayo na hiranyam yallohayasam naite krimayo nakrimayo yaddandasuka atha yallohayasam bhavati lohita iva hi dassasukastasmatkesavasya purusasya

The reference to smelting activity is found in the following verse which reads as
(Eggeling, 1894 XLI: 158)

6:1:3:5. From the sated he created the pebble: whence sand finally indeed becomes a pebble;--from the pebble the stone: whence the pebble finally indeed becomes a stone;--from the stone metal ore: whence from stone they smelt ore;--from ore gold: whence ore much smelted comes, as it were, to have the appearance of gold.

Sentence: a  sikatabhyah sarkaramasrjata
Sentence: b  tasmatsikatath sarkaraivantato bhavati sarkaraya asmanam tasmacharkarasмаvantato bhavatyasmano ‘yastasmadasmano ‘yo dhamsantyayaso hiranyam tasaradaya bahudhatam hiranyasamkasamiva bhavati

The verses 13.2.2.16-19 are significant as here iron has been associated with the peasantry. The context is the ritual of the horse sacrifice.
13:2:2:16. The slaughtering-knife of the horse is made of gold, those of the ‘paryangyas’ of copper, and those of the others of iron; for gold is (shining) light, and the Asvamedha is the royal office: he thus bestows light upon the royal office. And by means of the golden light (or, by the light of the gold), the sacrificer also goes to the heavenly world; and he, moreover, makes it a gleam of light shining after him, for him to reach the heavenly world.

(Eggeling, 1900 XLIV: 303)

Sentence: a  
hiranmayo'svasya saso bhavati

Sentence: b  
lohamayah paryangyanamayasa itaresam jyotirvai hiranyam
rastramasvamedho jyotireva tadrastrre dadhatyatho hiranyajyotisaiva yajamanah
svargam lokametyatho anukasameva tam kurute svargasya lokasya samastyai

13:2:2:17. But, indeed, the horse is also the nobility; and this also--to wit, gold--is a form (symbol) of the nobility: he thus combines the nobility with the nobility. (Eggeling, 1900 XLIV: 303-304)

Sentence: a  
atho ksatram va avsah

Sentence: b  
ksatrasyaitadrupam yaddhiranyam ksatrameva tatksatrena samardhayati

13:2:2:18. And as to why there are copper (knives) for the ‘paryangyas’,--even as the non-royal kingmakers, the heralds and headmen, are to the king, so those ‘paryangyas’ are to the horse; and so, indeed, is this--to wit, copper--to gold: with their own form he thus endows them. (Eggeling, 1900 XLIV: 304)

Sentence: a  
atha yallohamayah paryangyanam

Sentence: b  
yatha vai rajnorajano rajakrtah sutagramanya evam va ete'svasya
yatparyangya evamu va etaddhiranyasya yalloham svenaivainamstadrupena
samardhayati

13:2:2:19. And as to why there are iron ones for the others,--the other animals, indeed, are the peasantry, and this--to wit, iron--is a form of the peasantry, he thus combines the peasantry with the peasantry. On a rattan mat (lying) north (of the Ahavaniya) they cut the portions of the horse (flesh); for the horse is of anushtubh nature, and related to the anushtubh is that (northern) quarter: he thus places that (horse) in its own quarter. And as to (his doing so) on a rattan mat,--the horse was produced from the womb of the waters, and the rattan springs from the water: he thus causes it to be possessed of its own (maternal) womb. (Eggeling, 1900 XLIV: 304)
The association of iron with common people is also evident in 13:3.4.5 where the third oblation of blood after the horse sacrifice is supposed to be given ‘in an iron bowl; for the people (subjects) are of iron’.

13:3:4:5. The third oblation he offers in an iron bowl; for the people (subjects) are of iron, and the Svishtakrit is Rudra: he thus shields the people from Rudra, whence Rudra does not prowl after the cattle where this oblation is offered at the Asvamedha.

Regarding the people of iron, Eggeling suggests that “That is, their value—as compared with that of the king or nobles, and the Brahmans—is that of iron, compared with that of gold and silver” (Eggeling, 1900 XLIV: 339)

The following verse speaks of the use of iron rust.

6.5.1.6: Then there are these three kinds of powder (dust) —(sand of) gravel, stone, and iron-rust—therewith he mixes (the clay), just for firmness. And as to why (it is mixed) therewith, it is because there of this (earth) consisted when it was created in the beginning: thus whatlike this (earth) was created in the beginning, such he now makes it (the earth, or fire-pan).

(Eggeling, 1894 XLI: 231)

The verse 7.2.1.10 refers to the strength of iron as it speaks to loosen the iron bond.

7.2.1.10. Homage be unto thee full well, O sharp edged Nirrni! for Nirrni is indeed sharp-edged: to her he thereby renders homage;—‘loose thou this iron bond!’ for it is indeed with an iron bond that Nirr/ti binds him whom she binds; ‘being of one mind with Yama and Yami,’ —Yama doubtless is Agni, and Yami is this (earth), and by these two everything here is kept in check thus, ‘being of one mind with those two,’ —‘raise him
unto the highest firmament! the firmament is the heavenly world: thus, 'raise the
Sacrificer up to the heavenly world!(Eggeling, 1894 XLI: 322)

Sentence: a namah su te nirrte tigmateja iti
Sentence: b tigmateja vai nirrtistasya etannamaskarotyayasmayam vicrta
bandhametamiyayasmayena ha vai tam bandhena nirrtirbadhnati yam badhnati yamena
tvam yamya samvidanetyagnirvai yama iyam yamyabhym hidam sarvam yatamabhyam
tvam samvidanetyaduttame nake adhi rohayainamiti svargo vai loko nakah svarge loke
yajamanamadhirohayetatat

Among the Upanishads, the following verses of the Chhandogya Upanishad refers to
ayas as metaphor.

4.17.7. So, as one would mend gold with borax-salt, silver with gold, tin with silver, lead
with tin, iron with lead, wood with iron or with leather, even so with the power of those
worlds, of those divinities, of that triple knowledge one mends the injury to the sacrifice.
Verily, that sacrifice is healed in which there is a Brahmana priest who knows this. (Max
Müller, 1879: 71)

Sentence: 1 tad yatha lavanena suvarnam samdadhyat
   tad yatha lavanena su-varnam  samdadhyat
Sentence: 2 suvarnena rajatam rajatena trapu trapuna sisam sisena loham lohena daru
   (daru carmana /daruna carma) \417.7\From this context it is difficult to understand whether iron or copper/ bronze is
indicated.

The verses 6.1.4-7 categorically refers to lohamayam i.e., of gold whereas ayasam
i.e., of iron.

The father replied: 'My dear, as by one clod of clay all that is made of clay is known, the
difference being only a name, arising from speech, but the truth being that all is clay;
(Max Müller, 1879: 92)

6.1.5. And as, my dear, by one nugget of gold
All that is made of gold is known, the difference being only a name, arising from speech,
but the truth being that all is gold? Max Müller suggests that “the commentator takes
lohamani here as suvarnapinda”. (Max Müller, 1879: 92-93)
6.1.6. And as, my dear, by one pair of nail-scissors all that is made of iron (karshnayasam) is known, the difference being only a name, arising from speech, but the truth being that all is iron.—thus, my dear, is that instruction. (Max Müller, 1879: 93)

6.1.7. The son said: Surely those venerable men (my teachers) did not know that. For if they had known it, why should they not have told it me? Do you, sir, therefore tell me that. ‘Be it so,’ said the father. (Max Müller, 1879: 93)

6.1.4
Sentence: 1 yatha (somyaikena / saumyaikena) mṛtpindena sarvam mṛnmayam vijnatam syat
yatha (somya ekena / saumya ekena) mṛt-pindena sarvam mṛnmayam vijnatam syat
Sentence: 2 vacarambhanam vikaro namadheyam mṛttikety eva satyam
vaca arambhanam vikaro nama-dheyam mṛttika ity eva satyam

6.1.5
Sentence: 1 yatha (somyaikena / saumyaikena) lohamanina sarvam lohamayam vijnatam syat
yatha (somya ekena / saumya+ ekena) loha-manina sarvam lohamayam vijnatam syat
Sentence: 2 vacarambhanam vikaro namadheyam loham ity eva satyam
vaca arambhanam vikaro nama-dheyam loham ity eva satyam

6.1.6
Sentence: 1 yatha (somyaikena / saumyaikena) nakhanikrntanena sarvam karsnayasam vijnātam syat
yatha (somya ekena / saumya ekena) nakha-nikrntanena sarvam karsnayasam vijnatam syat
Sentence: 2 vacarambhanam vikaro namadheyam krsnayasam ity eva satyam
vaca arambhanam vikaro nama-dheyam krsnayasam ity eva satyam
Sentence: 3 evam (somya /saumya) sa adeso bhavatiti
evam (somya/ saumya) sa adeso bhavati iti

6.1.7
Sentence: 1 na vai nunam bhagavantas ta etad avedisuh
na vai nunam bhagavantas tae etad avedisuh
Sentence: 2 yad dhy etad avedisyan katham me navaksyan
yad dhy etad avedisyan katham me na avaksyan
Sentence: 3 iti bhagavams tv eva me bravity iti
iti bhagavams tv eva me bravity iti
Sentence: 4 tatha (somyeti / saumyeti) hovaca
Reference to heated axe is found in the verse 6.16.1.1.

6.16.1.1. ‘And also, my dear, they lead up a man seized by the hand, and call: “He has stolen! He has committed a theft! Heat the axe for him!” If he is the doer of the deed, thereupon he makes himself (atmanam) untrue. Speaking untruth, he covers himself with untruth. He seizes hold of the heated axe, and is burned. Then he is slain. (Max Müller, 1879: 108-109)

Maitri Upanishad, in the following verses gives reference to the iron smelting activities while explaining different philosophical facts of human body and soul

The inner Person remains unaffected in the elemental soul’s transformations (Max Müller, 1884: 297).

3.3. “Now, it has elsewhere been said: ‘Verily, he who is the doer is the elemental soul. The causer of action through the organs is the inner person. Now, verily, as a lump of iron, overcome by fire and beaten by workmen, passes over into a different form—so, assuredly, indeed, the elemental soul, overcome by the inner person and beaten by qualities, passes over into a different form. The mode of that different form, verily, has a fourfold covering, is fourteenfold, is transformed in eighty-four different ways, is a host of beings. These varieties, verily, are driven by the person, like “the wheel by the potter.” Now, as, when a lump of iron is being hammered, the fire [in it] is not overcome, so that person is not overcome. This elemental soul (bhutatman) is overcome (abhibhuta) because of its attachment [to Qualities].’

The light of the Brahma hidden in the body, made fully manifest and entered into in Yoga (Max Müller, 1884: 324).

6.27. And thus it has also been said elsewhere: This is the heat of the highest, the immortal, the incorporeal Brahman, viz. the warmth of the body. And this body is the clarified butter (poured on it, by which the heat of Brahman, otherwise invisible, is lighted up). Then, being manifest, it is placed in the ether (of the heart). Then by concentration they thus remove that ether which is within the heart, so that its light appears, as it were. Therefore the worshipper becomes identified with that light without
much delay. As a ball of iron, if placed in the earth, becomes earth without much delay, and as, when it has once become a clod of earth, fire and smiths have nothing more to do with that ball of iron, thus does thought (without delay) disappear, together with its support.

In the Baudhayana Srauta Sutra (XV 13), there is reference to the blacksmiths and their smelting activities. “……Blacksmiths manufactured articles of iron, copper and bell-metal. Ploughshares, spades, sickles, needles, knives, utensils and razors were some of the important articles manufactured by blacksmiths.” (Gopal, 1959: 136). It is also interesting to note that, blacksmiths and goldsmiths are separately mentioned here.

The Grihya Sutra of Gobhila informs that he who desires to do away with his enemy may sacrifice pegs made of iron.

4.8.11 One who is desirous of long life, should sacrifice (with that verse), in the night of the full moon, one hundred pegs of Khadira wood;

4.8.12. Of iron, if he desires that (his enemies) may be killed. (Oldenberg, 1892: 125)

Astadhyayi of Panini:

The metals which found their mention in the Astadhyayi of Panini are gold (hiranya or jatarupa), silver (rajata), lead (sisa), tin (trapu), bell-metal (kamsya), copper/ bronze (loha) and iron (ayas). Chakrabarti rightly surmised that in Astadhyayi, Panini (5.4.94) takes ayas both as a jati (genus) and as samjna (species)--- anosmayah sarasam jatisamjnayoh. (Agrawala, 1953; Chakrabarti, 1992: 105)

According to him, more logical explanation for considering copper and iron both as genus and species seems to be that, by jati, Panini means ayas as a generic name for both iron and copper or even metal in general while by samjna he refers to instances when ayas means only iron.

The references to ayas in Astadhyayi are found in the following verses

1.4.20. ayas maya made of metal (or iron);

3.3.82 karan-e ayas vi-dru-su (an iron instrument (probably hammer))

Besides reference to ayas are found in the verses 5.4.94., 8.3.49.

3.3.84 par-au gha-h (an iron instrument or bar used for locking doors)

4.3.168. kamsiya-parasavyay-or yan au lukca (parasavyay- made of iron)

5.2.76. ayah-sula danda ajina-bhyam tha than-au (ayah-sula- iron dart).
Other verses are 8.3.46 (ayas kamsa-iron goblet), 8.3.46 (ayas-karni- a woman having hard ears; ayas- kama, ayas-kara- blacksmith; ayas-kumbha- iron pot or boiler, ayas-kusa –a rope partly consisting of iron; ayas-patra- iron pot), 5.4.143 (ayo-dati- having teeth like iron) etc.

Ayovikara kusi has been interpreted by Agrawala as iron ploughshare (Agrawala, 1953). He also refers to a class of ascetics ayahsulikas ‘who flourished by the method of ayah sula or spikes’ (i.e., by brandishing their iron spikes/ tridents/ darts). A few references to ayaskara, ayaskumbha etc. are also found in the Mahabhasya of Patanjali (See Chakrabarti, 1992: 105).

**Arthasastra:**
Metallurgy was an organized subject during the time of Arthasastra. Directors of various government departments, one of whom was the ‘Director of Metals’ were responsible for such activities. By following the instructions of the authority, ‘the director of metals should establish factories for copper, lead, tin, vaikrintaka, brass, steel, bronze, bell-metal and iron, and also (establish) trade in metal-ware’. (Kangle, 1963: 124; Shama sastry, 1951: 86)

(lohadhyaksah tamrasisatrapuvaikrintakarakutavrittika msatalalohakarmantant karayet. Lohabhandavyavaharam cha).
For extraction of iron ore, there was superintendent of mines. They had been advised to examine mines which on account of their containing mineral excrement (kritta), crucibles, charcoal, and ashes may appear to have been once exploited or which may be newly discovered on plains or mountain slopes possessing mineral ores, the richness of which can be ascertained by weight, depth of colour, piercing smell and taste (Shama sastry, 1951: 83-84). The scope of the mines is expressed clearly: ‘gold, silver, diamonds, gems, pearls, corals, conchshells, metals, salts and ores derived from the earth, rocks and liquids-these constitute mines’

(suvarnarajatavajramanimuktapravalasamkhalohalavanabhumi prastararasadhatavah khanih) (Kangle, 1963: 87).

In the same sections several descriptions have been given to identify the ores (Shama sastry, 1951: 84-85). For example, those ores which are of orange colour (kurumba) (karumbah slakshnapashanaprayah; sinduvarapushpavarnah nirgundikusumavarnah) or pale red (pandurohita) or of the colour of the flower of...
sinduvara (vitex trifolia) are the ores of tikshna. Samasastri presumed that tikshnadhatu is none other than ayodhatu i.e., iron (Shamasastry, 1951: 86).

Specific references to iron in Arthasastra are meagre. It is also curious that the mention of ayas is found in two or three verses whereas in the remaining loha i.e., metal in general occurs.

Reference to ayas is found in 4.1.62 [iron rod (ayosula)], 2.19.10 [weights should be made of iron (ayomayaní) (or) of stone from the Magadhas or the Mekala hills or such as would not increase in weight by water and smearing or decrease in weight by heat], 13.2.23 [agents appearing as Nagas with their bodies smeared with burning oil, should at night time, pound together iron clubs and pestles (saktimusalyayomayaní) in a holy lake or in the middle of a tank and utter in the same way.], 2.18.10-11 [venu, sara, salaka, dandasana and naraca are arrows. Their tips for cutting, piercing and striking are made of iron, bone or wood (tesam mukhani chedanvedadananyasasthidarvani) etc.

The verse 4.4.20 mentions about the operational mode of royal spies and his way of exposing a manufacturer of counterfeit coins. It reads as ‘if he considers any one as an utterer of false coins, (being) a frequent purchaser of various metals and acids, of coals, bellows, pincers, vices, anvils, dies, chisels and crucibles, with indications of hands and clothes smeared with soot, ashes and smoke (and being) possessed of blacksmith’s tool, a secret agent should expose him by insinuating himself into his confidence as a pupil and by carrying on dealings with him’

(yam va nanalohaksaranam angarabhastrasamadamsamusikadhikaranivitaka musanamabhiksnam kretaram musibhasamadhumadigdahastabastralingam karmaropakaranasamsargam kutarupakarakam manyet) (Kangle, 1963: 308).

2.15.60 says in the context of the duties of Superintendent of Magazines that ‘he should cause charcoal and husks to be taken to metal workshops and for plastering walls’ (angaran tusan lohakarmantabhittlepyanam harayet).

In the verse 7.3.7 (in the context of the character of equal, inferior and superior kings and forms agreement made by an inferior king) the commentator gave an example of the art of joining two metals. According to him, no piece of metal that is not made red hot will combine with another piece of metal (tejo hi sandhanakaranam nataptam loham lohena sandhatta iti).

In Arthasastra, loha i.e., metals in general occurs in the following verses.
2.17.14- *kalayasatamravittakamsyasitasrapuvaikrintakarakutani lohani*- iron, copper, steel, bronze, lead, tin, *vaikrintaka* and brass (constituting the group of) metals. Interestingly, here, Kalaya denotes to iron

2.6.4. *loha* in the context of the mines-‘gold, silver, diamonds, gems, pearls, corals, conch shells metals salts and ores derived from the earth, rocks and liquids-these constitute mines.’

2.22.6: *lohavarnadhatunam* ‘minerals of the class of metals’.

1.21.7: *lohamanimayanam*-metals and gems.

5.2.9: *lohapanyah*- metals.

2.21.22: - *sastravarmakavachaloharatharatnadhanya pasunam* - for the (trader) taking out any one of the unexportable articles viz. weapons, armours, coats of mail, metals, chariots, jewels, grains and cattle- there shall be a fine as proclaimed as well as loss of goods.

2.19.13: *lohapatlat* a ball of metal five *palas* in weight.

2.19.24- *loha*- metal

3.19.12. *loha*- metal (for one causing hurt without blood with any one of objects made of wood, earth, stone or metal, or a stick or rope, the fine shall be twenty four panas, for causing a bleeding wound double, except in the case of impure blood. )

2.14.25: *lohapindavalukabhih*- At the time of fixing together afterwards or at the time of testing together that laid on plating leaf, interchange (of a gold article) by a silver article is tapping, or (the interchange) of sand lumps (containing gold) by sand lumps containing iron.

5.1.33: *lohamusalaih*: if a seditious minister is addicted to witchcraft…….. a spy may murder him, either by poisoning or by striking him with an iron bar.

13.2.29 *lohamusalaiah*: iron rods.

2.18.16: *lohajalikapattakavachasutarakam*: A coat of mail of metal rings or metal plates, armour of fabrics, and combinations of skin, hooves and horns of dolphin, rhinoceros, *dhenuka*, elephant and bull are armours. (Commentators explain ‘helmet for the head’ as *lohajala*, headless armour as *jalika*, armour *patta* and armour with many flaps or folds as *kavaca*).

Besides *loha*, the term *dhatu* may also correspond to metals. In 2.22.6 (*lohavarnadhatunam*) *dhatu* has been taken as ores and *loha* as metals whereas in 2.22.10
(dhatupanyadanesu- for taking metal goods from mines the penalty is six hundred panas) dhatu has been translated as metal.

Besides ayas, kalayasa might directly refer to iron.

2.17.14 kalayatasatamravittakamsyasisatrapuvaikrintakarakutani lohani- ‘iron, copper, steel, bronze, lead, tin, vaikrintaka and brass (constituting the group of) metals’.
3.17.7-8: kalayasa….tamravrittakamsakacha- ‘in the case of articles of iron, wood and ropes, small animals, cloth and other big articles, the fine is a minimum of twenty-four panas and a maximum of forty-eight panas.

In the case of articles of copper, steel, bronze, glass and ivory and other big articles, the lowest fine for violence i.e., minimum of forty eight panas and a maximum of ninety six panas shall be the punishment.’

2.13.55 kalayasasyardhabhagabhyaktam krisna bhavati (when smeared with half a part of black iron it becomes black)

4.1.41: kalayasapindah (a lump of iron has a reduction of one-fifth).

Third word used for iron is tiksna

2.12.15.: kurumvah panduro hitassinduvarapuspavarno vatiksnadhatu that which is made up mostly of smooth stones, is whitish red or of the colour of sinduvara flower is iron ore.

2.12.14: (tiksna) the mint master should cause to be minted silver coins with one fourth part copper (and) containing a hardening alloy one masa (in weight) of one of the following, (viz.) iron, tin, lead and antimony, (of the denominations of) one pana, a half pana, a quarter pana and a one-eighth pana……

2.13.48: (tiksna casya mayuragrivabham……kakanikah suvarnaragah)and iron of the colour of the peacock’s neck, while at the cut, shimmering, (and), powdered after being heated, is for this (gold) a colouring matter one kakani in measure for one suvarna (of gold).

Karmara (14.1.35) may denote blacksmiths and Karmarika (2.3.35) ‘produce of blacksmiths’.

There was also a new word vrtta (2.17.14, 3.17.7-8, 4.1.35) translated as steel by Kangle but as bronze by Shamasastri (Kangle, 1963: 149; Shamasatry, 1951: 109).

The Early Buddhist Canonical Literature in Pali

Anguttaranikaya contains following references to iron.
7.06.02: Like an iron pot heated throughout the day when struck sparks arouse and fade. 
Seyyathapi bhikkhave, divasasantatte ayokapale hannamane papatika nubbattivva nibbayeyya, (Hardy, 1899: 70)

7.07.08: Bhikkhus, which is more noble, a strong man with a blazing iron sheet wrapping the body or partaking the robes offered out of faith by warriors, brahmins or householders of high clans? (Hardy, 1899:130-133)

Tam kim mannatha bhikkhave, katamam nu kho varam yam balava puriso tattena ayopattena adittena sampajjalitena sajotibhutena kayam sampalivetheyya, yam va khattiyamahasalanam va brahmanamahasalanam va gahapatimahasalanam va saddhadeyyam civaram paribhunjeyyati.

Bhikkhus, which is more noble, a strong man with an iron stake causing the mouth to be opened and putting in the mouth a burning ball of metals which burns the lips, the mouth, the tongue, the throat, the chest, the insides and burning the large intestines.

Tam kim mannatha bhikkhave, katamannu kho varam yam balava puriso tattena ayo sankuna adittena sampajjalitena sajotibhutena mukham vivaritva tattam lohagulam adittam sampajjalitam sajotibhutam mukhe pakkhipeyya, tam tassa otthampi daheyya, mukhami daheyya, jivhampi daheyya, kanthampi1 daheyya, urampi daheyya,

07.07.10

Brahmin, a mass of flesh when put in an iron pot that was heated throughout the day quickly shrinks is unable to stand long. (Hardy, 1899: 137-138)

Seyyathapi brahmana, divasasammatte ayokatahe mansapesi pakkhita khippamyeva pativicchatthi, na ciratthitika hoti,

05.03.02.

Iron, metals, tin, lead and silver. Bhikkhus, these five are the defilements of raw gold, defiled by which the raw gold is not soft, workable, does not shine, is brittle and is not ready to work with.

Katame panca? Ayo loham tipu sisam sajjhu. (Hardy, 1896: 16)

03.04.06.36

Then the warders of hell give him the fivefold punishment. They fix a burning iron peg to each of his hands, and two others to each of his feet and another piercing his chest. On account of it he feels sharp, rough unpleasant feelings, but does not die until the results of that evil action gets exhausted. (Morris, 1885: 141)
The warders of hell then put him in the great hell. It is thus:
It has four doors in the four cornered squares, divided and subdivided.
All round is an iron wall and an iron roof on top
Its iron floor is burning all the time
It spread for seven hundred miles and stands there all the time. (Morris, 1885: 141-142)

Catukkanno catudvaro vibhatto bhagaso mito,
Ayopakarapariyanto ayasa patikujjito.
Tassa ayomaya bhumi jalita tejasa yuta,
Majjhima Nikaya has the following references to iron.

Volume I, Abhayarajakumarasuttam (58)
A man with an iron ring stuck in the throat would not be able to swallow or spit it out.
Seyyathapi nama purisassa ayosinghatakam kanthe vilaggam, so neva sakuneyya uggilitum, neva sakuneyya ogilitum. (Trenckner 1888: 393)

Volume I Latukikopamasuttam (66)
Like a man dropping a few drops of water to an iron pot heated through out the day.
Seyyathapi udayi puriso divasasantatte ayokatahe dve va tini va udakaphusitani nipateyya (Trenckner, 1888: 453)

Volume. Pancattayasuttam (102)
Like one bound to a wooden or iron post would run round and round the post. (Chalmers, 1898: 232)

Volume III. Balapanditasutam (129)
That is two hot iron spikes are sent through his two palms, and two other hot spikes are sent through his two feet and the fifth hot iron spike is sent through his chest.
Tamenam bhikkhave, nirayapala pancavidhabandhanam nama karanam karonti: tattam ayokhilam hatthe gamenti. Tattaṃ ayokhilam dutiye hatthe gamenti. Tattaṃ ayokhilam pade gamenti. Tattam ayokhilam dutiye pade gamenti. Tattam ayokhilam majjhe urasmim gamenti
Next the warders of hell throw him to the Great Hell. Bhikkhus, the Great Hell is square and has four gates. It's divided into two and is enclosed with an iron wall. The top is closed with an iron lid. (Chalmers, 1899: 166-167)

_Tamenam bhikkhave, nirayapala mahaniraye pakkhipanti. So kho pana bhikkhave, mahanirayo._

_Catukkanno catudvaro vibhatto bhagaso mito,_
_Ayopakarapariyanto ayasa patikujjito._
_Tassa ayomaya bhumi jalita tejas a yuta,_
_Samanta yojanasatam pharivita titthati sabbada._

**Volume III  Devadutasuttam** (130)

Then the warders of hell pull him out with a hook and ask him. Good man, what do you desire? He says, Sir, I'm hungry. The warders of hell open his mouth with hot iron spikes and pour into his mouth burning, flaming iron balls. (Chalmers, 1899: 185-186)

_Tamenam bhikkhave, nirayapala balisena uddharitva thale patitthapetva evamahamsu: amho purisa, kim icchasiti. So evamaha: jighacchitosmi bhatteti. Tamenam bhikkhave, nirayapala tattena, ayosankuna mukham vivaritva adittena samapajjalitena sajotibhutena tattam _lohagulam_ mukhe pakkhipatanti adittam samapajjalitam sajotibhutam._

Then the warders ask him. Good man, what do you desire? He says, Sir, I'm thirsty. The warders of hell open his mouth with hot iron spikes and pour into his mouth burning, flaming copper molten. They burn his lips, mouth, throat, chest, the intestines, the lower intestines and they come out with the insides. There he experiences sharp piercing unpleasant feelings, yet he does not die, until his demerit comes to an end.

_Tamenam bhikkhave, nirayapala evamahamsu: 'amho purisa, kim icchasiti. So evamaha: 'pipasitosmi bhanteti. Tamenam bhikkhave, nirayapala tattena ayosankuna mukham vivaritva adittena sampajjalitena sajotibhutena tattam tambaloham mukhe asincanti adittam sampajjalitam sajotibhutam._

**VOLUME III  Indriyabhavanatasuttam** (152)

Like two or three drops of water dropped on an iron plate heated through out the day would quickly vanish.

_Seyyathapi ananda, balava puriso divasasantatte ayokatahe dve va tini va udakaphusitani nipateyya._ (Chalmers, 1899: 300)
The following verses of the Samyukta Nikaya have the references to different articles of iron.

Part IV

35. Salayatana Samyuttam

(194) 8. Adittena

2. Monks, it is noble to destroy the mental faculty of the eye with a burning, blazing, iron spike, so that the details of forms cognizable by eye-consciousness would not be observed and consciousness would not tarry there, with the details.

Katamo ca bhikkhave adittapariyayo? Varam bhikkhave tattaya ayosalakaya adittaya sampajjalitaya sajotibhataya cakkhundriyam sampalimattham, na tveva cakkhuvinneyyesu rupesu anubyajanasa nimittaggaho. (Feer, 1894: 168)

"Monks, seeing this danger, I say it is noble to destroy the mental faculty of the ear with a burning, blazing iron spike, so that the details of sounds cognizable by ear-consciousness would not be observed and consciousness would not tarry there, with the details.

Varam bhikkhave tinhena ayosankuna adittena sampajjalitena sajotibhutena sotindriyam sampalimattham, na tveva sotavinneyyesu saddesu anubyajanasa nimittaggaho.

Part IV

35. Salayatana Samyuttam

(203) (7) Dukkhadhammā - Unpleasant Things

10. Monks, the monk behaving and abiding thus on a certain day recollects demerit thoughts that are bonds, owing to bewilderment of mindfulness. Slowly his mindfulness arises, yet quickly he dispels, chases them away, destroys them and makes them not arise again. Like the manner in which a few drops of water put into an iron pot heated throughout the day vanishes and disappears in no time.

Seyyathapi bhikkhave, puriso divasasantatte ayokatahe dve va tini va udakaphusitani nipateyya (190)

Part IV

35. Salayatana Samyuttam

(206) 10. Chappana

7. “Monks, like a man who gets hold of six living things of different pasture would tie each one with a strong rope. He would tie a serpent, a crocodile, a bird, a dog, a jackal and a monkey with six strong, different ropes and would fix the six ropes tightly to an
iron pole or post Monks, the six living things with different objectives and different pasture would go round in search of their individual pasture. (200)

**The Sutta Nipata- Mahavagga also contains the following references to iron.**

110. 'For one's deeds are not lost, they will surely come (back to you), (their) master will meet with them, the fool who commits sin will feel the pain in himself in the other world. (666)

111. 'To the place where one is struck with iron rods (*ayos amkusa*), to the iron stake (*ayosula*) with sharp edges he goes; then there is (for him) food as appropriate, resembling a red-hot ball of iron (*ayogula*). (667)

112. 'For those who have anything to say (there) do not say fine things, they do not approach (with pleasing faces); they do not find refuge (from their sufferings), they lie on spread embers, they enter a blazing pyre. (668).

113. 'Covering (them) with a net they kill (them) there with iron hammers (*ayokutehi*); they go to dense darkness, for that is spread out like the body of the earth. (669)

114. 'Then (they enter) an iron pot (*lohamayam pana kumbhin*), they enter a blazing pyre, for they are boiled in those (iron pots) for a long time, jumping up and down in the pyre. (670) (Fausboll, 1881: 123)

Another very important reference is found in this text as reported by Kosambi. According to him,

‘The fourth discourse in the collection is of 'Farmer Bharadvija', (Kasi-Bharadvaja-sutta), a brahmin who farmed land at Dakkhinagiri in Magadha. This is the portion of Mirzapore district along the southern bank of the Ganges. The word phala or plough-share occurs in both the prose and the metrical portions of the discourse. The simile runs: ‘like a phala heated for a whole day and plunged suddenly into water...’ . . .Iron reduced from ores by any primitive method comes out as a spongy mass which has to be heated and forged repeatedly as well as hardened by sudden chilling before it is of any use for tools” (Kosambi, 1963:313).

Similar reference is also found in the Mahavagga of the Vinaya text- VI.26.7 (Rhys Davids and Oldenberg, 1881: 95)

As a ploughshare, which has been heated through the whole day and is thrown into water, hisses and bubbles, and steams, and sends forth smoke.
Seyyathapi nama phalo divasasantatto udake pakkhitto ciccitayati, citicitayati, sandhupayati, sampadhupayati, evameva.

Reference to armour is found in X.2.4 of the same text. (Rhys Davids and Oldenberg, 1881:295)

'And ere long, O Bhikkhus, the queen-consort of king Dighiti of Kosala became pregnant. And there came upon her the longing of pregnant women; and she desired, at sunrise, to see an army, with its four hosts set in array, clad in armour, standing on auspicious ground, and to drink the water in which the swords were washed.

Atha kho bhikkhave, dighitissa kosalaranno mahesi na cirasseva gabbhini ahosi. Tassa evarupo dohalo uppanno hoti: icchati suriyassa uggamanakale caturangininim senam sannaddham vammitam subhumiyam thitam passitum, khaggananca dhopanam patum.

There are references to sword, shield, bow and quiver in the Cullavagga of the Vinaya texts VII.3.7.

And that man took his sword and shield, and hung his bow and quiver at his back, and went to the place where the Blessed One was, and when at some little distance from the Blessed One, being terrified, anxious, excited, and alarmed, he stood stark still and stiff. (Rhys Davids and Oldenberg, 1885: 243-244)

Asicammam gahetva dhanuakalapam sannayithitva.

References to lohakataha, lohakumbhi, lohabhanda etc. are found in the Cullavagga VI. 15.2 (Rhys Davids and Oldenberg, 1885:210-211) and V.28.1 (Rhys Davids and Oldenberg, 1885:140). However, it is difficult to identify the said term with iron cauldron, pitcher, pot etc as they are prefixed by the word loha.

Regarding other texts of the Buddhist ideology, Chakrabarti mentions that, ‘The Dhammapada mentions ayogula but more interesting is: ‘as rust sprung from iron eats into its own source’ (ayasa va malan samutthitam taduttaya tam eva khadati). Ayogula or iron ball occurs in the Therigatha and a smith’s daughter, Subha, is mentioned, but a hook and a stake are mentioned as well. The Theragatha refers to sickles, ploughs, curved spades (asitasu maya nangalasu maya khuddakuddalasu maya) and razor (khuram). There is also a reference to armour (‘I myself am binding on my armour’- esa bandham sannaham). Ayogula is all that one can get in the iti vuttuka, while both Pettavatthu and Niddesa II Cullaniddesa repeat the description of the Niraya hell noted earlier in the context of the Majjhimanikaya. The Udanam refers to a blazing spark of fire, struck from the anvil (ayoghana)” (Chakrabarti, 1992: 114).
The Jatakas also provides a substantial number of evidence regarding the use of iron during the contemporary period.

Ghatajataka refers to the following.

The ass replied, “I cannot help braying. But if you come first, and four of you bring great iron ploughs (ayanangalam), and at the four gates of the city dig great iron posts (ayakhanuke) into the ground, and when the city begins to rise, if you will fix on the post a chain of iron (ayasamkhalikam) fastened to the plough, the city will not be able to rise.” (Vol. IV, No.454) Rouse, 1901: 53). The context as a whole suggests a preoccupation with the magical properties of iron.

Reference to iron chain and ploughshare are found in the Kurunga- Miga-Jataka and Kuta-Vanjila Jataka respectively.

A hunter, wandering about in the wood, observed the Bodhisatta's footprint at the going down into the water; and he set a trap of leather, strong, like an iron chain, and went his way. In the first watch of the night the Bodhisatta went down to drink, and got caught in the noose: whereat he cried loud and long. Thereupon the Woodpecker flew down from her tree-top, and the Tortoise came out of the water, and consulted what was to be done (II. book II Kurunga Miga Jataka No.206.) (Rouse, 1895: 106).

“My lord,” he answered, “I have a question to ask you. If hawks cannot carry off boys into the air, can mice eat iron ploughshares?” (II. book II Kuta-Vanjila-Jataka. No. 218) (Rouse, 1895:128)

There is a separate Jataka called the Ayoghara Jataka.

The king gathered a number of people together, and said: “Each son my queen has brought forth, a she-goblin comes and devours him. [492] What is to be done?” ….. Another said, “It is an iron house they fear; one should be made.” The king was willing. He summoned all the smiths in his realm and bade them build him an iron house, and set overseers over them. Right in the town in a pleasant place they builded a house; pillars it had, and all the parts of a house, all made of nothing but iron: in nine months there it stood finished, a great hall foursquare: it shone, lighted continually with lamps.

When the king knew that she drew near her time, he had the iron house fitted up, and took her into it. She brought forth a son with the marks of goodness and luck upon him, and they gave him the name of Ayoghara-Kumāra, the Prince of the Iron House.

…………
“For ten months I was in my mother's womb, as it might have been the Hell of the Iron Caldron or the Hell of Dung, and when I came forth from the womb, for sixteen years I dwelt in this prison, never a chance of looking outside. Though I have escaped the hands of the goblin I am neither free from old age nor death. What care I for royalty? Once established in the royal place it is hard for one to get away. This very day will I ask my father's leave to embrace the religious life, and I will go to Himalaya and do so.” (IV, No. 510. Ayoghara Jataka) (Rouse, 1901: 305-306).

In Suci Jataka, presence of a separate community associated with needle making is quite evident. Reference to iron needles and iron workings has been found in this Jataka.

Once upon a time when Brahmadatta was king in Benares, the Bodhisattva was born in the kingdom of Kasi in a smith's family, and when he grew up he became excellent in the craft. His parents were poor. Not far from their village was another smith's village of a thousand houses.

…… so he took iron of the best kind, and made one delicate strong needle which pierced dice and floated on water:

.... Quickly threaded, strong and straight,

    Rounded properly,

Iron they will penetrate,

    Needles! who will buy? (III. No. 387.Suci-Jataka) (Francis and Neil, 1897: 178)

In iron-work we have renown,

    In weapons we excel:

We all are smiths in this good town:

    Needles! who can sell? (III. No. 387.Suci-Jataka) (Francis and Neil, 1897: 179)

Reference to iron is also found in one of the gathas of the Dhamma Jataka. It says ‘by iron gold is beaten’. The word is loha

"By iron gold is beaten, nor do we

Gold used for beating iron ever see:

    If Wrong 'gainst Right shall win the fight to-day,

Iron as beautiful as gold will be." (IV. Dhamma Jataka No. 457) (Rouse, 1901: 102)

Reference to iron city is found in Chatu Dvara Jataka.

"Four gates this iron city hath, where I am trapt and caught:

A rampart girds me round about: what evil have I wrought?
"Now fast are closed the city gates: this wheel destroyeth me:
Why like a caged bird am I caught? why, Goblin, should it be?" (IV Catu Dvara Jataka No. 439) (Rouse, 1901: 3).

**Reference to iron spike has found its mention in the Kanhadipayana Jataka and the Dhonasakha-Jataka.**

The king made no enquiry, but only said, "Off with him, impale him upon a stake!" To the cemetery they took him, and lifted him up on a stake of acacia wood; but the stake would not pierce the ascetic's body. Next they brought a nimb stake, but this too would not pierce him: then an iron spike, and no more would that pierce his body. (IV. Kanhadipayana No.444) (Rouse, 1901: 18)

At this moment a vulture took a sharp-pointed bone, and perched on the top of the tree, in eating the flesh it let drop the bone, and the sharp point falling as with iron spikes on the king's left eye, destroyed that eye too. (III No. 353. Dhonasakha-Jataka) (Francis and Neil, 1897: 106)

**Udaya Jataka and Panch Uposatha Jataka refer to the use of iron bowl in the contemporary society.**

Next day, at the same time, he took an iron bowl full of coins, and said, "Lady, if you will bless me with your love, I will give this iron bowl full of coins to you." (IV Udaya Jataka no. 458) (Rouse, 1901: 68).

He tried the belly—it might have been a basket. So he fell on to the tail, [327] it was like an iron bowl. Then he attacked the rump, and lo! it was soft as a cake of ghee. (IV Panc Uposatha Jataka No. 490) (Rouse, 1901: 206)

**Reference to iron band/bands is found in the following Jatakas.**

Thus following the advice of the Great Being, he made friends with every body, those in the household and those without, all in the city, the subjects of the kingdom, strangers, by his winsomeness binding them to him as it were by a band of iron: to all of them he was dear and beloved. (IV Samvara Jataka No. 462) (Rouse, 1901: 84)

As soon as they were gone, the priest was seized with a violent pain in the head, as if it were being pounded by a sharp spike, or crushed by an instrument of iron……. They would have removed them, but could not, for they were fastened as it were with an iron band. (III. No. 326. Kakkaru-Jataka) (Francis and Neil, 1897: 59-60).
The next day the goose-king coming down stuck its foot, as it alighted, into the snare, which grasping the bird's foot as it were with a band of iron held it fast in its grip. (V. No. 534. Mahahamsa-Jataka) (Francis, 1905: 190)

Ah! iron bands must bind my heart,—or else what could it do but break? (VI. No. 542. Khandahala- Jataka) (Cowell and Rouse, 1907: 78)

[580] Let fourteen thousand chariots be yoked and well arrayed, Their wheels well wrought of iron bands, and all with gold inlaid. (VI. No. 547. Vessantara-Jataka). (Cowell and Rouse, 1907: 298).

**Reference to iron net has found its mention in the Bhadda Sala Jataka and the Abbhantara Jataka.**

Hearing the clatter of the chariot as it went over the threshold, he said, "The noise of the chariot of Bandhula the Mallian! [149] This day there will be fear for the Licchavis!" By the tank there was set a strong guard, within and without; above it was spread an iron net; not even a bird could find room to get through. But the general, dismounting from his car, put the guards to flight with the blows of his sword, and burst through the iron network, and in the tank bathed his wife and gave her to drink of the water; (IV Bhadda Sala Jataka No. 465) (Rouse, 1901: 94)

**In the Abbhantara Jataka a tree is encircled with seven iron nets; the text uses the word lohajaleni. Loha may mean iron in this context.**

That is the portion of the king Vessavaṇa. It is impossible to get near it. The whole tree from the roots upwards is encircled with seven iron nets; it is guarded by thousands of millions of Kumbhaṇḍa goblins; if they see any one, he's done for. The place is like the fire of the dissolution and the fire of hell. Do not ask such a thing!” (II. Book III. Abbbhantara No.281, (Rouse, 1895: 271)

**Besides, references to various iron objects are found in the following verses.**

**IV. Phandana Jataka No.475** (Rouse, 1901:131)

You can make a fine cart out of that tree, says he. But I tell you that if you flay off the skin from a black lion's neck, and put it around the outer edge of the wheel, like a sheath of iron, just a strip four fingers wide, the wheel will be very strong, and you will gain a great deal by it.

**IV Duta Jataka No.478** (Rouse, 1901: 139-140)
He showed that young gentleman Nanda the host of nymphs, and gave him sainthood; he gave a cloth to his little foot-page, and bestowed sainthood on him along with the four branches of mystic science; to the blacksmith he showed a lotus, and gave him sainthood; with what diverse expedients he instructs living beings!

**IV Matanga Jataka No. 497** (Rouse, 1901: 239)

“Revile a sage! to swallow blazing fire as much avails, Or bite hard iron, or dig down a mountain with your nails.”

**IV Rohanta Miga Jataka No.501** (Rouse, 1901: 259)

“Go, timid doe, and run away; an iron snare holds me: Go with the rest, and linger not, and they shall live with thee.”

In the *Jarudapana Jataka*, aya is iron while loha is copper.

**II. Book III. Jarudapana Jataka No. 256.** (Rouse, 1895: 205)

In a difficult part of their road they observed a disused well. There was no water in it that they could see, and they were athirst; so they resolved to dig deeper. As they dug, they came upon successive layers of minerals of all sorts, from iron to lapis lazuli.

**II. Book III. Jarudapana Jataka No. 256.** (Rouse, 1895: 206)

“Some merchants, wanting water, dug the ground In an old well, and there a treasure found:-- Tin, iron, copper, lead, silver and gold, Beryls and pearls and jewels manifold”.


Reference to the activity associated with holding of iron with tongs is found in Kakkata Jataka. (Volume II book III No. 267) (Rouse, 1895: 236)

And so they did. Then the Crab, seeing the Bodhisatta coming up last, caught his feet tight in his claw, like a smith who seizes a lump of iron in a huge pair of tongs. The Bodhisatta's mate did not leave him, but stood there close by him.

Reference to iron Cauldrons is found in Lohakumbhi Jataka (Volume III. No. 314. Lohakumbhi Jataka) (Francis and Neil, 1897: 29)
After misconducting themselves with their neighbours' wives, however carefully guarded they might be, and indulging their amorous propensities, their evil life had been cut short by the Wheel of Death, near Sāvatthi. They came to life again in Four Iron Cauldrons.

((Volume III. No. 314. Lohakumbhi Jataka) (Francis and Neil, 1897: 31)

“Yes, Your Majesty,” he said. “Then tell me, Reverend Sir.” “Sire,” he answered, these men in a former existence were guilty of gross misconduct with the carefully guarded wives of their neighbours near Benares, and therefore were re-born in four iron cauldrons……..And after getting out just one syllable each, they sank again in the iron cauldrons.

**Brahachatta Jataka contains reference to iron pots**

Now the king of Benares, having got all the kingdom of Kosala into his possession, set up loyal officials as governors, and himself, having collected all their available treasure, returned with his spoil to Benares. And filling iron pots with it, he buried them in the royal garden, and then continued to live there. (Volume III. No. 336. Brahachatta Jataka) (Francis and Neil, 1897: 77).

**Ayakuta Jataka indicates that dreadful deeds were perfomed by using iron** (Volume III. No. 347. Ayakuta Jataka) (Francis and Neil, 1897: 96-97)

The Bodhisattva proclaimed by beat of drum, “No living creature is to be put to death.” The Yakkhas were enraged against the Bodhisattva at losing their offerings, and calling together an assembly of their kind in the Himalayas, they sent forth a certain savage Yaksha to slay the Bodhisattva. He took a huge blazing mass of iron as big as the dome of a house, and thinking to strike a deadly blow, immediately after the mid watch, came and stood at the bed's head of the Bodhisattva.

Similar references also occur twice in the following sections of the said Jataka.

**Reference to iron pin is found in Putimansa Jataka** (Volume III. No. 437 Putimansa Jataka) (Francis and Neil, 1897: 316)

Therefore it is good, Brethren, that the eye of the senses should be touched with a red-hot iron pin.

The reference to iron as found in the Chhadanta Jataka is possibly the most important. It mentiones ‘She summoned smiths and gave them an order and said, “Sirs, we have a need of an axe, a spade, an auger, a hammer, an instrument for cutting bamboos, a grasscutter, an iron staff, a peg, an iron three-pronged fork……”’. The set of implements is called to be of asiloha. In fact, this seems to be a completely new term for iron.
"Sirs, we have need of an axe, a spade, an auger, a hammer, an instrument for cutting bamboos, a grass-cutter, an iron staff, a peg, an iron three-pronged fork; make them with all speed and bring them to us."

Then he bound a three-pronged grappling-iron with a rope and flinging it aloft he caused it to lodge fast in the mountain. Then climbing up by the rope he drilled the mountain with an iron staff tipped with adamant, and knocking a peg into the hole he stood on it. Then drawing out the grappling-iron he once more lodged it high up on the mountain, and from this position letting the leather rope hang down, he took hold of it and descended and fastened the rope on the peg below.

Reference to iron-built moat is found in the Pandara Jataka (Volume V, No. 518) (Francis, 1905: 45)

As some huge city fenced on every side
With moat, of iron wrought, has long defied
   All entrance of a foe to Fairy Land,
So e’en are they that do their counsels hide.

Besides Suci Jataka, Sarabhanga Jataka contains reference to arrows made of iron. (Volume V, No. 522) (Francis, 1905: 68)

The Great Being, striking them severally with his iron arrow, in some way or other, made them drop on the ground, and then throwing a wall round them, he piled them together and so made a magazine of arrows, fitting each arrow, handle level with handle, stock with stock, feathers with feathers, till the bowmen’s arrows were all spent, and when he saw that it was so, without spoiling his magazine of arrows, he flew up into the air and stood before the king.

[131] Thus did he display these twelve unrivalled acts of skill, and then he cleft seven incomparably huge substances. He pierced a plank of fig-wood, eight inches thick, a plank of asana-wood, four inches thick, a copper plate two inches thick, an iron plate one inch thick, and after piercing a hundred boards joined together, one after another, he shot an arrow at the front part of waggons full of straw and sand and planks, and made it come out at the back part; and, shooting at the back of the waggons, he caused the arrow to come out at the front.
In the description of the hell meant for a parricide, the *Samkicca Jataka* refers to dome of iron, iron wall, iron cauldron, iron ball, iron ploughshare, iron beak, iron jaw, iron mouth etc.

*(Volume V. No. 530 Samkicca Jataka* (Francis, 1905: 134)

too shall surely be swallowed up by the earth." And he was so terrified that he found no enjoyment in his royal splendour, and thinking he would rest awhile, he had no sooner fallen asleep than he seemed to be dropped into a world of iron nine leagues thick, and beaten as it were with iron spikes and devoured by dogs continually snapping at him, and with a terrible cry he rose up.

*(Volume V. No. 530 Samkicca Jataka* (Francis, 1905: 137)

Four square with fourfold doors is each, in due proportion spaced,
With dome of iron 'twas o’erarched, by iron wall embraced,
Its base of iron wrought is such no raging flame may melt,
Though e’en a hundred leagues around its mighty power is felt.

*(Volume V. No. 530 Samkicca Jataka* (Francis, 1905: 138)

In iron cauldron boiled till he shall peel,
The parricide is pierced with shafts of steel,
Then blinded and on filth condemned to feed
He's plunged in brine, to expiate his deed.

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Then goblins 'twixt his jaws, lest they should close,
Hot iron ball or ploughshare interpose,
These fixed with cords his mouth so firmly prop,
They into it a stream of filth can drop.

Vultures, both black and brown, and ravens too,
And birds with iron beaks, a motley crew,
Rending his tongue to many a fragment small,
Devour the quivering morsel, blood and all.

*(Volume V. No. 530 Samkicca Jataka* (Francis, 1905: 139)

There powerful demons seize upon the guilty matricide,
And plough with iron shares his back in furrows deep and wide.
Enormous worms with iron mouths, piercing their victim's skin,  
Devour his flesh right greedily and suck the blood within.

Silk-cotton trees with thorns foot long of iron wrought, 'tis said,  
On either bank, Vetaranī, o'erhang thy gloomy bed.

At dawn they hide themselves in Iron Cauldron, known to fame,  
Big as a mountain 'tis and full of water like to flame.

Assailed with swords and iron clubs, headlong, these men of blood,  
Pursued with spears and arrows fall into a briny flood.

The forger, harried night and day with club of iron forged,  
Feeds only on the filthy mess by some poor rogue disgorged.

Crows, ravens, vultures, jackals too, all armed with iron jaw,  
Entomb the struggling wretch alive in their insatiate maw.


A blazing mass of iron that can frighten the king is found its mention in Volume VI. No. 542. The Khandahala Jataka (Cowell and Rouse, 1907: 79). Reference to Iron veins is found in Volume VI. No. 543. Bhuridatta Jataka (Cowell and Rouse, 1907: 111). Mahanaradakassapa Jataka contains reference to the teeth of iron (Volume VI, No. 544) (Cowell and Rouse, 1907: 124)

The same Jataka also contains references to iron spikes, knives, swords etc.

There are lofty thickets like heaps of clouds, full of thorns, with sharp iron spikes which drink the blood of men,—women and men who go after other people's wives have to climb it, driven on by the servants of Yama bearing spears in their hands........
There are lofty forests like heaps of clouds, covered with swords for leaves, armed with iron knives which drink the blood of men; as he climbs the tree with iron leaves, cut with sharp swords, his body gashed and dripping blood,—who would press him for the thousand pieces in the next world?

When he escapes from that hell of iron leaves and falls into the river Vettarani, who would ask him for his old debt?

On flows the river Vettarani, cruel with boiling water and covered with iron lotuses and sharp leaves; as he is hurried along covered with blood and with his limbs all cut, in the stream of Vettarani where there is nothing to rest upon,—who would ask him for his debt?

Reference to iron sledge-hammer is found in Volume I, No. 2. Vannupatha Jataka (Chalmers, 1895: 11). Reference to blacksmiths is found in the following Jataka VI. No. 546. The Maha-Ummagga Jataka (Cowell and Rouse, 1907: 220)

"he shewed great favour to these, and took with him eighteen companies of men, masons, blacksmiths, carpenters, painters, men skilled in all arts and crafts, with their razor-adzes, spades, hoes, and many other tools. So with a great company he went out of the city”.

The non-canonical text like Milindapanho gives enough evidence regarding the use of iron during the 1st century BCE. The ubiquitous ‘red-hot ball of iron’ (tattam ayogulam) occurs twice.

'Now, what do you think, great king? Suppose a man were to hold in one hand a red-hot ball of iron, and in the other a lump of icy snow, would they both hurt him?' (Part I, Book II, Chapter 2) (Rhys Davids, 1890: 70)

References to iron pins and iron ball are found in the following verses.

Painful are (the tortures inflicted on traitors)--being subjected to the Gruel Pot (that is, having boiling gruel poured into one's head from the top of which the skull bone has been removed --or to the Chank Crown (that is, having the scalp rubbed with gravel till it becomes smooth like a polished shell)--or to the Râhu's Mouth (that is, having one's mouth held open by iron pins, and oil put in it, and a wick lighted therein) (Part I, Book IV. Chapter IV) (Rhys Davids, 1890: 276)

……… skin as soon as removed tied to the hair, so that these strips form a veil around one)--or to the Spotted Antelope (that is, having one's knees and elbows tied together, and being made to squat on a plate of iron under which a fire is lit)--or to the Flesh-hooks (that is, being hung up on a row of iron hooks)--or to the Pennies (that is, having bits cut
out of the flesh, all over the body, of the size of pennies)--or to the Brine Slits (that is, having cuts made all over one's body by means of knives or sharp points, and then having salt and caustic liquids poured over the wounds)--or to the Bar Turn (that is, being transfixed to the ground by a bar of iron passing through the root of the ear, and then being dragged round and round by the leg)--or to the Straw Seat (that is, being so beaten with clubs that the bones are broken, and the body becomes like a heap of straw)--or to be anointed with boiling oil, or to be eaten by dogs, or to be impaled alive, or to be beheaded. (Part I, Book IV. Chapter 4(Rhys Davids, 1890: 277-278)

Reference to iron ore (Kalaloham) has found its mention in the following verse.

there is gold and silver, and the pearl, and the diamond, and the chauk, and rock, and coral, and the ruby, and the Masāra stone, and the cat's-eye, and crystal, and quartz, and iron ore 1, and copper, and brass 2, and bronze;--there is flax, and silk, and cotton........ - -all is in the world. Tell me, Sir, what there is, then, which is not in the world.' (Part II, Book IV Chapter 7) (Rhys Davids,1894: 101-102)

There is another reference to ‘workers in iron’ (ayakara)

smiths and florists, workers in gold and silver and lead and tin and copper and brass and iron (Part II, Book V) (Rhys Davids,1894: 210)

Other references are:

[286] But even as if a bar of iron, heated the livelong day and glowing throughout, had entered the orifice of his ear, so was it that those words, O king, entered the ear of the Bodisat. (Part II, Book IV. Chapter 8) (Rhys Davids, 1894: 136)

As a man, O king, if a mass of iron had been heated the livelong day, and were all glowing, scorching, and red hot, would find no spot on it, whether at one end or in the middle or at the other end, fit to be taken hold of--just so, (Part II, Book IV. Chapter 8) (Rhys Davids,1894: 198-199)

Reference to black iron is found in (Part II. Book VII. Chapter 7) (Rhys Davids, 1894: 364-365)

2. 'Venerable Nāgasena, those two qualities of black iron you say he ought to take, which are they?"

[415] 'Just, O king, as black iron even when beaten out 1 carries weight (yatha maharaja kalayaso sudhito va vahati); just so, O king, should the mind of the strenuous Bhikshu, earnest in effort, be able, by his habit of thoughtfulness, to carry heavy burdens. This, O king, is the first quality of black iron he ought to have.
3. 'And again, O king, as black iron does not vomit up the water it has once soaked in (*Kalayaso sakim pitam udakam na vamati*); just so, O king, should the strenuous Bhikshu, earnest in effort, never give up the faith he has once felt in the greatness of the Blessed One, the Supreme Buddha, in the perfection of his Doctrine, in the excellence of the Order—never give up the knowledge he has once acquired of the impermanence of forms, or of sensations, or of ideas, or of qualities, or of modes of consciousness. This, O king, is the second quality of black iron he ought to have. For it was said, O king, by the Blessed One, the god over all gods.

**Jaina Sutras**

Reference to iron is found in the following verses of the text **Uttaradhyayana**

**Nineteenth Lecture**

No repose as long as life lasts; the great burden 4 of duty is heavy like a load of iron, which is difficult to be carried, O son. (35) (Jacobi, 1895: 92)

It is difficult (always to observe the rules of) right conduct with one's eyes for ever open like (those of) a snake, O son; it is difficult to eat iron grains, as it were. (38) (Jacobi, 1895: 92)

I have been forcibly yoked to a car of red-hot iron full of fuel. I have been driven on with a goad and thongs, and have been knocked down like an antelope (56) (Jacobi, 1895: 94-95)

An infinite number of times have I violently been lacerated by birds whose bills were of iron and shaped like tongs, by devilish vultures (58) (Jacobi, 1895: 95)

As iron I have been malleated, cut, torn, and filed by blacksmiths, an infinite number of times. (67) (Jacobi, 1895: 96)

I have been made to drink hissing molten copper, iron, tin, and lead under horrid shrieks, an infinite number of times. (68) (Jacobi, 1895: 96)

Jacobi suggests that “Kumara; this is obviously the modern kamar ‘blacksmith’ (derived from karmakara); and it is of interest to find this form in an old text like the Uttaradhyayana”.

**Twelfth Lecture: Harikesa.**

'You may as well dig rocks with your nails, or eat iron with your teeth, or kick fire with your feet, as treat contemptuously a monk. (26) (Jacobi, 1895: 53)

**Thirty-sixth lecture: on living beings and things without life**
The Earth Lives are of two kinds: subtile and gross; and both of them are either fully developed or undeveloped. (71) (Jacobi, 1895: 213)

The gross and fully developed are of two kinds: viz. smooth or rough. The smooth ones are of seven kinds: (72)

Black, blue, red, yellow, white, pale dust, and clay.

The rough ones are of thirty-six kinds: (73)

Earth, gravel, sand, stones, rocks, rock-salt, iron, copper, tin, lead, silver, gold, and diamond; (74)

Sut rakritanga has the reference to iron in the following verses

Book 1, Lecture 3, Chapter 4: Do not, by disdaining it, lose much for the sake of little. If you do not give up this (wrong law), you will repent of it as the man did who carried iron (a long way) believing it to be silver. (7) (Jacobi, 1895: 269)

Book 1, Lecture 5, Chapter 1: The prisoners in hell come to the dreadful place called Santakshana (i.e. cutting), where the cruel punishers tie their hands and feet, and with axes in their hands cut them like wooden planks. (14)

And they turn the writhing victims round, and stew them, like living fishes, in an iron caldron filled with their own blood, their limbs covered with ordure, their heads smashed. (15) (Jacobi, 1895: 281)

Book 1, Lecture 5, Chapter 2: The (sinners) walk over ground burning and glowing like red-hot iron; scorched they shriek horribly, being urged on with arrows and put to a red-hot yoke. (4)

The sinners are driven over slippery ground which is like a road of red-hot iron; in this dreadful place (the ministers of hell) make them go forward like slaves (beating them) with sticks. (5) (Jacobi, 1895: 283)

There is a place of smokeless fire in the form of a pile where (the sinners) greatly distressed shriek horribly; head downwards they are lacerated and cut into pieces with iron knives. (8) (Jacobi, 1895: 284)

They break the sinner's back with a weapon, and smash his skull with iron clubs; their bodies are split and sawn like a plank; and tortured with red-hot awls (the sinners) are subjected (to cruelties). (14) (Jacobi, 1895: 285)

There is the dreadful, slimy river, which is always flowing and full of molten iron; in this very dreadful river (the sinners) must descend one by one. (21) (Jacobi, 1895: 286)
Book 2, Lecture 2

.........A man will (occasionally) severely punish even the smallest offence of his domestics, viz. a slave or messenger or hired servant or vassal or parasite; e.g. punish him, pull out his hair, beat him, put him in irons, in fetters, in stocks, into prison, screw up in a pair of shackles (his hands and feet)......... (63) (Jacobi, 1895: 374-375).

......... As a ball of iron or stone, when thrown in the water, sinks below the surface of the water till it stops at the bottom, so a man of the sort we are treating of, who is full of Karman, full of sin, full of demerit, full of disgrace (According to Jacobi, in 376:1 There is, apparently, a pun in the three words vagga, panka, ayasa, for they mean also steel, mud, iron.) full of iniquity, full of wicked thoughts, deceit, imposture, and fraud, and, as a rule, kills animals, having died at the allotted time, will sink below this earth, and go to the bottom of the hell. (65) (Jacobi, 1895: 376).

......... One man took hold of a vessel quite full of burning coals by an iron pair of tongs, and addressed those philosophers, founders of systems of their own, differing in intellect, (&c., all down to) undertakings and plans, in the following way: 'Heighho! ye philosophers, (&c., all down to) undertakings and plans! take this vessel full of burning coals and hold it for a minute in your hands! But do not take hold of it by a pair of tongs, nor put out the fire, nor come to the help of one of your own creed or of an alien creed (by putting out the fire, &c.); but fair and honest, without using any trick, stretch out your hands.' Having thus spoken, the man took hold of the vessel quite full of burning coals by an iron pair of tongs, and (offered to) put it in the hands of those philosophers. But the philosophers, (&c., all down to) undertakings and plans, held back their hands. ..... (80) (Jacobi, 1895: 385-386).

They will many times undergo punishment, pulling out of the hair, threatening, putting in irons, whirling round; (they will witness) the death of their mothers, fathers, brothers, sisters, sons, daughters, and daughters-in-law; (they will experience) poverty, bad luck, company of hated people, separation from those whom they love, misery, and despair; they will again and again wander about in the beginningless and endless, immense wilderness of the fourfold Samsâra……(81) (Jacobi, 1895: 387)

Book 2, Lecture 3

(This paragraph treats of wind-bodies in the same way as the preceding ones treated of fire-bodies; like it, it consists of four paragraphs). (35) (Jacobi, 1895: 397)
And again it has been said of old: some beings, of various birth and origin, come forth, in the manifold animate and inanimate bodies of movable and immovable creatures, as earth, gravel, &c. Here the following verses (from the Uttarādhyayana XXXVI, 74-77) are to be made use of:

1. Earth, gravel, sand, stones, rocks, rock-salt, iron, copper, tin, lead, silver, gold, and diamond;

In the Acaranga sutra the reference to iron is found only in one verse.

Book II, Sixth Lecture, First Lesson.

A monk or a nun should not accept any very expensive bowls of the following description: bowls made of iron, tin, lead, silver, gold, brass, a mixture of gold, silver, and copper, pearl, glass, mother of pearl, horn, ivory, cloth, stone, or leather; for such very expensive bowls are impure and unacceptable. (2) (Jacobi, 1884: 166-167)

In Kalpasutra, Risabha is said to have taught the lessons of art which according to Jacobi also includes iron working as performed by blacksmiths.

The Arhat Rishabha, the Kosalian, clever, with the aspirations of a clever man, of great beauty, controlling (his senses), lucky, and modest, lived two millions of former years as a prince, and six millions three hundred thousand former years as a king. During his reign he taught, for the benefit of the people, the seventy-two sciences, of which writing is the first, arithmetic the most important, and the knowledge of omens the last, the sixty-four accomplishments of women, the hundred arts, and the three occupations of men. At last he anointed his hundred sons as kings, and gave each a kingdom.

Jacobi suggests that “the arts, as those of the potter, blacksmith, painter, weaver, and barber, each of which five principal arts is subdivided into twenty branches, are inventions and must be taught; while the occupations, agriculture, trade, have everywhere developed, as it were, of themselves”. (Jacobi, 1884: 282)

In Bhagwati Sutra, Book 5, Chapter 2, reference to iron and iron sheet occur (Lalwani, 2006: 150)

Q. 37. Bhante! Iron (aye), copper, zinc, lead, coal and iron sheet (Kasattiya ee nam) to which species do these belong?

A. 37. Gautama! Iron (aye), copper, zinc, lead, coal and iron sheet (Kasattiya ee nam) belong, by virtue of their previous state, to the species of earth-bodies; but after these have been burnt, these become part of fire-bodies
In Bhagwati Sutra, Book 3, Chapter 7 (Lalwani, 2006: 117-118), reference to iron mines occur.

149. To the south of Mount Meru, which is in Jambu-dvipa, the following activities that take place, viz., iron mines (Ayogarañ), zinc mines, copper mines, lead mines, silver mines, gold mines, diamond mines, vajra rātana mines……

In Book 5, Chapter 7. No.141 (Lalwani, 2006: 206-207) reference to iron vessel (Lohiloḥakdai Kaduchhaya) has been found.

Book 6, Chapter 1. No 4. (Lalwani, 2006: 235-236) referred to the incidence of pouring drops of water on a hot iron ball (Ayakavallamsi)

Iron was converted into steel and various tools and weapons and coats of mail, already referred to, were prepared on a large scale. Knives (pippalaga), needles (sui: ariya), nail cutters (nakkaccani) and surgical boxes (satthakosa) were fashioned for the use of monks. Smith shops (Kammarsala: aggitkamma) are mentioned. One such shop was situated in Vesali. Smith’s shops were also known as Samara or aesa. Iron furnaces (ayakottha) were used for heating ore. Men handled it with tongs (Sandasi), then put on the anvils (ahikarani) for hitting. Iron was malleated, cut, torn, filed and was moulded by blacksmiths (Jain, 1984: 132).

Alchemic texts also contain some valuable references to iron. Varahamihira in his Khadgalakshanaṃ assignable to 550 CE gives an elaborate description of carburization of sword blades. “There are suggestions of plunging the red hot sword into the solution of plantain ashes and whey, and keeping it for twenty-four hours followed by grinding the blade on lathe” (Ray, 1956: 103). It could also be quenched by thrusting it directly into the trunk of a plantain tree and allowing it to cool overnight. Prakash suggests that, this would first convert the austenite into martensite and transform it into tempered martensite due to reheating of the sharp edge of the blade by the flow of the heat from the thick back edge.” (Prakash, 2002: 29)

The process of ‘killing’ iron is vividly described by P.C. Ray and P. Neogi by referring to the works of Nagarjuna and Chakrapani. Ray has incorporated the details of ‘killing iron’ as promulgated by Nagarjuna of the 2nd century CE. “A bar of iron is to be rubbed with the levigated powder of the following vegetable products among others: the belleric myrobalans, clitoria ternatea, vitis quadrangularis, boharhaavia diffusa and verbesina calend. It is then strongly heated to the fusion point and plunged into the decoction of the myrobalans. The iron is then powdered by being beaten with an iron hammer. The
powder is then digested in the decoction of the myrobalans and roasted repeatedly in a crucible” (Ray, 1903: 63-64).

Neogi in his work referred to the works of Chakrapani of the eleventh century CE in which Chakrapani stated that “I shall now describe the science of iron as promulgated by the sage Nagarjuna”. Neogi suggests that “the first notice of ‘killing’ iron and other metals occurs in the Uttarantaṇa or supplement of the Sushruta, which is said by the commentator Dalhana to have been added by Nagarjuna…. In it we find the process called ayaskriti-bidhi of iron and other metals in which thin leaves of iron are to be smeared with the levigated powder of the salts and heated in the fire of the cow dung cakes and then plunged into a decoction of the mycrobalans and asafoetida. This process is to be repeated sixteen times. The leaves are then to be ignited in the fire of the wood of mimosa catechu (khadira) and afterwards finely powdered and passed thorough a linen of fine texture.” (Neogi, 1914: 53-54).

Foreign Accounts:
Foreign accounts amply testify to the fact that Indian iron was in great demand. Chakrabarti categorically summarized the works which have highlighted on the Indian iron (Chakrabarti, 1992: 116). According to him, one should begin with the testimony provided by Ktesias. To Ktesias belongs the distinction of having been the first writer who gave to the Greeks a special treatise on India- a region concerning which they had, before his time, no further knowledge than what was supplied by the few and meagre notices of it which had appeared in the Geography of Hekataios of Miletos, and in the history of Herodotus. “This Ktesias was a native of Knidos , an important Lakedemonian colony situated on the sea coast of Karia….His family, as we learn from Galen, was a branch of the Asklepiasai, caste of priests settled principally in Kos and Knidos, with whom medicine was an hereditary profession….he must have risen to eminence by the practice of his art before the year 416 B.C. for about the time he repaired to Persia….Here he remained for 17 years, of which the first eleven years were spent under Darius II, and the remaining six under his successor Artaxerxes Mnemon. He accompanied the latter when he took the field against Cyrus….Soon after this he appears to have left Persia and returned to his own country. This was in the year 398…” (McCrindle, 1882: 1-2)
Among other things, he wrote a number of historical and geographical treatises on Persia. His work on India like his other works, has been lost but has survived in the form of
abridgement done by Photios. He was the Patriarch of Constantinople between 858 CE and 886 CE.

He referred to Indian iron in the following fragments:

Fragment 1.4. He notices also the iron found at the bottom of this fountain (Which is square in shape having of eleven cubits in circumference and a fathom in depth and yields gold also), adding that he had in his own possession two swords made from this iron, one given to him by the king of Persia, and the other by Parysatis, the mother of that same king. This iron, he says, if fixed in the earth, averts clouds and hail and thunderstorms, and he avers that he had himself twice seen the iron do this, the king on both occasions performing the experiment. (McCrindle 1882: 9)

Regarding such property of iron, McCrindle assumed that “Bachr thinks that Ktesias here refers to the magnet, the properties of which were not at that time so well known as now.

Fragment I:27. He states that there is bred in the Indian river a worm like in appearance to that which is found in the fig, but seven cubits more or less in length, while its thickness is such that a boy ten years old could hardly clasp it within the circuit of his arms……for catching this worm a large hook is employed, to which a kid or a lamb is fastened by chains of iron. (McCrindle 1882: 27-28).

1: 30. There is a fountain among the Indians of a square shape and of about five ells in circumference. The water logdes in a rock……. and when they leap in the water casts them up again, and not only does it throw up human beings to the surface, but it casts out upon dry land any kind of animal, whether living or dead, and in fact anything else that is acst into it except iron and silver and gold and copper, which all sink to the bottom. (McCrindle 1882: 31).

Reference to iron ploughshare has been given in the Kosmos Indikopleustes While giving the description of the skin of rhinoceros.

“The animal is called the rhinoceros from having horus growing upon its nose. Its skin, which is dry and hard, is four fingers thick--- and from this instead of from iron some make ploughshares…”(Kosmas Indikopleustos, De Mundo, XI, McCrindle 1882: 92)

Quintus Curtius (Quintus Curtius Rufus) was a Roman historian, writing probably during the reign of the emperor Claudius (41-54 CE) or Vespasion (69-79 CE). His only surviving work, Historiae Alexandri Magni, is a biography of Alexander the Great in Latin in ten books, of which the first two are lost, and the remaining eight are
incomplete.) in his treatise referred to the envoys from Malli and Sudracae in the following way.

“After the envoys of the Indians had been sent home, they returned a few days later with gifts. They consisted of 300 horsemen, 1030 chariots, each drawn by four horses abreast, a quantity of linen cloth, 100 Indic shields, 100 talents of white iron, lions and tigers of unusual size (previously tamed), also some skins of huge lizards, and shells of tortoises” (Rolfe, 1946: II, 431-432). According to J.C. Rolfe, who was the translator of the text assumed that, *ferri candidi* of which the Malli and Sudracae sent 100 talents weight to Alexander is a mixed product: it denotes the presence of an alloy, but whether for increasing the beauty or strength of the iron is uncertain.’(Rolfe 1946). He further suggests that *Ferri candidi* probably is not “white” but “bright” which signifies some form of polished iron.

In the voluminous work by McCrindle it has been revealed that, according to Nearkhos, the commander of the Greek fleet under Alexander, the people of the Marakan coast were not familiar with the use of iron. ‘They carried thick spears about 6 cubits long, not headed with iron, but what was as good, hardened at the point by fire’ and ‘those they captured had shaggy hair, not only on their head but all over their body; their nails resembled the claws of wild beasts, and were used, it would seem, instead of iron for dividing fish and splitting the softer kinds of wood. Things of a hard consistency they cut with sharp stones, for iron they had none’. (McCrindle, 1879: 183).

McCrindle while referring to the works of Megasthenes suggests that,

Fragment 1 (35). “And while the soil bears on its surface all kinds of fruits which are known to cultivation, it has also under ground numerous veins of all sorts of metals, for it contains much gold and silver, and copper and iron in no small quantity, and even tin and other metals, which are employed in making articles of use and ornament, as well as the implements and accoutrements of war.” (McCrindle 1877: 31)

“The fourth caste consists of the Artisans. Of these some are armourers, while others make the implements which husbandmen and others find useful in their different callings. This class is not only exempted from paying taxes, but even receives maintenance from the royal exchequer.” (McCrindle 1877: 42-43)

“for it is a practice with them to control their horses with bit and bridle, and to make them move at a measured pace and in a straight course. They neither, however, gall their
tongue by the use of spiked muzzles, nor torture the roof of their mouth”. (McCrindle 1877: 89)

Specific references are also made in the Megasthenes to the blacksmiths also with woodcutters, carpenters and miners (McCrindle 1877: 86).

Regarding the war equipments, Arrian stated that,

“They do not put saddles on their horses, nor do they curb them with bits like the bits in use among the Greeks or the Kelts, but they fit on round the extremity of the horse’s mouth a circular piece of stitched raw ox-hide studded with pricks of iron or brass pointing inwards, but not very sharp. If a man is rich he uses pricks made of ivory. Within the horse’s mouth is put an iron prong like a skewer, to which the reins are attached.” (McCrindle 1877: 221)

Substantial references to Indian iron are also available in the Periplus of the Erythraean Sea. It categorically mentions the exporters and importers of Indian iron. The province of Ariake which is identified by W. H. Schoff with the ‘northwest coast of India, especially around the Gulf of Cambay; the modern cutch, Kathiawar and Gujrat’ used to send along with Indian cloth, Indian iron and steel to the eastern coast of Africa (Schoff, 1912: 70).

McCrindle while categorized the important articles mentioned by Periplus adds the following notes on iron.

“Σίδηρος, σιδηρᾶ σχείη” Iron, iron utensils were exported from Egypt to Malao, Moundou, Tabai, Opone (8, 9, 12, 13). Iron spears, swords and adzes were exported to Adouli (6). Indian iron and sword-blades were exported to Adouli from Arabia (Ariake ?). Spears manufactured at Mouza, hatchets, swords, awls were exported from Mouza to Azania (17).

‘The Arabian poets celebrate swords made of Indian steel. “Ex omnibus autem generibus palma Serico ferro est.’ This iron was sent to India along with skins and cloth.. Indian iron is mentioned in the Pandects as an article of commerce.” (McCrindle 1879: 31-32)

Schoff adds a note on ‘Indian Iron and Steel’ and the following excerpt from him is interesting:

“Marco Polo Book I, chap. XVI I, mentions iron and ondanique in the markets of Kerman. Yule interprets this as the andanic of Persian merchants visiting Venice, an especially fine steel for swords and mirrors, and derives it from hundwaniy ‘Indian’ steel. Kenrick suggests that the ‘bright iron’ of Ezekiel XXVII, 19, must have been the same.
Ctesias mentions two wonderful swords of such material which he had from the King of Persia. Probably this was also the *ferrum candidum* of which the Malli and Oxydracae sent 100 talents' weight as a present to Alexander. *Ferrum indicum* also appears in the lists of dutiable articles under Marcus Aurelius and Commodus. Salmasius notes a Greek chemical treatise ‘On the tempering of Indian Steel’. Edrisi says ‘The Hindus excel in the manufacture of iron. They have also workshops wherein are forged the most famous sabres in the world. It is impossible to find anything to surpass the edge that you get from Indian Steel’.” (Schoff, 1912: 70-71).

In the *Periplus* of the Erythraean Sea, it has been mentioned that among the articles imported from the interior parts of Ariake, mention may be made of Indian Iron (Σιδηρος Ἰνδικὸς) (McCrindle, 1879: 52).

In that encyclopedia of the Roman Empire compiled by the elder Pliny under the title of “Historia Naturalis”, there is a passage about iron in the 34th book which deals with metals and metallurgy, paragraph 145, as follows: Of all the kinds the palm is to the Seric iron.

It is sufficiently evident from these references that the fine iron of the Roman trade was Indian steel. (Schoff, 1915: 236).

The forgoing delineation of some of the major literary sources gives an idea about the nature of the use of iron and how the society were gradually getting accustomed to the increasing utility of iron. It is clearly apparent that the metal is an indispensable one. Reference to varied objects of iron, methods of its production certainly suggests its role a society that was well knit by procurement networks (evident from database found from excavated and explored sites over different physiographic zones of the subcontinent).

This development obviously attained merit so as to be codified in different texts. Lack of specific reference to each and every stages of development (technically, as well as the utilization value of the finished products both secular and religious) in the literary records is a major limitation. The other side may also be true. There possibly are several literary sources (not known at present) which must have referred to such technical details. Further investigations are therefore, are a desideratum.