Prehistoric Copper implements in the Gungeria-Balaghat.

-Dr N L Dongre

"If you follow the ancient maps written on the stars, no person will ever understand you. So if you could read these maps, would you follow them? And forever be misunderstood? Or would you close your eyes tightly and pretend to be like everyone else?"

— C. JoyBell C.

The copper nuggets from Malanjkhand Copper mine in Balaghat are found in this size. Image of-elements found could sharpen a stick to defend himself; we have realized the importance of good quality tools in making our life easier and more beautiful. In our search for better and better tools and weapons, wood gave way to rocks tied to sticks that were in turn replaced by Copper chiseled pieces glued and fastened to hardy handles. Whole communities came to rely on those that could turn their hand to working stone, to people such as Otzi.

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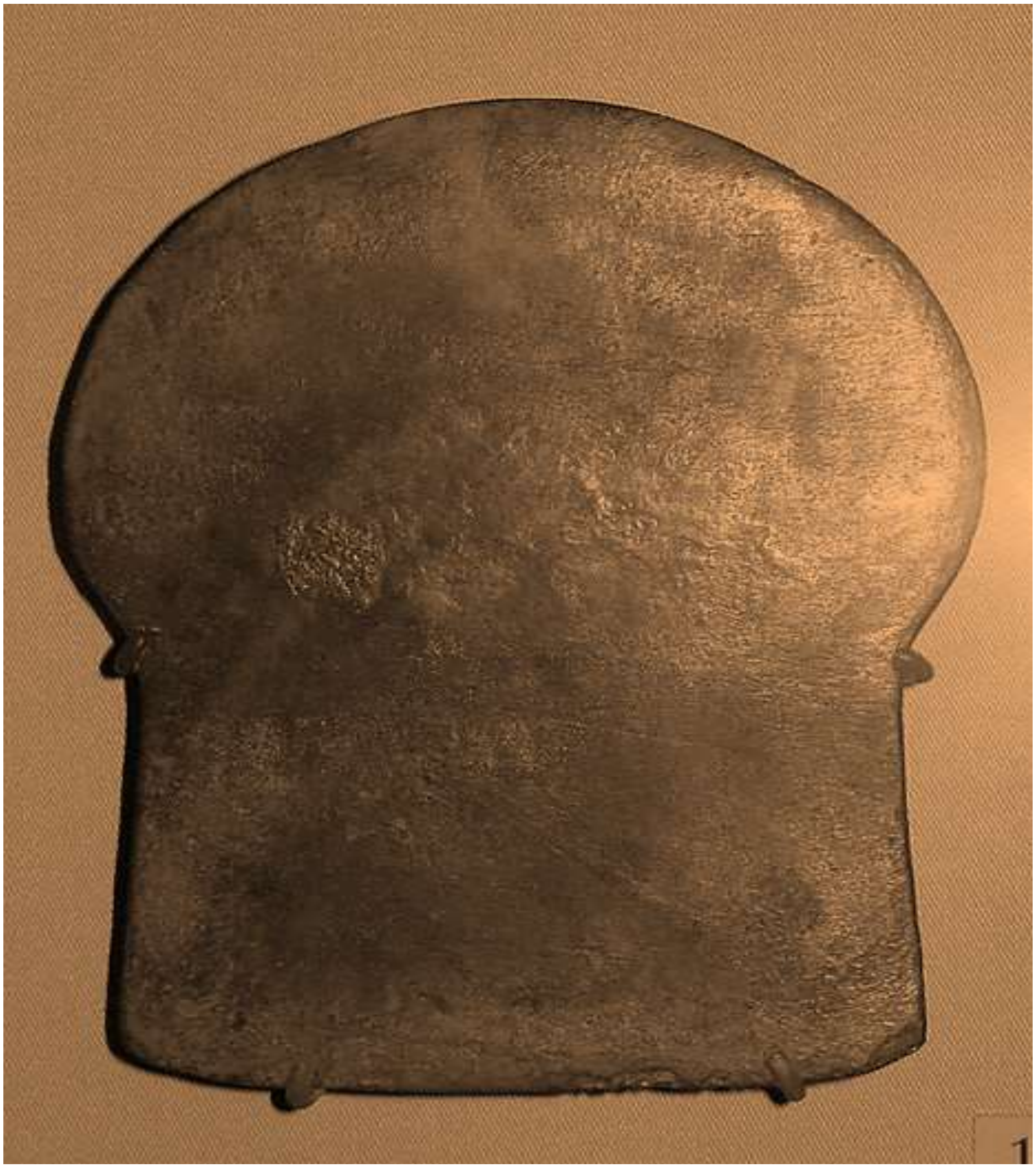
Introduction.



The Copper implement discovered from Gungeria copper hoard is a copper hoard cultures of 2nd millennium BC which is a continuum of the Bronze Age Revolution from 4th to 2nd millennium BCe. This was a copper anthropomorph (not an axe) of earlier times (perhaps 2nd millennium BCE) which was used to inscribe the land grand by Raja.

1. Half century before the recognition of the prehistoric Harappa culture in Western India with its varied metal equipment, at least one very remarkable find of primitive copper implements had brought India to the notice of European prehistorians. The discovery of the Gungeria hoard of over 400 copper axes and tools of similar types aroused some considerable interest in the 1870's, and the allocation of the bulk of these objects to the British Museum literally brought the matter home to British students. Indian prehistory was in those days in a state of bewildered vagueness typified by the title chosen for a paper by that engaging eccentric, Colonel Meadows Taylor, in 1873 when he wrote on the Celtic, Druidical or Scythian Monuments in the Dekhanand it was left to Vincent Smith to publish, in 1905-07, a comprehensive statement on the Gungeria and allied finds which gives an admirable account of the whole subject in the light of the archaeology of the day. Since then fresh finds have been made, and the identification of the Harappa culture has given us some concrete facts with regard to early metallurgy in India which can be related culturally and chronologically to the ancient civilizations of Iran and Sumer. It seems worthwhile therefore to review the whole question of the hoards of copper tools from the Ganges Basin and the adjacent highlands to the southeast—hoards from some twenty sites and totaling between 500 and 600 implements.

2. As in all Indian archaeological problems, the geography of the area concerned is on a vast scale. The two great riverine plains of northern India, formed respectively by the Indus and the Ganges, are a commonplace of junior school geography, but it is not always realized that if Delhi, approximately at the apex of the obtuse triangle formed by these two plains, is considered as London, a journey to the mouth of the Indus would be equivalent to one to Portugal, while the mouth of the Ganges would correspondingly lie to the east of Danzig. On this enormous background we must set out prehistoric cultures; the known sites' of the Harappa civilization stretch from the Himalayan foothills to the Gulf of Cambay, a distance of 700 miles, (1126.541 kilometer) and the hoards of copper implements discussed in this paper, all showing characteristics uniting them as the product of one culture, have been found over an area at least 800 (1728.748 kilometer) by 500 miles, (804.672 kilometer) mainly lying within the Ganges Basin.

3. The hoards vary in number from over 400 copper objects at Gungeria down to two or three: isolated finds of implements are comparatively rare and may be suspected as residual examples from hoards otherwise lost. Details of known finds arc given in an appendix, and while it is probable that more exist unpublished or recorded in obscure publications, the distribution pattern seems consistent and sound. The copper types represented in these finds may be divided into two main groups—axes (including specialized forms of ' barcelts and harpoons; there is also a notable hoard of swords, and silver ornaments were associated with the Gungeria hoard. No find has been made under conditions of scientific or even moderately intelligent supervision, water-buffaloes and peasants

4. The sources of present study is from which materials have been drawn similar to those which had been utilised in the preparation of study on Indian iron, In addition to medico-chemical Sanskrit texts examined by Dr. P. C. Ray in his "*History of Hindu Chemistry"* non-medical Sanskritic, mineralogical and specially archeological literature has freely been laid under contribution. I take this opportunity of submitting that archaeological literature, which has hitherto remained unexplored history of" Hindu Chemistry, affords by far the most convincing evidence which can be brought to the solution of a problem relating to the knowledge of metals in ancient India, as archeological specimens unearthed by the unceasing labours of the Archeological Departments can be seen, tested and handled by the public at large and speak with unerring emphasis of the existence of a prosperous metallic industry in ages gone by.

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[1] Indian Antiquary 1905, xxxiv, 229-44, supplement in ibid, xxxvi, 1907, 53-55. Full references to all finds up to that date.

Owing to that reason I have, wherever possible, attempted to collect archeological evidence to the best of my abilities, and I believe that literary texts when supported by archaeological evidence receive an added confirmation which would convince even the most sceptic.

5. So far as India is concerned, it appears that copper was known in the later Vedic age and specially in the Brahman age, and it does not appear to have been mentioned in the Rig-Veda, the earliest of the Vedas. A copper age intervened in Northern India after the Neolithic period, the copper implements being very likely used by the original non-Aryan inhabitants of India, their Aryan conquerors being fully acquainted with the use of iron from the time of their first settlement in the Punjab. Southern India passed directly from the stone to the Iron Age and no bronze age intervened in any part of India as in the case of Europe. As a matter of fact I concur in the assertion that, the Eastern origin of the Bronze Age must definitely be abandoned.

6. India abounds in ancient specimens of copper though in this respect the specimens of iron in the shape of pillars and beams still existing in India are certainly more wonderful. Nevertheless a continuous story of the existence of a copper industry may be read from pre-historic times down to the 17th century in the unique find of about 400 pre-historic copper implements in the village of Gungeria in the Balaghat, India to begin with, to the remarkable copper bolt in the Asoka-pillar discovered near the frontiers of Nepal, the colossal copper statue of Buddha discovered in Sultanganj and ' another such statue 80 feet (24.384 meter) high witnessed by the Chinese traveller Hieyn-Tsang near the Nalanda Convent, the brass convent 100 feet (30.48 meter) at the base constructed by King Siladitya, copper coins, plates, caskets and utensils from prechristian time onwards, and lastly the enormous brass guns and cannon of the Moghul period. These varied and numerous archaeological specimens of copper articles of all ages bear eloquent testimony to the existence of a flourishing copper industry in ancient India.

7. As regards the important alloys of copper, India can boast nothing in comparison with the bronze colossus at Rhodes or the bronze statue of Apollo at the Roman Palatine Library but as regards brass, India can justly claim superior knowledge about its chemistry. Owing to the much earlier discovery of zinc in India the chemistry of brass was much better understood in India than in contemporary Europe, and in fact brass was recognised in India as an alloy and prepared directly from zinc as distinguished from its ores several centuries earlier than in Europe. Of the ores of copper known in ancient India and from which copper was extracted, copper pyrites were the most important. Copper glance, malachite and red copper ore were very likely known.

8. Regarding the Compounds of copper the sulphide and the sulphate we're prepared artificially. The sulphate or blue vitriol as .well as green vitriol were known from the 3rd century B C thus showing that the difference between the two vitriols was known in India at a time when it was not suspected in Europe. Copper sulphate was prepared by the direct action of sulphuric acid on copper in the 16th century, the reaction being rediscovered in Europe by Glauber in 1648. The sulphide was very likely discovered by Vrinda (900 A. D.) but certainly by Chakrapani (1060 A. D.) by the combination of copper and sulphur.

9. I have attempted to identify the location of copper mines which existed in ancient India. References on this subject are however quite casual-, nevertheless sites of 'ancient copper mines have been discovered in many places throughout India. It is to be noted that copper obtained from Nepal was of superior value and there is also evidence to show that in the Middle Ages copper used to be imported also from foreign countries to supply the demand in India.

10. As regards metallurgy of copper, alchemical literature gives formulae for preparing copper by heating copper pyrites with various organic substances in closed crucibles. Description of the process of manufacture on a large scale as well as of furnaces is however wanting. Fortunately the old indigenous process of manufacturing copper from " pyrites still continues in several places in Rajsthan, Sikkim and Nepal and from the description of these processes as left by several observers about a century ago we get some idea of the process and furnaces as might have existed in ancient India. The pyrites after proper roasting was heated with charcoal and flux in small blast furnaces, the blast being provided by hand bellows. As references have been profusely given in the body of the study no separate bibliography is necessary. The dates of alchemical works such as Rasaratnakar, Rasarnava and Rasaratnasamuchchya are taken here as given by Dr. P. C. Ray in his History of Hindu Chemistry. I have to thank to Superintendent of Archaeology, Bengal, for his permission to photograph the copper bolt of the Rampurwa Asoka-Pillar and also to the authorities of the Asiatic Society of Bengal for permission to reproduce Plates I and V I from their Journal. My acknowledgments are also due to the editor of the *' Indian Antiquary"* {or reproduction of Plates II, III, IV from the " *Indian Antiquary"* of 1905 and 1907.

CHAPTER I.

COPPER IN ANCIENT INDIA.

Earliest Times.

The Vedic Age (Circa 2000 B.C.—1000 B.C.)

1.1 In the study abundant evidence has been put forward to show that iron was known to the Aryan Hindus from the earliest Vedic times, and as time went on, the Hindus perfected their metallurgical skill in working iron to such an extent that they produced the famous Delhi Pillar in the fifth century A.D., the gigantic Orissan beams, the Dhar Pillar, the Mount Abu pillar and other notable iron monuments in later centuries. During the Moghul rule India was still a rich iron producing country as could easily be learnt from the numerous wrought iron guns and cannon of enormous calibre still existing throughout India. India again undoubtedly produced the steel from which the famous Damascus blades were made in the middle ages. In fact the history of manufacture of iron in ancient India is almost unique in the annals of the world's metallurgy of iron. After the eighteenth and nineteenth centuries however, European iron of a superior quality began gradually to supplant the indigenous product until as at present it wholly dominates the Indian market. But it should be remembered that before that time India was always a rich iron producing country from very early times.

1.2 It stands to reason that proficiency of a nation in working metals cannot remain confined to one metal, and judging from the present potential mineralogical richness of the Indian soil it can easily be presumed that the ancient Indians were equally conversant with other metals besides iron. So far as copper is concerned, its manufacture by indigenous people and methods is at present confined to a handful of low-class and aboriginical people here and there in mountain fastnesses, but the main industry passed away several centuries ago, and copper from over-seas now completely dominates the Indian market as in the case of iron. Whilst studying the history of Indian metallurgy of any one of the metals the reader will have to divorce himself from the existing circumstances and transport himself to a remote past, rich in memories of ancient greatness, not only in religion and philosophy but also in science and literature, arts and industries. I convinced of the greatness of the iron industry in ancient and medieval India, and as regards copper, though copper is a less useful metal than iron in the sense that its chief use lies principally in coinage and making alloys like brass and bronze, existing literary and archaeological evidence points to the fact that India produced copper from the earliest times down to the seventeenth century. The history of copper is much the same as that of iron, though perhaps India produced iron on a much larger scale than copper possibly owing to geological causes,-—the history of the rise, development and final extinction of an industry through known and unknown causes inherent to gradually decadent national vitality.

1.3 We would now proceed to discuss the existing literary and other evidences from the earliest epoch of Aryan civilization in India viz. the Vedic Age.

1.4 Copper has not been mentioned in the Rig-Veda, the earliest of the Vedas. It has, however, been mentioned in the White Yajurveda as *loha* (from *lohiia* or red) in a list of six metals[1]

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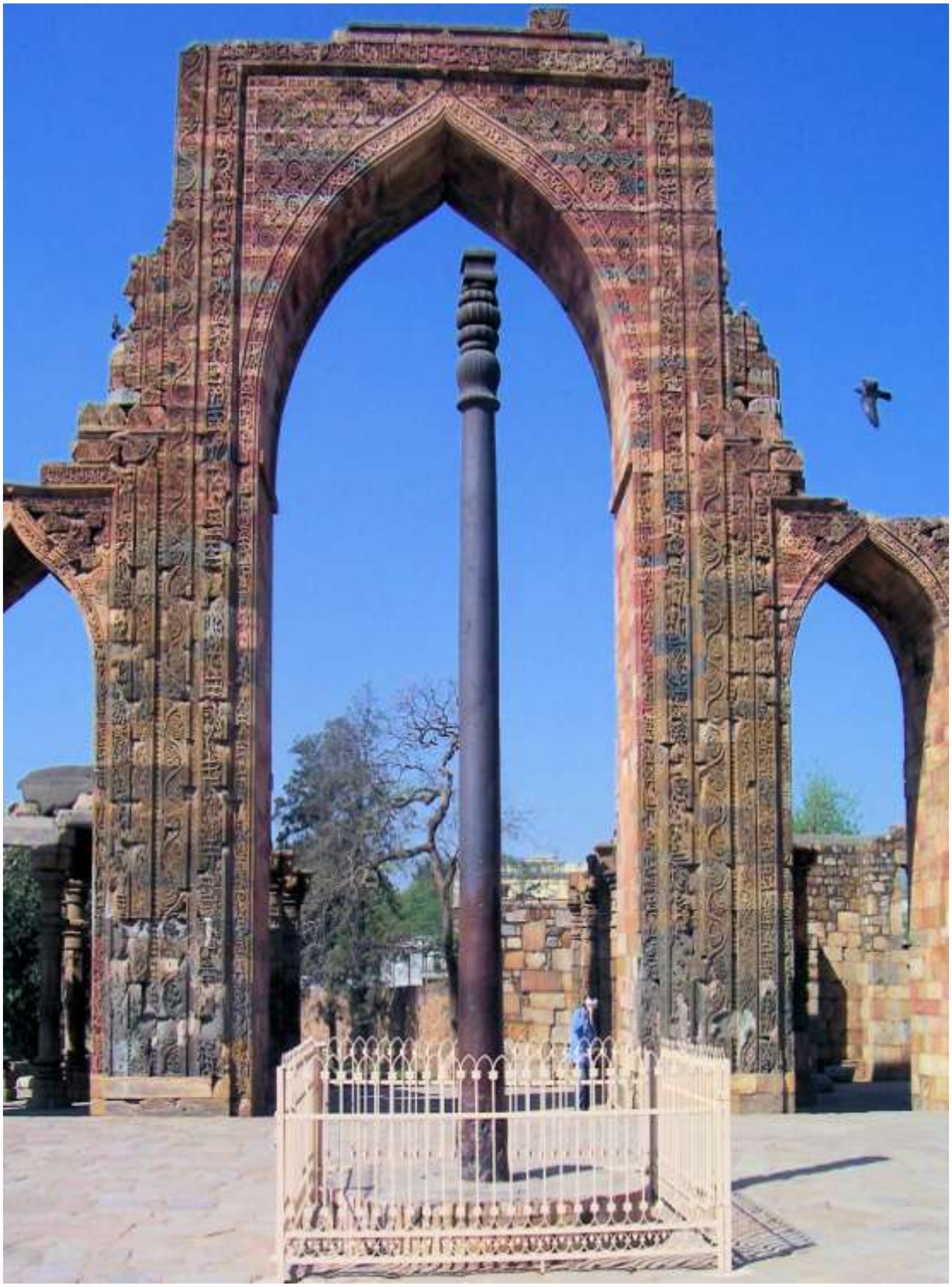
1. हिरण्यं च मे अयश्च मे श्यामं च मे लोहं च मे सीसं च मे त्रपु च मे यज्ञेन कल्पन्ताम्—*White Yajur Vēda*, XVIII, 13.



The iron pillar of Delhi is a 7 m column in the Qutb complex at Mehrauli in Delhi, India. It is notable fo the rust-resistant composition of the metals used in its construction.

Another surviving example of ancient iron metallurgy is the Iron Beam at the Konark Temple premises.

Iron pillar at Dhar Madhya Pradesh.

1.5 That the word *loha* here unmistakably refers to copper is shown by the fact that this identical passage has been repeated in the Taittirya Samhita and also in the Maitrayani Samhita with this difference that in the last named Samhita the word *loha* has been replaced by the work *lohilayas* or " red metal" meaning evidently copper.

1.6 In the Atharva-Veda, the last of the Vedas (being composed at circa 1ooo B. C.), copper continues to be designated as the red metal *(lohita).* In Atharva, XI, 3, 7, *lohitamaya* has been used in contrast to *Shyamamaya* or black metal, evidently iron [1]. In Atharva, VI, 141, 2, a knife made of "red metal" has been mentioned [2]. In addition to the word lohita, the modern equivalent of copper viz. famra occurs in one passage (Atharva, X, 2, 11) [3] which has been translated by Whitney simply as "red" but by Griffiths as "Copper-hued." -It is doubtful if the word really meant copper, as we find that in the Brahmans composed later than the Atharva-Veda copper continues to be designated as *lohita* or *lohitayas*. The word *tamra* for copper appears to have become current in the 3rd century B.C. as it occurs in the ancient medical treatises of Charaka and Sushruta as well as in Kautilya's Arthashastra.

The Brahman Age (Circa 1000 B.C.-—-500 B.C.)

1.7 In the Brahman Age copper continues to be designated, as has already been pointed out, as the "red metal." The word lohitayas occurs in the Taittiriya Samhita (IV, 7, 5, 1) as distinguished from shyama or "black metal":[4]. It also occurs in the Maitrayani Samhita (II, 1 1, 5 and IV, 44) and in the Kathaka Samhita (XVIII, 10).

1.8 Its other variant *loha* occurs in the Satapatha Brahman (XIII, 2 .2, 18), Chhandogya Upanishad (IV, 17, 7 and VI, 1, 5) [5] and Jaimini Upanishad Brahman (IV, 1, 4).

1.9 The third variant *lohayas* is mentioned in the Satapatha Brahman (V, 4, 1,2) where it is distinguished from *ayan* and gold. It also occurs in the Jaimini Upanishad Brahman (III, 17, 3) in contrast to *Karsnayas* and in the Taittiriya Brahman (III, 62, 6, 5) in opposition to *Krishnayas* meaning "black metal" or iron [6].

1.10 In all these passages the sense of copper is extremely clear. From the consideration of the foregoing passages in the Vedas and the Brahmans relating to copper, it appears that copper was possibly unknown to the early Aryans at the time when the Rig-Veda was written (circa 2000 B.C.) as it is not mentioned in it. The Rig- Veda, however, makes copious mention of two metals, gold and iron, in which, it is to be noted, India has been

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1 श्याममयोऽस्य मांसानि लोहितमस्य लोहितम्—"Dark metal its flesh, red it-blood" (Whitney). Whitney comments that they are doubtless iron and copper ress pectively.

2 लोहितेन स्वधितिना—"With the red kuife. The red kuife is doubtless of copper" (Whitney).

3. लोहिनीलाम्रधूम्रा—"ruddy, red, dark" (Whitney)—"red, copper-hued and purple" (Griffiths).

4. हिरण्यं च मे &c. with the exception that *lohitāyas* is uscd in the place of *loha*.

5 लवणेन सुवर्णं संदध्यात्, सुवर्णेन रजतं, रजतेन त्रपु, त्रपुणा सीसं, सीसेन लोहं, लोहेन दारु, दारु चर्मणा—Chhāndogya Upanishad, IV, 17, 7.

एकेन लोहमणिना सर्वं लोहमयं विज्ञातं स्यात् एकेन नखनिकृन्तनेन सर्वं कार्ष्णायसं विज्ञातं स्यात्—Chhāndogya Upanishad, VI, 1, 5.

6. Macdonell & Kieth, *Vedic Index*.

pre-eminently rich in all ages[1] As copper is mentioned once in the White Yajurveda, which was composed later than the Rig Veda, it is apparent that it was known at the time when the Yajurveda was written, though from the frequent mention of copper in the Atharva Veda (1000 B.C.) and the Brahmans it can easily be surmised that copper came into general use amongst the early Aryans at about 1000 B.C.

1.11 Enough evidence are available in "*Iron in Ancient India*" (pp. 3-7) to show that the use of iron and iron weapons was well-known at the time when the Rig-Veda was composed not to speak of the times of the later Vedas and the Brahmans. The general use of copper by the first Aryan settlers appears to be distinctly later as it is not mentioned in the earliest of the Vedas. In the Rig- Veda we find that arrows were "tipped with iron" though we come across with a "copper knife" (p. 7) in the Atharva-veda. It is possible that a copper knife, owing to the peculiar sanctity attached by the Hindus to copper might have been used in the sacrifices. Even taking it for granted for the sake of argument that the mention of a copper knife in the Atharva Veda presupposes the use of copper as a material for making weapons, there is hardly anything to be wondered at this, as, so long as the process of hardening iron by quenching or the process of steel-making is not discovered there is not much to choose between malleable iron and copper, though bronze would certainly be more preferable to copper being in point of hardness more approachable to iron. Bronze does not appear to have been known in the Vedic Age [2] and as a matter of fact there was. No bronze age in India at all. The process of hardening' on by quenching, as well as steel were certainly discovered in India as Early as the third century B.C., as both are mentioned in the well-known 'medical treatise of Sushruta and it impossible that during the Vedic age, in addition to iron, copper might have sometimes been used as a material for making weapons.

The Epic Age {Circa 500 B.C.—200 B.C.)

1.12 In the Epic Age the knowledge of copper had much advanced and we find copper designated by its modem name *tamra* which occurs in the two Epics. The law-giver Manu in his Institutes gives directions for the purification of copper utensils[3]. Brass and bronze vessels are also referred 'to in the same passage. Copper finds a place amongst the six metals in the medical work of Sushruta. The other medical treatise Charaka Samhita composed at the same time mentions brass besides copper and bronze

1.13 Copper is mentioned in many places in Kautilya's Arthashastra (3rd century B.C.), which mentions the ores of copper as heavy and green, grey and red in colour probably meaning there by malachite, pyrites and red copper ore[4]. The Arthashastra also mentions the use of copper in making alloys and in gold and silver coins and articles. It further describes the process of gilding by "covering the copper article with gold leaf and then polishing its outer surface and sides."

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1. As regards Indian iron see "*Iron in Ancient India"Pancharan Neogi*

2. As both copper and tin are not mentioned in the Rig Veda, Macdonell and Kieth's contention that " ayas" as in the Rig Veda means " bronze" is untenable.

3 ताम्रायःकांस्यरैत्यानां त्रपुणः सीसकस्य च।
शौचं यथार्हं कर्तव्यं क्षाराम्लोदकवारिभिः॥ Manu, V, 114.

4 भारिकः स्निग्धो मृदुश्च प्रस्तरधातुर्भूमिभागो वा पिङ्गलो हरितः पाटलो लोहितो वा ताम्रधातुः--Kautilya's Arthashastra, edited by Shama Sastri, p. 83

1.14 From the accounts left behind by the Greek ambassador Megasthenes who visited India in 302 B.C. we learn how "vessels of Indian copper set with precious stones contributed to the brilliancy of the dublic ceremonies during Chandra Gupta's reign." From Megasthenes' account of the court of Chandra Gupta and also from the big copper bolt discovered in the Asoka pillar near the frontiers of Nepal we can unhesitatingly say that the output of copper was quite considerable in India as early as the 3rd and 4th centuries B.C. As we have come to historical times we shall not have the necessity of confining ourselves to purely literary evidence but would be able to produce before the readers many ancient specimens of copper from the 3rd century B.C. onwards. Before doing so we would turn our attention to the consideration of an important question, viz., whether there was a copper age in ancient India. As the question is an important one we would discuss it in a separate chapter.

The Copper Age in India.

CHAPTER II.

2.1 India evidently had no bronze age, as bronze implements are scarcely to be found. So far as Southern India is concerned it is an admitted fact that the Neolithic period, during which time stone implements and weapons were used, passed directly into the Iron Age, as no copper or bronze weapons have been found in Southern India. Old cromlechs in various parts of Southern India have been found to contain iron weapons[1]. The southern bronzes of pre-historic times, as will be described later on, were objects used for ornamental purposes and do not include weapons. In Northern India, however, including the copper tools in Madhya pradesh and weapons have been discovered in several places besides two in Baluchistan which may be regarded archaeologically as a part of India. Mr. Vincent A. Smith in an excellent paper describes these interesting finds and concludes that "in the greater part of Northern India a copper age intervened between the Neolithic period and the iron age[2]." We would examine his theory later on and in the meantime a short description of these implements will prove interesting.

Copper in Ancient India.

COPPER IMPLEMENTS DISCOVERED IN GUNGERIA -BALAGHAT

2.2 "The most important discovery of instruments of copper yet recorded in the Old World", as Evans puts it in his Ancient Bronze Implements, was made by some shepherd boys who, while tending cattle in the village of Gungeria in the district Balaghat of the Madhya Pradesh, observed a piece of red metal peeping out of earth in a plot of waste land.

2.3 On receipt of this news in 1870 Mr. Bloomfield, Deputy Commissioner of Balaghat, had the place excavated and as many as 424 copper implements and weapons and 102 pieces of thin silver plates were discovered in one place measuring about three feet in length, three feet in breadth and four feet in depth. The discovery of this remarkable find was announced at the May meeting of the Asiatic Society of Bengal, 1870[3].

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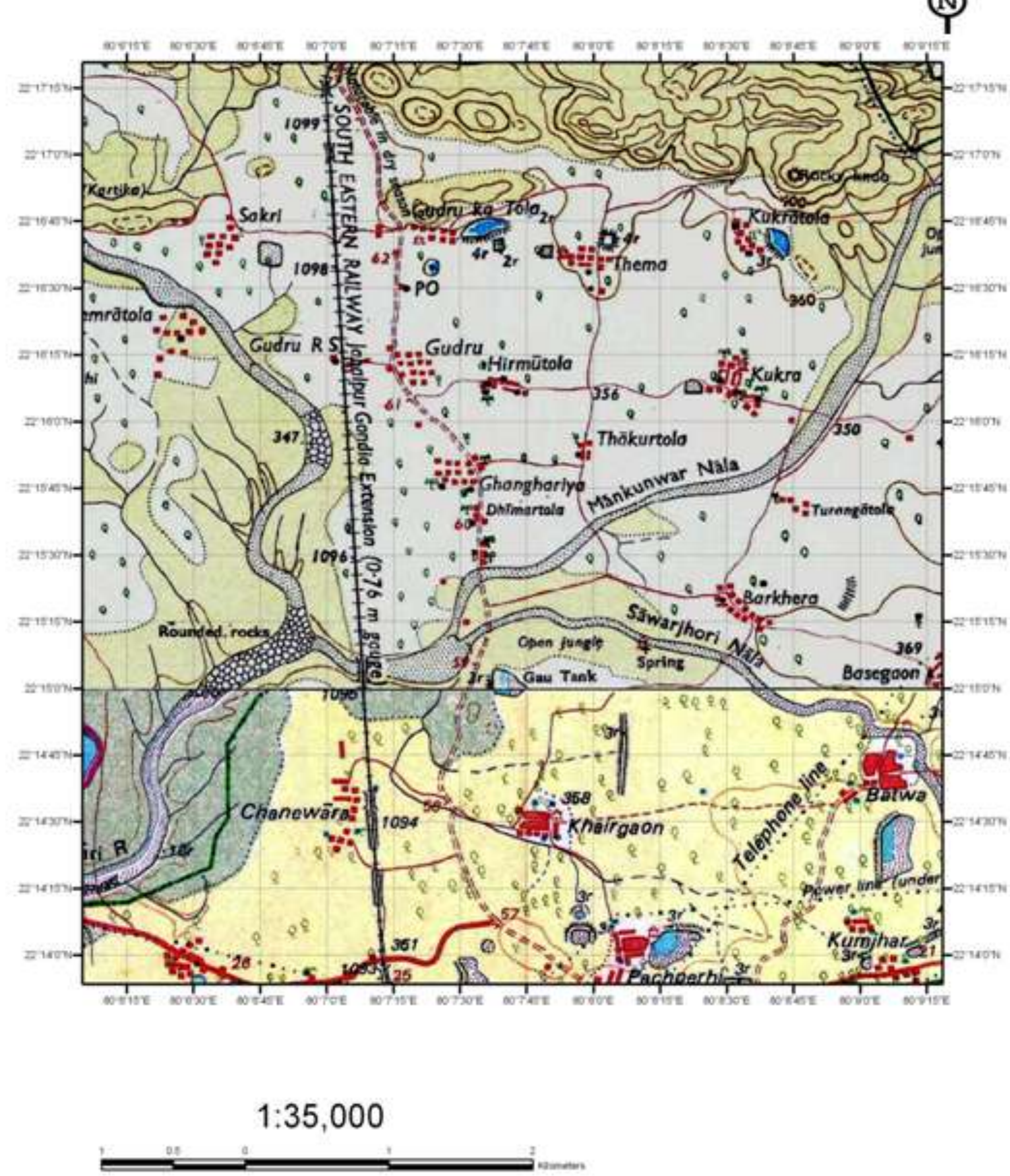
(1) " Weapons and other objects made of iron are found abundantly in many parts of India in stone circles or associated with cromlechs and other stone monuments, many of which appear to be of great antiquity and to have been erected by tribes long since extirpated or driven from the country. The erection of rude stone monoliths is still practised by some of the wilder tribes, so that the date of such erections is in many cases doubtful. There can be little, if any, question, however, that many of the stone circles of Central India and the ' Koruinba rings' of Southern India date from a period previous to the Aryan immigration, and they were possibly contemporaneous with the very similar remains found in Europe and Central Asia. In Europe, however, stone circles and chromlehs are considered characteristic of the bronze age whereas in India iron implements have been found associated with them in several places, amongst others near Nagpur in the Wardha district, near Firozabad and Sonapur, east of. Hydrabad in the Deccan, in Maisur (Mysore) and Kurg (Coorg), 011 the Nilgiri Hills, in Malabar, Coimbatore, Salem and Tinnevelly. It appears not improbable that iron may have been discovered in India at an earlier period than in Europe"—Medlifcott and Bland fords Geology of India, Part 1, p. 443.

(2) Vincent A. Smith, "On the copper age and pre-historic' bronze implements of India." Indian Antiquary 1905, Vol. XXXTV, p. 229. Supplement to the above, Indian Antiquary, 1907, Vol. XX XVI, pp. 53-55.

(3) Bloomfield, Proceedings of the Asiatic Society of Bengal, 1870, p. 131'

TOPOGRAPHIC MAP OF GUNGERIA



Prehistoric copper implements of Gungeria Hoard

1. Gungeria, Dist. Balaghat. M. P. - Axe, type III a. 11.9 x 7.2 x 1.3 cm, irregularly cast *(Ptj% 443).* – Brn ish Mux. (1873.11-3-24). - Unpuh.
2. Gungeria, Dist. Balaghat, M.P. - Axe, type IV d variant. 14.3 x 7.2 x 10 cm, one comer bem% Apparently recently *(PL* 37, *444).* - British Mus. (1873.n-3.2a). •~ Read,CH. 1920, 182-183 pi. 10, 5.
3. Gungeria, Diss. Balaghat;, M.P. - Axe, type IV f. 17.3 x 8.74 x 1.8 cm, irregularly and asymm etrically cast *(Pi. 37, 44Sl* - British Mus. (1873.11*3.19). -Read, CM. 1920,181-183 pk |Qi a.
4. Gungeria, Dist. Balaghat, M.P. - Axe, type IVf. 20.7 (pres.) x8.07 x 1.91 cm, 1539 gm (Brown), butt end recently flattened *(PL 37,446).* - Indian Mus. Calcutta (A 21404 Ga j). - Bloomfield, A. 187O, 132 pi. 2; idem. c. 1890, 1-8 pi. 1, 2; Brown, J. Coggin, 1917, 147no. 5.
5. Gungeria, Dist. Balaghat, M.P, - Axe, typeVa. 14.6 x 13.2X 1.02 cm, in profile asymmetrical, surface patterned lengthwise with light gouges *(PL 38,447).* -British Mus. (1873.11-3.26). - Bead, C.H. 1920, 182-183 pt. to, 6.
6. Gungeria, Disc Balaghat, M.P. - Axe, type Va. *iy4* x 11.7x0.98 cm, in profile asymmetrical, corroded, sharp edges *(PL 38, 44M** ~ British Mus. (1873.n-3.28). - Unpub.
7. Gungeria, Dist. Balaghat, M.P. - Axe, type Va.17.6 x 144 x 0.8 cm, recent damage to the cutting edge *(PL 38, 44$).* § British Mus. (1873.11-3.29). - Read, C.H^.1920,182-183 pi. 10,1*
8. Gungeria, Dist. Balaghat, M.P. - Axe, typeVa. 17.7 x 15.6 x 0.9cm, well-formed with sharp edges *(Pi. 38, 4fo),* - British Mus. (1873.11-3, 30). - Unpub*
9. Gungeria, Dist. Balaghat, M.P. - Axe, typeVa. 17.3X13.7X0.8 cm, 902 gm (Brown), slightly plano convex, cutting edge somewhat flattened (recently) *(PL 38,* 4;/). - Indian Mus. Calcutta (A 21 y 36 Ga 19). -Anderson, J. 1883, 424; Brown, J. Coggin 1917, 150 no. 19.
10. Gungeria, Dist. Balaghat, M.P. - Axe, typeVa. 16.j x 1 J.J xo.88 cm, 992 gm (Brown) *(Pi 38,4%!).* – Indian Mus. Calcutta (A 21404 Ga 20). - Anderson, J. 1883, 424; Brown, J. Coggin 1917,150 no. 20 pi. 10, 7.
11. Gungeria, Dist. Balaghat, M.P- - Axe, typeVa. 17.0 x 14.6 x 1.1 cm, 112a gm (Brown) *(PL 38, 4s3).* -Indian Mus. Calcutta (A 21 s 37 Ga 21). - Anderson, J. 1883,424; Brown, J. Coggin 1917,1 jono.21.
12. Gungeria, Dist, Balaghat, M.P. - Axe, typeVa. 18.J x 15.9 x 1.0cm, 1260 gm (Brown) *(PL 38, 454).* – Indian Mus. Calcutta (A 21538 Ga 22). - Anderson, J. 1883, 425;Brown,],Coggin 1917, IJI no.22.
13. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 18.9 x 12.7 X 1.3 cm, rough surface *(PL 38, 4$?),* -Ashmolean Mus. Oxford 0954^*)> donated by A.W. Franks 1873 or by Mai- Gen. Houghton. - Unpub.
14. Gungeria, Dist. Balaghat, M.P. - Axe, typeVII. 21.8 x 17.1 x 1.7 cm, sharp edges *(PL 39,456% -* British Mus. (1873.11-3.10). - Unpub.
15. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 2J.9x 15.3x 14cm *(PL* 39, 437). - British Mus. (1873.u-3.11).- Read»CH. 1920,182-183 pi. 10, j.
16. Gungeria, Dist. Balaghat, M.P. - Axe, typeVH. 19.7 x 1.5.8 x 1.55 cm, green, sharp edges *(PL 3% 4$$),* - British Mus. (1873.11-3.12). - Read, C.H. 1920, 182-183 pl-10> 4-
17. Gungeria, Dist, Balaghat, M.P. - Axe, typeVII. 18.2 x 14.5- x 1.02 cm *(PL 3 9,4s 9)-* - British Mus. (1873.11-3.13). - Unpub.
18. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 18.6 x 14.1 x 1.64 cm, in plan asymmetrical *(PL 39, 460).* - British Mus. (1873.11-3.14), — Read, CH. 1920,182-183 pi. to, 13.
19. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 20.6X 12.1 x 1.46 cm, in plan somewhat asymmetrical *(H 3% 461).*- British Mus. (1873.11 -3.15). - Unpub.
20. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 19.0x 12,6 x 1.7 cm *(PL 39*462).* - British Mas, (1873.11-3.16).—Unpub.
21. Gungeria, Dist. Balaghat, MP. — Axe, type VII. **9S*x**}4#*Acm, dull cutting edge *(Pi* j9, *463% -* British Mus. (1873.u-3.17). - Unpub.
22. Gungeria, Dist. Balaghat, M.P. - Axe, typeVII. 18.5 x 12.8 x I.J cm, mottled surface, angular ridges and traces of hammering on two edges *(Ft 40,464).* -British Mus. (WG 938 1880-82). - Unpub.
23. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 20.1 x 13.2 x 1.4 cm, edges sharp *(PL 40,46;).* – British Mus. (WG 1880-83). - Unpub.
24. Gungeria, Dist. Balaghat, M.P. - Axe, typeVII. Dimensions unknown *(Ft 40, 4$$),* - Ethnographical Mus. Copenhagen. - Franks, A.W. 1876, 233: fig. 6; Monteiius, O. 1900,133-134 fig. 328.

25. Gungeria, Dist. Balaghat, M.P. - Axe, typeVIL 15. $ X 9,8 x 2.0 cm *(Pt. 40, 467).* - National Mus. Copenhagen (OB IIB4). - Unpub.
26. Gungeria, Dist Balaghat, M.P.Axe, type VII. 13.7X9.1 x 1.22 cm, 706 gm (Brown) *(PL 40, 468).* | Indian Mus, Calcutta (A21 525 Ga 6). - Anderson, J. 1883, 420; Brown, J. Coggin 1917.147-148 no.6.
27. Gungaria, Dist. Balaghat, M.P. - Axe, type VII, 17.4 x 97 x 1.51 cm, 875 gm (Brown) *(Pi.* 40, *469).* Indian Mus. Calcutta (A *21402 Ga* 8). - Anderson, J. 1883, 421; Brown, j. Coggin 19.17, 148 no.8 P». 10, 5.
28. Gungeria, Dist. Balaghat, M.P. - Axe, type VII.22.6 x 16,8 x 1.86 cm, 2116 gm (Brown) *(Pt. 40^ 470),* — Indian Mus. Calcutta (A 21527 Ga 9). ~ Anderson, J. 1883,421-422; Brown, J. Coggin 1917,148-149,
29. Gungeria, Dist. Balaghat, M.P. - Axe, type VIL 21.5 (pres.)x 15.0 x 1.62 cm, 1810 gm (Brown), butt end recently broken off *(PL 40, 471).* - Indian Mus. Calcutta (A21528 Ga to). — Anderson, J. 1883, 422; Brown, J. Coggin 1917, 149 no. 10.
30. Gungeria, Dist. Balaghat, M.P. - Axe, typeVSL 19.0x 14.9 x 1.5 cm, 1458 gm (Brown) *(H 40,472).* - Indian Mus. Calcutta (A 21 529 Ga 11). - Anderson, J.1883,422; Brown, J. Coggin 1917,149 no. n.
31. Gungeria, Dist. Balaghat, M.P. - Axe, type VII.20.2 x 13.8 x 1.57cm, i64t gm {.Brown) *(PL 41,473).* -Indian Mus. Calcutta (A 21530 Ga 12). - Anderson, J. 1883,422; Brown, J. Coggin 1917,149 pi. 10, 1.
32. Gungeria, Dist- Balaghat, M.P. - Axe, type VII.21.7 x 14.5 x 1.3 cm, 1630 gm (Brown) *(Pt. 41, 474).* -Indian Mus. Calcutta (A.21531 Ga 13), - Anderson, J. 1883,4*3 > Brown, J. Coggin 1917,149,
33. Gungeria, Dist. Balaghat, M.P- - Axe, type VIL 23.0 x 15.5 x 1.25 cm, 1875 gm (Brown), in plan asymmetrical *(PL 4% 4?$}.* - Indian Mus. Calcutta (A 215 32 Ga 14). - Anderson, J. 1883, 423; Brown, J. Coggin *T-917** 149-
34. Gungeria, Dist. Balaghat, M.P. - Axe, type VII. 19.21 x 13.73cm *(PL 41,476).* — National Mus. Dublin (1873,47). - Smith, VA, 190s. 233 ˙pt.j» p| B.B. *jjjjfy* 92 fig. 5,9, Gordon, D. H. 195 8,136 fig. 17,9.
35. Gungeria, Disc Balaghat, M.P. - Axe, type VIL 15.97x 10.89cm *(Pt. 4h 477)-* - National Mus. Dublin (1873,49). - Smith, VA. 1905,233 pi 5, 4-
36. Gungeria, Dist. Balaghat, M.P. - Axe, type VIL 19.5 x ijpkx 14 cm *(PL 41, 478). - Umvemiy* Mus. of Archaeology and Anthropology, Cambridge (1922,1475). — Unpub.
37. Gungeria, Dist Balaghat, M.P. - Axe, type VIL 21.3 x 12.7 x 14 cm *(PL 41,479).* - Unr«rsny Mus, of Archaeology and Anthropology, Cambridge (192x1476). - Unpub.
38. Gungeria, Dist. Balaghat, M.P, - Axe-ingot, type IV, 14.1x10.0 x14 cm *(PL* 4/, *480).* - British Mus. (1873.11-3.18).-Unpub.
39. Gungeria, Disc Balaghat, M.P. - Axe-ingot, type IV. 15.8 xiajx 1.6 cm, irregularly formed *(PL 41, 481),* - British Mus. (1873.11-3.20), - Read, C.H. 1920,182-183 pi. 10, 7.
40. Gungeria, Dist. Balaghat, M. P. - Axe-ingot, type IV. 13.9 x 8.6 x 14 cm, irregularly shaped *(Pt. 42,482}.*- British Mus. (1873.11-3.21). - Unpub.
41. Gungeria, Dist. Balaghat, M.P. - Axe-ingot, type IV. 13.5 x 9.9 x 0.96 cm, green patina *(PL 42,483).* - British Mus. (1873.11-3.23). - Unpub.
42. Gungeria, Dist. Balaghat, MLP. - Axe-ingot, typeIV. 15.8x9.4x 1.22cm, irregularly formed *(PL* 42, *484).* - British Mus. (1873.11-3.25). - Read, C.R 1920,182-183 pi. 10,8,
43. Gungeria, Disc Balaghat, M.P. - Axe-ingot, type IV. 134X 12.2 x 1.03 cm, irregularly formed, green patina *(Pt. 42,485),* — British Mus. (1873,11-3.27).- Read, C.H. 1920,182-183 pi. to, 9.
44. Gungeria, Disc Balaghat, M.P. - Axe-ingot, type IV. 12.6x7.9x1.2 cm, 514 gm (Brown) *(PL 43^ 486).* - Indian Mus. Calcutta (A21526 Ga 7). - Anderson, J, 1883, 426; Brown, j. Coggin 1917, 148 no.7 pl.10,3.
45. Gungeria, Dist. Balaghat, M.P. - Axe-ingot, typeIV. 14.5 X 12.7 X 1.28 cm, 853 gm (Brown), roughly formed *(PL 42, 487).* - Indian Mus. Calcutta (A 21533 Ga 15). - Anderson, j. 1883,423; Brown, J, Coggin 1917,149-150 no. 15 pi 10,8.
46. Gungeria, Disc Balaghat, M. P. - Axe-ingot, type IV. 14.24 x 1 z.06 cm *(PL 42,488).* - National Mus. Dublin (1873.48). - Smith, V A. 1905,233 pi. 5,*6.*
47. Gungeria, Disc Balaghat, M.P. - Axe-ingot, type IV. 14.27 x 1046 cm *(PL 42* 489).* - National Mu$. Dublin (1873.50). - Smith, V, A. 1905,233 pL 5,3.

48. Gungeria, Dist. Balaghat, M.P. - Bar celc 68.4x5.9x1.3 cm *(PL 42,* 490). - British Mus. (1873.11-3.1). - Read, C.H. 1920, 182-183 pLio, 11.
49. Gungeria, Dist. Balaghat, M.P. — Bar celt.61.7 x 8.0 x 2.1 cm, hammer marks visible *(PL 42,491).*- British Mus. (1873.11-3.2), - Read, C.H. 1920, 182-183 pi. 10,12.
50. Gungeria, Disc Balaghat, M.P. - Bar celt. 56.2 x 10.2 x 0.6 cm, sharp cutting edge, butt end slightly bent *(Pi. 43,492),* - British Mus. (1873.11-3.3).- Unpub.
51. Gungeria, Dist. Balaghat, MP. - Bar celc 53.2x8.4X 1.12cm, cutting edge slightly damaged *((Pi. 4j, 4$j).* - British Mus. (1873.1.-3.6). - Read, C.H. 1920, 182-183 pi. 10, 10.
52. Gungeria, Dist. Balaghat, M.P. - Bar celt. 48.1 X 5.6 x 0.8 cm, cutting edge recently damaged *(PI 44,496).* - British Mus. (1873.11-3.7). ~ Unpub.
53. Gungeria, Disc Balaghat, M.P. - Bar celt. 43.8 x 5.94 x 1.13 cm green patina, somewhat corroded *(PL 44, 497).* - British Mus. (1873.11 -3.8). - Unpub.
54. Gungeria, Dist. Balaghat, M.P. - Bar celt. 43.3.x 5,7 x 1.8 cm *(PL 44, 40).* - British Mus. (1873.1[1]"3-9)' - Unpub.
55. Gungeria, Disc Balaghat, M.P. - Bar celt. 60.8 x 6.8 x 2.i cm, 4717 gm (Anderson), edges worked flat *(PL 44** 499j. — Indian Mus. Calcutta (A 21 jai Ga 1). - Anderson, J-1883,418-419; Brown, J. Coggin 1917,146-147 no. t; Lai B.B. 1953,92 fig. 3, 13; Gordon, D.H. 1958,136 fig, 17, 13.
56. Gungeria, Disc Balaghat, MP. - Bar celt. 49.2X4.6x0.94 cm, 845 gm (Brown) *(PL 44.* 300J. -Indian Mus. Calcutta (A 215 22 A Ga 2). - Anderson, J. 1883, 419; Brown, j. Coggin 1917,147 no.a.
57. Gungeria, Disc Balaghat, M.P. - Bar celc 40.1 x 4.9 x 1.8 cm, i486 gm (Brown), burr end damaged recently *(Pi. 43,* 30/). — Indian Mus. Calcutta (A2f 532 Gaj). - Anderson, j. 1883 419; Brown, J. Coggin 1917 147110.3.
58. Gungeria, Disc Balaghat, M.P. - Bar celt. 3°-3 ^{x} 7-3 * i.83cm»4t|74 gm (Brown) *(PL. 4h 1°*)*- - Indian Mus. Calcutta (A 21 524 |HH - Anderson, J. 1883, 419; Brown, J. Coggin 1917, 147 no.4; Lai, B.B. 1951, 32-33 fig. s, 2 pi-11 B; Muller-Karpe, H. 1980 pi. 564 B.
59. Gungeria, Disc Balaghat, .M.P. - Bar celc 57.3 x 10.oxo.64cm, 1051 gm (Brown), surface covered with hammer marks, repeated hammer marks of the same sixe line the edges *.(PL 45,* jojj* - Indian Mus. Calcutta (A 21534 Ga 16). - Anderson, j, 1883, 423; Brown, J. Coggin 1917,1 yo no. 16; Gordon, D.H. 1958, 136 fig. 17,12.
60. Gungeria, Disc Balaghat, M.P. - Bar celc 55-3 * 9,8 x0.9cm, 1330 gm (Brown) *(PL* 43, *$04).* -Indian Mus. Calcutta (A 21535 Ga 17). — Anderson, J. 1883,424; Brown, J. Coggin 1917, IJO *no.* 17.
61. Gungeria, Dist, Balaghat, M.P. - Bar celc 50.0 x 8.66 (pres.) X 0.72 cm, 832 gm (Brown) *(PL* 47, 303*).* - Indian Mus. Calcutta (A 21403 Ga 18). - Anderson, J, 1883, 424; Brown, J. Coggin 1917, 150 no. 18.
62. Gungeria, Dist, Balaghat, M.P. - Bar celc 48.5 x 7.3 x 0.7 cm *(PL 46, so6).* - National Mus. Copenhagen (OB II B3). - Franks, A.W. 1876, 23 fig. 5; Monielius, 0.1900,134 fig. 327.
63. Gungeria, Disc Balaghat, M.P. - Bar celt. 31.75 x 7.92 cm *(PL 46,* 307). - National Mus. Dublin (1873*50. - Smith, V.A. 1905,233 pi. 5, 7-
64. Gungeria, Dist. Balaghat, M.P. - Bueranion, type I. 12.2 x 6.6 x 0.01 cm, silver, hammered from the centre toward the peripherae, originally slightly convex, now flattened and thus wrinklcd$_{4}$ edge hatched in places *(PI 46, $o8).* - British Mus. (1873.11-3.34). -Unpub.
65. Gungeria, Disc Balaghat, M.P. — Bueranion, type I. 13,3x0, 7.5 cm, silver, slightly convex *(Pi.* 46, 309). - British Mus. (1894.7-27.56). - Unpub.
66. Gungeria, Disc Balaghat, M,P< — Bueranion, type I. 11.8 xc. 7.0 (pres.) x 0,01 cm, silver, somewhat convex *(PI. 46,* j/oi -British Mus. (1894.7-27,57). -Unpub,
67. Gungeria, Disc Balaghat, M.P. - Bueranion, type 1.12.0 X 6.65 cm, silver, somewhat convex *(PL 46, pi).* - British Mus. (1894.7-27.58). - Gordon, D.H. 1958 pi. 27c; Rau, W. 1974,67 fig-6.
68. Gungeria, Dist. Balaghat, M.P. — Bueranion, type I. 13.6x7.6x0.03 cm, silver, flattened *(PL 46), $12).* - Indian Mus. Calcutta (A 21 544 Ga 28). — An*> derson, J. 1883, 425; Brown, J. Coggin 1917, 151 no. 28.
69. Gungeria, Dist. Balaghat, M.P, - Bueranion, type I. 13.6x7.7x0.03 cm, silver, flattened *(Pi. 46> Sij).* - Indian Mus. Calcutta (A21540 Ga 29). - Anderson, J. 1883, 425; Brown, J, Coggin 1917, 151 no. 29.
70. Gungeria, Dist. Balaghat, M.P. - Bueranion, type I. 13.0x7.1x0x4cm, silver, flattened *(PL 46** 3/4/ - Indian Mus. Calcutta (Ga 30). - Anderson, *J.* 1883,4|j;Brown, j. Coggin 1917,151 no. 30.'*
71. Gungeria, Disc Balaghat, M.P. - Bueranion, type 1.12.79 x 7.2 cm, silver, upper edge damaged, pre

sented by Lc Col. Keating, Bombay Staff Corps *(Pi. 46,j 1j).* - National Mus. Dublin (1873$ 3). - Smith, V.A. 1905,233 pl.5,2.

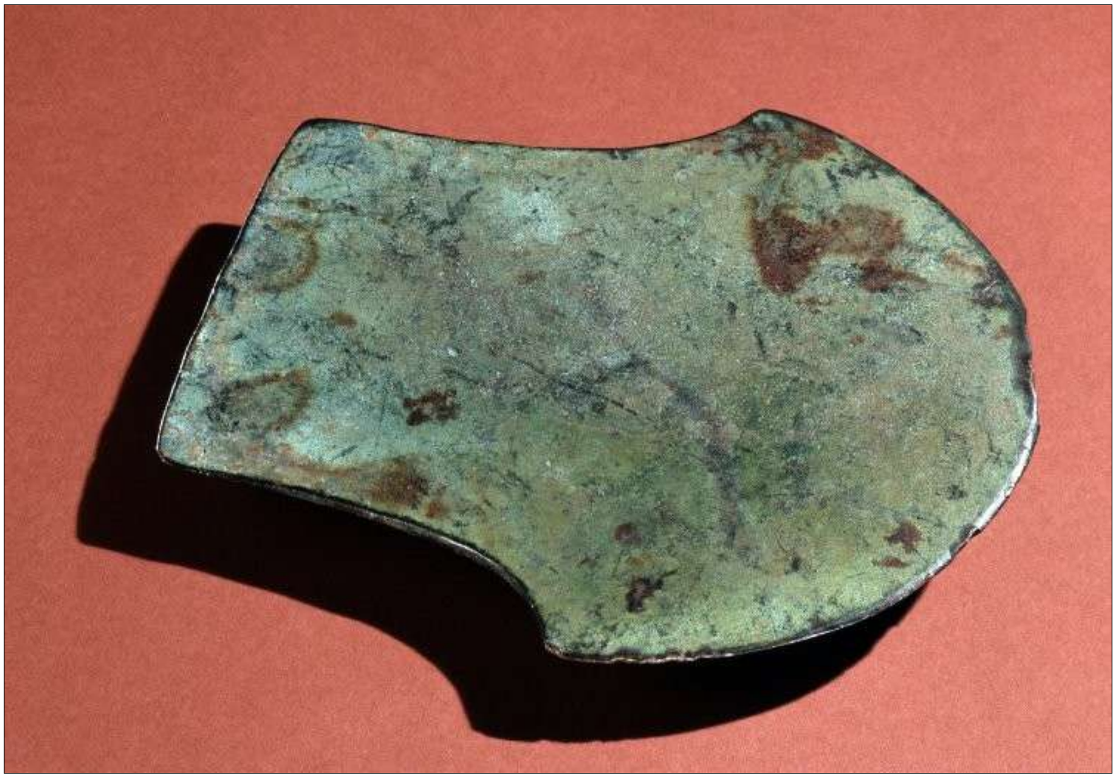
72. Gungeria, Dist Balaghat, M.P. - Bueranion, type II. 13.8 x 9. j *cm*, silver, originally slightly convex, line impressed on the peripherae, edges damaged *(PL 46*, 3/6). - British Mus. (.1873.11-3-33). ~ Unpub.
73. Gungeria, Disc Balaghat, M.P. - Bueranion, type 1X432.7xc. 9.72cm, silver, flattened, perforated from corrosion *(Pt. 46, ft7).* - British Mus, (1894.7-27-J3). - Unpub.
74. Gungeria, Disc Balaghat, M.P. - Bueranion, type II. 14-j x i2,i x0,04cm, silver, right side folded *(PL 46, $iR).* - Indian Mus. Calcutta (A 21539 Ga 23).- Anderson, J. 1883,425; Brown, J. Coggin 1917, iji no. 23; Smith, V.A. 1903, 239.
75. Gungeria, Dist. Balaghat, M.P. - Bueranion, type II. 12.1 (pres.) x 12.0 cm, silver, left lionf torn off *(PL 46,* 3/9I - Indian Mus. Calcutta (A2, $46). -Brown, J. Coggin 1917, 151 no.24 (?).
76. Gungeria, Dist. Balaghat, M.P. - Bueranion, type II, 14.2 X 10.3 x c. 0.01 j cm, silver, line impressed peripheral to the edge, left *hom" broken off *(PL* 46, 320). - Indian Mus. Calcutta (A 21542 Ga 2$). - Anderson, J. 1883,42$; Brown,J. Coggin 1917,151 no. 25 If
77. Gungeria, Dist. Balaghat, M.P. - Bueranion, typeII. 13.8 x 10.9 x c.cs cm, silver, line impressed pe ripheral to the edge, left'horn* damaged *(PI. 46.* 32/). -Indian Mus. Calcutta (A 21541 Ga 26). - Anderson, J. 1S83,425; Brown, J. Coggin 1917, 151 no. 26.
78. Gungeria, Dist. Balaghat, M.P. - Bueranion, type II, 13.6 x 1 o.i xo.015 cm, silver, line impressed peripheral to the edge *(PL 46.*322). — Indian Mus. Calcutta (A 21 J43 Ga 27). - Anderson, J. 1883,425; Brown, J. Coggin 1917,151 no.37 pi. 10,4.
79. Gungeria, Dist. Balaghat, M. P. - Disc. D 13.6 cm, silver, slightly convex *(PL 47, $23).* - British Mus. (1873.11-3.21). - Unpub.
80. Gungeria, Dist. Balaghat, M.P. - Disc. D 12.3 x 12,6cm, silver, convex (c 1.2cm), hatching on the edge *(Pi. 47, 324).* - British Mus. (1873.11-3.32). -Unpub.
81.Gungeria, Dist. Balaghat, M.P, - DiscD 13.0cm, silver, wrinkled, flattened *(Pi. 47,525).*- British Mus. (1894,7-27,53). - Unpub.
82. Gungeria, Dist. Balaghat, M.P. - Disc. 11.9 x 12.1 x 0.02 cm, H of the convexity 0.9 cm, silver, perforated from corrosion, edges hatched *(PL.* 47, *$26%* - British. Mus. (1894.7-27.54). - Unpub.
83. Gungeria, Dist Balaghat, M.P. - Doc 13.3 x 13.6 x 0.015 cm, silver, wrinkled, edge hatched, flattened *(PL 47* 5²?)-* - Indian Mus. Calcutta (A 21547 Ga 31). - Anderson, J 1883, 425; Brown, J. Coggin 1917,151 no.31.
84. Gungeria, Dist Balaghat, M.P.- Disc. D 12.3cm, silver, edge hatched, flattened, wrinkled *(PL 47, $28).* -Indian Mus. Calcutta (A at 548 Ga 32), - Anderson, J. 1883,425; Brown, J. Coggin 1917,131 no. 32 pi. 10,6.
85,. Gungeria, Dist, Balaghat, M.P. - Disc. 11.75 x0.05 cm, silver, edge hatched, flattened, wrinkled *(PL 47*, 329). — Indian Mus. Calcutta (A2i 549 Ga 33), - Anderson J, 1883, 425; Brown, J. Coggin 1917,151 no.j|,.
86. Gungeria, Disc. Balaghat, M.P. - Disc 7.1 X 4.2 x 0.025 cm, silver, fragment, perforated on the edge *(Pi. 47,* 330). - Indian Mus. Calcutta (A 21550 Ga 34). - Anderson, j. 1883, 425; Brown, J. Coggin 1917,151 no. 34.
87. Gungeria, Dist Balaghat, M.P. ~ Disc. D 11.73 em, silver, wrinkled *(PL 47% JJJ).* - National Mus. Dublin (1873.52). - Smith, V.A. 1905,233 pi. $, t.;
88. Pondi, Dist. Rewa, M.P. - Axe, type Ilia, 18.7 X 14.4 x 1.3 cm, 2010 gm, very good workmanship, symmetrical form, slight traces of hammering, some tiny superficial cracks visible, cooperated colour *(PL 47, 532%* - Municipal MuS. Allahabad (7). - Lai, B.B. 1951, 22.24. 38Afig.2,6pl. 6B, 3.
89. Pondi, Dist Rewa, M.P. - Bangle, type I. D 9-4-9-7 cm, *it D 1.6 cm, 420 gm, 'join sawed true?, Copper-red colour *(PL 47,533).* - Municipal Mus. Allahabad (no no.). - Lai, B.B. 1931,22-23 *fy-¹*¹* p'-^B, i._
90. Pondi, Dist. Rewa, M.P. - Bangle, type I. D 10.2x10.4 cm, wire D 1.49cm, 465 gm, ends nearly touch, partially cut through recently, copper-red colour *(PL 47,* 5*34),*- Municipal Mus. Allahabad

Beginnings of metallurgy. – A primitive Copper smithi-

Copper was shaped via cold hammering into objects from very early dates the oldest archaeological evidence of copper mining and working was the discovery of a copper hoard in Gungeria-Balaghat.

Prehistoric copper implement, discovered in Gungeria, of Balaghat, India (Proc. As. Soc. Beng. 1070).

Copper implements from Gungeria



Copper implements from Gungeria

Copper implements from Gungeria

Copper implements from Gungeria

Copper implemenrs from Gungeria

Copper implements from Gungeria

2.4 The weight of the copper implements was 10 maunds (373.2419 kilogram) $14\frac{1}{2}$ seers (13.53 kilogram) (about 826 lbs.) and that of the silver pieces 1 seer (0.933105 kilogram) and $\frac{1}{2}$ tola (about 20 lbs.). The copper implements were mostly celts, shovels, axe-blades} spades, . manufactured for war like, domestic and agricultural purposes. The copper implements were of different sizes, the longer pieces being $24\frac{1}{2}''$, (62.23 cm), $21\frac{1}{2}''$, (54.61 cm), $17\frac{1}{2}''$ (44.45 cm) "Long and variously broad by $6\frac{1}{2}$ (16.51 cm) $''4''$(10.16 cm) or $3''$. (7.62 cm)"They were mostly $\frac{3}{4}''$(22.86 cm) "thick. Mr. Bloomfield presented 8 pieces of these silver discs and 17 copper implements to the Asiatic Society and these have now been kept in the Archeological Department of the Indian Museum, Kolkata.

2.5 The copper implements were packed in regular layers with the silver objects lying in mass on one side. They appear to have never been put to use. It has been surmised that the place marks the site of a treasure house in which these articles were kept for safety. It is more likely, however, that there was a depot at that place in which these goods were stored for sale. Mr. Vincent A Smith contends that this large collection of copper implements affords conclusive evidence that at one time the manufacture of Implements of pure copper were conducted in India on an extensive scale. It is impossible that more than four hundred such implements should have been collected in a single deposit unless they were of a kind in common ordinary use."

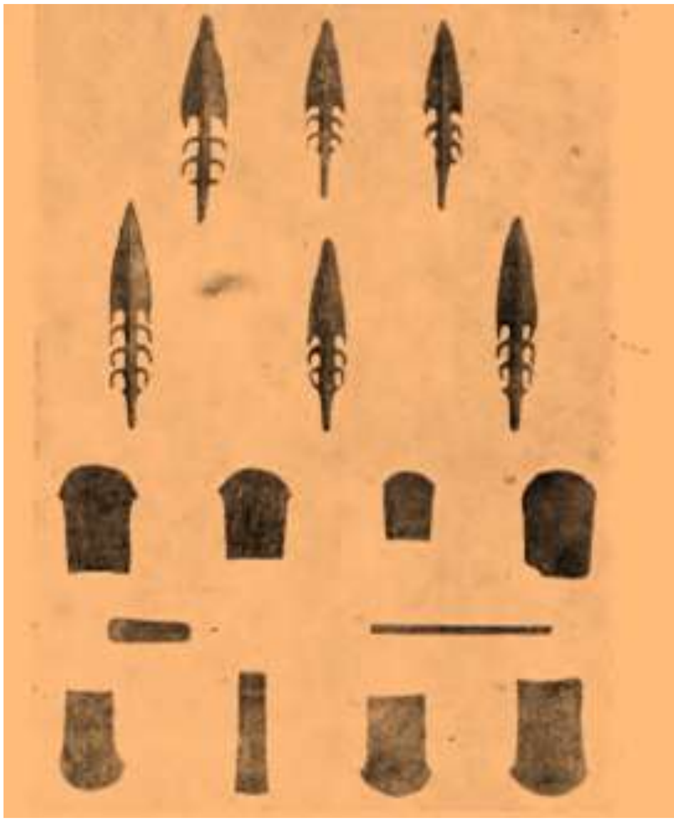
2.6 There is no doubt that the implements are made of pure copper and not bronze. Mr. A. Tween has analyzed them and found the metal to be pure copper mixed with only $1\frac{1}{2}$ percent (1.50 percent) lead. The silver was also pure, being contaminated with only 3.7 percent gold.

2.7 As regards other finds of copper implements in ancient India they may be summarized in the accompanying list as given by Mr. Smith. Most of these implements have been analyzed and found to be made of pure copper. They may be conveniently divided into flat celts, bar celts, swords and daggers, harpoon or spear heads and arrow heads.

Ancient Indian Copper Implements.

	Locality.	*Contents of find*
1	Rajpur, Bijnor district, United Provinces.	16 objects — 9 flat celts, I long bar celt, 6 barbed spear or harpoon heads.
2	Mathura	... I copper flat c e it; it is said that harpoon or spear heads were found.
3	Manipuri ...	2 flat celts, I barbed harpoon head, I set of rings.
4	Fahtehgarh	13 swords, 1 human figure.
5	Niori, Itawah District.	1 harpoon head and 1 sword.
6	Bithur, Cawnpore District	2 flat celts, 3 harpoon heads.
7	Kosam, Allahabad District.	1 flat celt.
8	Parior, Unao District.	"A large number" of harpoon heads.
9	Saurajuri, Midnapur District	1 flat celt.
10	Karharhari, Pachamba Subdivision, Hazaribagh District.	3 unfinished flat celts and two pieces of unwrought copper.
11	Bhagotoro, KarachiDistrict, Sindh	I flat celt.
12	12. and 13. Kohistan Hill near Soorag and Tank in Beluchistan ...	... Arrow-heads associated with silver bracelet.

Location of Gungeria



Prehistoric copper celts and spear or harpoon heads discovered in the Bijnor district. (Indian Antiquary, 1915, p. 236).

Prehistoric copper celts discovered at Bithur (one of them being a spear-head). (Indian Antiquary, 1907, p. 53.)

2.8 Many new copper implements have, however, been discovered after Mr. Smith prepared his list. In a recent paper Pandit Hirananda Sastri gives an account of some additional copper implements discovered in Northern India specially at Bithur in the Kanpur District1. Three copper hatchets about 7" (17.78 cm) long and $4\frac{3}{4}$ "(12.446 cm) broad have been found in the temple of Bava Gudardas Uttam Das in Bithur which resemble those already described by Mr. V. A. Smith. One similar specimen, though smaller, is lying in the sanctuary of Radhakrishna at Bithur. Two additional copper hatchets have been found at Parior.

2.9 Mr. Ortel has obtained four fine copper specimens from Bithur ------ one of them being a spear-head weighing about 2 lbs 9 oz., the second a hatchet weighing 2 lbs 5 oz., the third a sword resembling the Fatehgarh swords in the Calcutta Museum and the fourth a small hatchet. Pandit Shastri has secured four additional copper implements, two being harpoon heads and two hatchets. They have been chemically analysed and found to be made of copper and not bronze.

2.10 In addition to these, ten more copper implements from the Bulandshar and Hardoi districts—one of them being an axe-blade, two swords, one hatchet and the remainder celts—have been collected in the Lucknow Museum.

2.11 In addition to these, quite a large number of copper implements has recently been discovered in different parts of Bihar and Orissa and described in the Journal of the Bihar and Orissa Research Society. Dr. A. Campbell describes 27 specimens of copper axeheads in the Manbhum district of which he got possession of twenty four. They were found by digging in the stretch of country between the hills running almost due east from Paresnath to Pokhuria in the north of the Dhanbaid Subdivision and the Barakar River. A dozen of these magnificent

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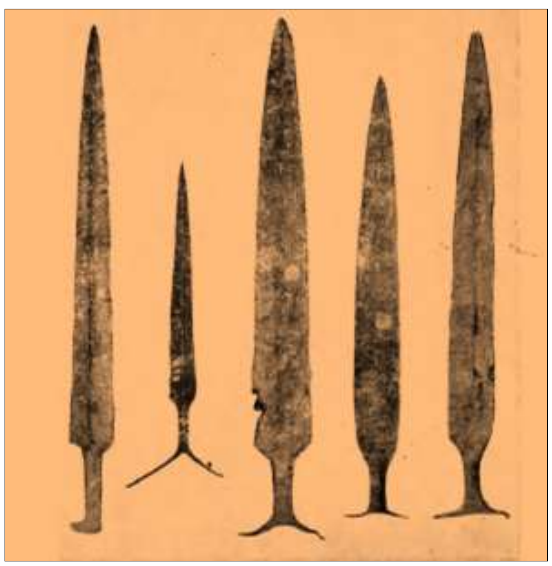
(1) Journ. As. Soc. Beng., 1915, XI, pp. 1-5.

Specimens were dug up in a lot about a foot below the surface of the earth by coolies engaged in making the road going from the village of Kolher to the boundary of the Hazaribag District. Regarding the method of construction of these axe-heads Dr. Campbell writes “the method of manufacturing these axe-heads seems to have been to run the metal into a mould, of the shape of but thicker and smaller than, the finished article. It was then beaten out to the required thickness. This appears to me to account for the variety of the shape of those that have been found. A little difference in the thickness of the cast in the mould or else the metal beaten irregularly would result in the slight differences in shapes which exist. I possess one of these rough castings” [1].

2.12 Mr. J. Coggin Brown describes a copper celt found in the Palamau District which he describes as a fine specimen, 18.5 cm. long and 15. 4 cm. wide across the widest portion. Its greatest thickness, was 2.3 cm. It seems to have been roughly cast and then beaten into its present shape. The form is a very primitive one and closely imitates a well-known stone model. It is related to certain flat forms from the Gungeria hoard[2].

2.13 Twenty-one copper-axes were excavated in a place in the Bassia Thana of the Ranchi District of which two are described by Mr. Coggin Brown[3]. They were similar to the Palamau celt and evidently similarly manufactured.

2.14 The Mayurbhanja State in Orissa has supplied its quota in respect of ancient copper implements in the shape of 3 double-edged copper battle-axes which have been collected by Mr. Cobden Ramsay Political Agent, Feudatory States of Orissa. They were found with 6 or *7* similar pieces on the bank of the Gulpha River in the village of Bhagra Pir in the Mayurbhauja State. The large axe was $18\frac{1}{4}$"” (21.083 cm) in length and $15\frac{3}{4}$" (38.862 cm) in breadth and the two others were 10 "(25.4 cm) by $8\frac{1}{4}$" (46.482 cm)and $10\frac{1}{2}$" (26.67cm) by 7 " (17.78 cm) respectively in dimensions. The first, two were about 1/8" (8.600 cm) and the third 1/20" (0.508 cm) thick[4].



Prehistoric copper swords discovered at Fahtehgarh. (Indian Antiquary, 1905, p. 236***).***

1. Dr. A. Campbell, “Note on the occurrence of copper Celts in Manbhum Journal of the Bihar and Orissa Research Sociaty, 1916, 85--6.
2. J. Coggin Brown, Journ. B. & O. lies. Soc., 1915, 125-6;
3. Ibid, p. 127.
4. Ibid, 1916. 386.

2.15 The discovery of these numerous copper implements in different parts of Bihar and Orissa, besides affording more conclusive evidence in favour of a copper age in ancient India supplies a missing link in the names of the countries in Northern India where copper implements have been found. Bihar and Orissa were originally represented in the list of places mentioned by Mr. Vincent A. Smith where copper implements were discovered by " 3 unfinished flat celts and two picces of unwrought copper" found in the Pachamba Subdivision of the Hazaribagh District but now more than fifty well-finished copper implements have been discovered in various parts of the two provinces. The evidence adduced by Mr. Smith in favour of a copper age in Northern India has been materially strengthened by the finds in the old United Provinces (Uttar Pradesh) described by Mr. Sastri and in the new discoveries in Bihar and Orissa. Almost all countries throughout Northern India down to certain parts of the Madhyapradesh in the south are now well-represented in the list of places where a copper age undoubtedly intervened between the stone and the iron age.

Date of the Copper Age in India.

2.16 We would now proceed to consider the question of the probable date of the copper age in India. Two hypotheses are possible— either these implements were used by the Aryan conquerers or they were used by the original inhabitants of India who were ultimately conquered by the Aryans and gradually brought to the Aryan fold.

2.17 Regarding the first hypothesis it has already been pointed out that the Aryans were acquainted with the use of iron (ayas) from the time of their earliest habitation in the Punjab as it is frequently mentioned in the Rigvada, the earliest of the Vedas, and according to Max Muller, the earliest composition of any nation in the world. On the other hand copper (loha) came into general use amongst the Aryans much later on (about 1000 B.C.) as it is frequently mentioned in the Atharva-veda and the Brahmans but not in the Rigveda. Having known the use of iron it is not very likely that the ancient Aryans used copper as an ingredient for making implements to an appreciable extent. Though a copper knife is mentioned in the Atharva-veda it is likely that owing to the peculiar sanctity attached to copper, a copper knife might have been used in sacrificial rites. It is therefore very likely that the copper implements discovered in ancient India were not used by the Aryans themselves.

2.18 If these implements were not used by the Aryans, the other alternative becomes that they were used by the original inhabitants of Northern India, who passed from the Neolithic period to the Iron Age through an intermediate copper age before the conquest of Northern India by the Aryans who taught them the use of iron. Direct evidence in favour of this hypothesis is forthcoming.

2.19 Mr. Vincent A. Smith has dealt with the question of the probable date of the copper age in Northern India and concludes that all the Indian copper implements are certainly extremely old and must be dated previous to 1ooo B. C. Probably they are much earlier "and that the primitive celts of Northern India, which are obviously copies of Neolithic patterns, may be as old as 2000 BC. ' He further writes 'the guess hazarded above as to the possible date of the northern examples has really little foundation, being largely based upon the dates assumed for Ireland".

2.20 But Europeon analogies are not always very safe guides in determining questions of age relating to ancient Indian history. European analogy would suggest a bronze age to have intervened between the stone and iron ages in India, whilst as a matter of fact there was no bronze age in India. If any guess regarding the probable date of the copper age is permissible, such hypothesis should be based mainly on internal evidence as the evolution of Indian civilization took place in a different manner from Ireland. I would venture to put forward here my own views on the subject.

2.21 I would entirely agree with Mr. Vincent A. Smith in thinking that "in the greater part of Northern India a copper age intervened between the Neolithic period and the Iron Age." Two evidences on this subject are conclusive. Is the first place the wide area over which the finds of the copper implements have been distributed shows that the copper implements were used throughout the greater part of Northern India including certain parts of the Madhyapradesh, as the Gungeria deposit by reason of its contents must be associated with Northern India. Secondly, this very large number of weapons including agricultural and domestic implements in the Gungeria deposit is a conclusive proof of the fact that copper implements were largely used in Northern India at some period of her history. As Mr. Smith himself points out, the celts from Upper India found at Mathura, Bijnor Mainpuri and Bithur are all, with one exception, of the kind known to archaeologists as 'flat celts/ extremely primitive in form " *closely imitating common stone models and, obviously referable to a period when metal teas only beginning to supersede stone"* As the Aryans were undoubtedly well acquainted with at least two metals viz. gold and iron even at the time of the composition of the Rigveda, it would thus appear that the people who used these copper celts were not the Aryans but the *direct lineal descendents of the Neolithic people* who in habitated India before the Aryan conquest. The copper age appears to have been spread over a tolerably wide interval of time, as much improvement in the technique of the construction of some of the implements as those found in the Gungeria deposit and the spear heads would suggest.

2.22 The question of the copper age naturally therefore resolves into the determination of the time when the Aryans conquered Northern India from its aboriginal inhabitants. That date would form the lower limit of the copper age, as the Aryans evidently taught the original inhabitants of Northern India the use of iron in the place of copper. Now in the time of the Rigveda the Aryans were in their first settlement in the Punjab on the banks of the Indus and its tributaries. "The Yajurveda introduces us not only to a geographical area different form that of the Rigveda but also a new epoch of religious and social life in India We no more hear of the Indus and its tributaries, for the geographical data of all the rescissions of the Yajurveda point to the territory in the middle of Northern India occupied by the neighboring people of the Kurus and Panchalas. It lay in the plain between the Sutlej and the Jamuna[1] But the conquest of Northern India appears to have been complete during the Brahman age. In the Sathapatha Brahman we find that "the Brahminical system had-by this time spread to the countries to the east of Madhaya pradesh, to Koshala with its capital Ajodhya (Oudh) and Videha (Tirhut or Northern Bihar} with its capital Mithila ,[2]. Buddha who preached a religion antagonistic to Brahmanism in many respects was born in 567 B. C. and when Alexander came to invade India; the Indian troops as we learn from Herodotus had arrows tipped with iron[3]. It would thus appear that by 1000 B.C. the greater part of Northern India was conquered and Aryanised and by the seventh century B.C. the Aryans begen to penetrate into Southern India. I would therefore agree with Mr. Smith, though for entirely different reasons, that all the copper implements must be dated previous to 1000 B.C. and that the most primitive forms may be as old as 1500-2000 B.C.

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(1) Macdonell, History of Sanskrit Literature, p. 175.
(2) Ibid. 214.
(3) Rawlinson's Herodotus.

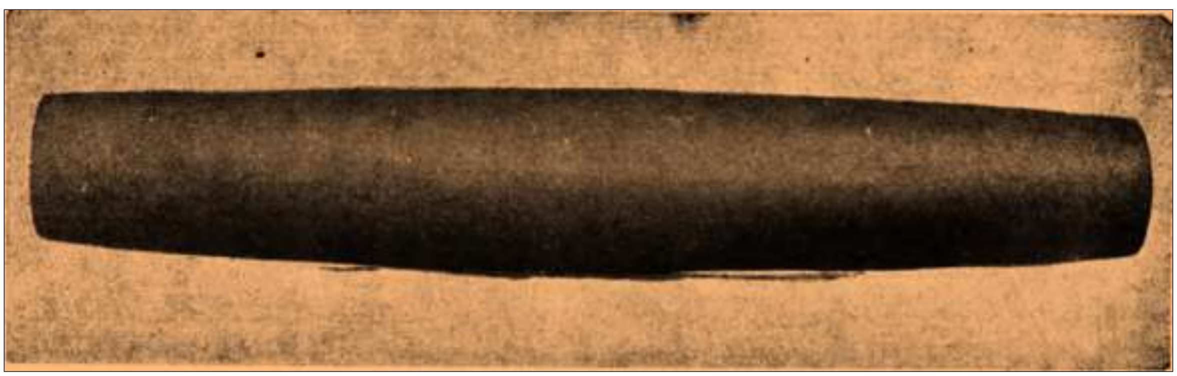
CHAPTER III.

Ancient Specimens of Indian Copper.

Copper bolt in Asoka Pillar.

3.1 We would now pass on to the consideration of ancient specimens of copper of historical importance in which India abounds. The principal use of copper of course lies in coinage and preparation of useful alloys such as brass and bronze. Archaeological specimens, however, of pure copper are abundant in India in the shape of statues, plates, caskets and utensils which fact unmistakably shows the use of copper in large quantities in ancient India.

3.2 The most remarkable of these ancient specimens of copper is a big solid copper bolt found in the Rampurwa Asoka pillar near the frontiers of the Kingdom of Nepal. Mr. H.B.W.. . Garrick has presented this remarkable copper bolt to the[1] Indian Museum, Kolkata, where it has been kept in the Archaological Section. It was evidently employed in fastening the colossal lion-shaded stone capital to the pillar itself. The bolt is barrel-shaped in appearance slightly tapering at the two ends. It is $24\frac{1}{2}''$ (61.722 cm) inches long, circumference at the centre being 14 inches (35.56 cm) and at the sides about 12 inches. (34.48 cm) " The copper is exquisitely worked into shape apparently with the hammer slight marks of which are still visible and altogether is a surprising piece of metal "work for so early an age, for I have no doubt that 'this bolt is the original one placed in the pillar simultaneously with its' erection being'



Copper bolt in Rampurwa Asoka pillar (Photograph by Panchanan Neogi).

So true in form" [1]. The metal is pure copper and not bronze. This is massive piece of copper work. and would fully subscribe to the eulogium bestowed on it by Mr. Garrick.

3.3 The bolt appears to have been shaped by the hammer though originally made by casting copper, as the shape is quite perfect and the flat ends quite smooth. The copper implements _ discovered at Gungeria also bear unmistakable signs of having been hammered and Mr. Vincent A. Smith is of opinion that they were "cast in the first instance and then finished by the hammer." Mr. Smith further writes about the Gungeria implements "Mr. Reginald Smith pointed out to me that several of the British Museum specimens exhibit ridges which apparently indicate the line of junction of two open moulds face to face. When the two moulds had thus been applied and closed the metal was probably poured in through an aperture at the narrow end. The Pachamba or Karharhari find permits of no doubt that in Bengal roughly cast 'blooms' of copper were knocked into shape as celts by hammering.

(1) Garrick, Report of Tours in North and South Bihar, 1881, Arch. Sur. Ind., Vol. XVI, p. 113 and Vincent A. Smith, Indian Antiquary, 1905, p. 239.

3.4 The more highly finished articles from Gungeria were no doubt, made in regular moulds and merely finished with the hammer". There is however one argument against the hypothesis that the Gungeria implements were made by casting which, as pointed out by Mr. Bloomfield himself, is that out of the 424 weapons "hardly two of the copper pieces are of the same size, weight or shape." This objection may be met, as Dr. Campbell has suggested, by supposing that the metal was run into moulds of the shape of, but smaller and thicker than the article which was then finished by the hammer. I think this explanation is correct. From the perfect shape of the copper bolt it would appear that it was also made by first casting copper and then finishing the product with the hammer.

3.5 As the bolt is a solid one it is very heavy. It is so. Heavy that it is moved with difficulty, by two men when it was photographed.[1] bearing in mind that this bolt was constructed as early as the third century B.C. it unmistakably testifies to the high metallurgical skill of the ancient Hindus in pre-Christian times.

Colossal copper statues of Buddha.

3.6 A remarkable copper statue of Buddha was discovered at Sultanganj in the district of Bhagalpur in the ruins of an old Bhuddhist monastery. It has been taken away and now preserved in the Birmingham Museum. The attention of students of metallurgy has not been sufficiently drawn to this remarkable copper colossus, which, according to the mode of its construction and owing to the discovery of a coin of the last Western satrap of Surastra accompanied with one of Chandragupta II in the vicinity of the monastery, has been taken to be a specimen of the metallurgical skill of the ancient Hindus of the fifth century A.D.[2]

3.7 Dr. Rajendra Lal Mitra, who first describes this Buddha statue and other articles obtained in the ruins by Mr. Harris, a Resident Engineer, East India Railway[3], says that it was 7 feet (2.1336 meter) 6 inches (15.24 cm) high and its weight is estimated to be nearly 1 ton (90.185 kilogram) . There is one very remarkable fact about it, *viz.*, that the outer garment is markedly transparent so that the body proper is visible through the outer garment. Dr. Mitra in describing the process of its construction says " the material is a very pure copper cast in two layers, the inner one in segments on an earthen mould and held together by iron bands which were originally $\frac{3}{4}$ (0.762 cm) of an inch thick, but are now very much worn down by rust. The casting of the face down to the breast was effected in one piece, the lower parts down to the knee in another and then the legs, feet, hands and back in several pieces". The outer layer of copper seems to have been cast over the inner one presumably by the *cire perdue* process. Some iconoclast had bored a hole through the breast with the object of discovering treasure inside, but this process led to the discovery of nothing beyond the mould on which the figure had been cast. The substance of this mould looks like a friable cinder. Originally it consisted of a mixture of sand, clay, charcoal and paddy husks.

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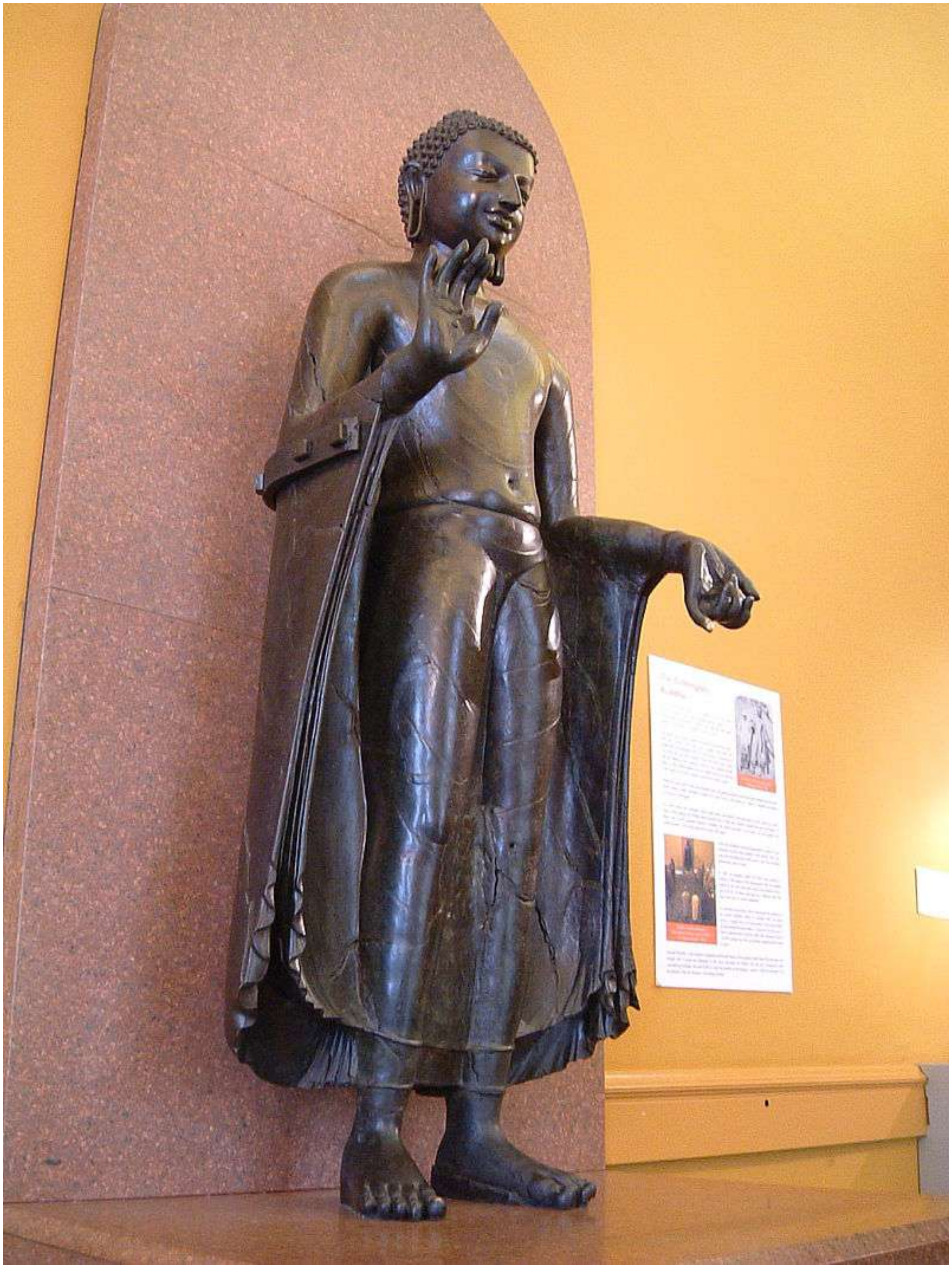
(1) A photograph of the bolt is given here perhaps for the first time by Neogi. It is a matter of some surprise that no notice has hitherto been taken of this remarkable specimen of copper work of ancient India excepting a brief notice in the Report of the Archaeological survey of India,
(2) Vincent A Smith, History of fine arts in India and v Ceylon. p. 172.
(3) Journal, Asiatic Society of Bengal, 1864, p. 360. i' his statue has been referred to by Mr. Vincent A. Smith in his History of fine arts in India and Ceylon, p, 171 and 172 ; Cunningham in Arch. Sur. Ind. Reports, Vol. X, p. 127 and XV, p. 126 ; Anderson, Catalogue of the Indian Museum, Part Hr, Mr. Smith points out that in the draft illustrated Handbook of the Birmingham Museum the Statue is wrongly described as made of bronze.



The 7th Century AD Statue, known as Sultanganj Buddha, is testimony to the skills of sculptors and metal workers of ancient India.

3.8 In the list of other articles found in the vicinity, as given' by Dr. Mitra, we find the hand of another large copper figure and three small standing Buddha figures of copper. Lumps of copper ore were also found suggesting that the smelting and casting operations were done on the spot.

3.9 Two facts are of metallurgical interest in connection with this remarkable figure. In the first place the virtual transparency of the outer copper garments reflects the greatest credit on the Hindu copper Workers of the 5th century. In the second place the date naturally reminds one of the celebrated iron pillars at Delhi which was also constructed in the 5th century. This colossal copper statue and the Delhi iron pillar jointly serve to show that by the 5th century A.D. the ancient Hindus attained remarkable skill in smelting and working different metals. Moreover it is apparent that the production of iron and copper in India at that time was quite considerable.

3.10 The same fact is borne out by another gigantic copper colossus of Buddha image, *no less titan 80 feet (34.384 meter) in height*, described by the celebrated Chinese traveller Hiuen-Tsiang who actually saw it standing upright towards the east of the great Nalanda convent[1]. Hiuen-Tsiang asserts that “a pavillion of six stages is required to cover” this gigantic copper colossus which in dimensions would approach the bronze colossus of the Rhodes Island. It was the work of Raja Purnavarman, the last descendant of King Asoka, a king of the seventh century[2]. The Rhodes colossus was destroyed by lightning, but history does not record the manner in which this less known wonder of the world has gone out of sight from India. At any rate this gigantic colossus deserves special mention in the world’s history of metallurgy of copper as a very remarkable specimen of copper work of the seventh century.

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(1) Beal’s Bhddhist Records, ii, 174; Life or Hinen-Tsiang by Shaman Hwni Li translated by Beal, p. 119.
(2) Beal, Buddhist Records ii, 118, 174; Waters, 115. Nalanda has been identified with the village of Baragaon which lies seven miles north of Rajgir in Bihar.

Copper Coins.

3.11 The principal use of copper for state purposes is certainly its use in coinage. In Kautilya's Arthashastra we find that copper was used not only in copper coinage but also as an alloy in the coins of the noble metals as well. Copper was used in coinage in India from pre-Charistian times. Some of the earliest Indian copper coins are those of the Indo-Greek and Bactrian Kings, such as Euthy demos, king of Bactria (230 B.C.) and Demetrios, king of the North-Western frontier of India (200 B.C.) The punch-marked copper coins such as those of the old Mitra Dynasty of Ajodhya and many other kings of Northern India, are also some of the earliest copper coins known in ancient India (first century B.C.). Copper coins of the Kushana kings such as Kaniksha (first century A.D.) and the Gupta kings have also been found in many places. In Central and Southern India copper coins of the Andhra and Khatrapa Dyansties are amongst the earliest. It is needless to enumerate the later copper coins as copper has ever continued to be one of three principal metals employed for coinage.

Copper Mints.

3.12 The location of mints in which copper used to be coined would be of interest. The Ayeen Akbari says that gold coins were struck "first in the capital Agra, second Bengal, third Ahmadabad in Gujarat, fourth Kabul. Silver and copper besides being coined at the four above-mentioned places are also struck in ten other cities viz. Allahabad, Agra, Owjani, Surat, Dakha, Patna, Kashmir, Lahore, Multan and Tandah. and in the following 28 places only copper viz., Ajmer, Owedh, Attock, Allore, Badawar, Banaras, Behkar Behret, Pulten, Jowhpoor, Jalundhar, Seharungpoor, Sarungpur, Serrocne, Kannaja, Rehutone, Hariduwar, Hissar, Feerozeh, Kalpee, Gwaliar, Gorkhkpur, Kelower, Lucknow, Mundow, Nagore, Sirhind, Secalhoote and Serownj[1]". In Akbar 's time the price of 1 maund (37.324 kilogram) 2of copper was 1044 *dams* or *pysahs* (in value the fortieth part of a rupee) or abour 24 rupees, and out of one maund of copper 1seer (0.933105 kilogram) was burnt out during minting and 1170 *daws* were coined[2]. Dr. C.P. Taylor[3] has compiled an interesting table of Indian mints during the rule of the Moghul Emperors "commencing with the accession of Babar in 1525 A.D. and closing-with the deposition of Bahadur (Shah) in the fateful year of the Mutiny," from which the list of places in which copper coins used to be minted has been compiled[4]-. It is to be noted that mints for coining copper coins Existed in every considerable town throughout India during the Moghul period.

Method of copper coinage.

3.13 Regarding the early methods of coinage adopted in India, the punch-marked coins were evidently small flat ingots marked irregularly by small punches of various patterns applied at different times. Others were struck with a die. Princep writes "the great analogy which is observed between the earliest Indian coins and those of the Macedonian colonists is a very strong argument in favour of the supposition that die-cutting was introduced in India at that period[5]". In later centuries copper coins were evidently prepared by first casting molten copper in suitable moulds in order to make them uniform in shape and then struck between dies. Mr. Henry Cousens while

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(1) Gladwin's Ayeen Akbari, Vol 11, p. 32.
(2) Ibid, p. 40.
(3) G.P. Taylor, "the mints of the Moghul Emperors of India" (Journ. Bomb. Roy. As. Soc., 1905, pp 411-436).
(4) The names of places marked with an (*) are those in which silver coins were coined along with copper ones and with an (†)are those in which both gold and silver coins were coined in addition to copper.
(5) Princep's Essays on Indian Antiquities, edited by Thomas, Vol. 1, p. 55;

Copper Coins found in India

Admadnagar†	Burhanpur	Indrapur	Manghir
Adogam	Champanir	Islamabad†	Manikpur
Agra†	Chhachrauli	Ismailgarh	Mirath
Ahmadabad†	Chitor*	Jahangirnagar†	Multan†
Ajmir†	Chitrakut	Jaipur†	Muninabad*
Akbarabad†	Chunar*	Jalalnagar	Muzaffarnagar
Akbargarar†	Dadar "	Jaunpur†	Nahan
Akbarpur*	Damta	Jhansi	Narnol*
Alwar*	Delhi†	Jodhpur*	Patna† '
Amirkot	Dhar	Kabult	Peshwar†
Atak Banaras*	Elichpur*	Kachrauli	Oanauj
Aurangabed	Farrukhabad	Kalpi	Oandahar
Awad*	Farrukhnagar	Kanan	Saharanpur
Azimabad†	Fathpur†	Kashmir	Sambal
Bahraich	Ferozpur	Katak*	Sarhindt
Bairat*	Gobindapur	Khairpur	Shajanabad
Banaras	Gorakpur	Kharpur	Sherpur
Bandarshahi	Gulburga'	Kiratpur	Sholapur†
Baroda*	Gwalior†	Lahor†	Sirouj*
Bhakkar*	Hafizabad*	Laknau	Surat†
Bharatpur*	Haidarabad†	Machlipattam†	Tatt†
Bijapur†	Hasanabad	Madankot	Udaipur*
Buidraban	Hisar*	Malpur	Ujjain
Bunch	Illahabad†	Mandu	Urdu Zafarquarin†
Burhanabad†	Illahabas	Mangarh	VYalijaead.

3.15 Exploring the ruins of the old town of Mansura, the first Arab capital in Sindh when it was conquered by the Mahomedans in the ninth century found a number of copper coins which were evidently struck at Mansura itself together with heaps of honey-combed baked clay slabs. Mr. Cousens writes “these clay slabs or cakes are about half (1.27cm) to three-fourths of an inch (1.905 cm) thick upon one side of which are impressed rows of little cup-like hollows, forming a regular honey-comb pattern, while the lower sides have been subjected to great heat and are vetrified. The honey-combing is found in three sizes, the hollows in the largest being about seven-sixteenths of an inch (1.11125 cm) in diameter. These puzzled when this found for first at Bhambor, a ruined site near one of the mouths of the Indus upon a small heap at one corner-, but upon finding – near them both at that place and Brahman bad (afterwards Mansura,) not only copper coins but little pellets of copper which fitted' them, the real use of these clearly marked tablets became apparent. There are many fragments with small lumps of verdigris (sub-acetate of copper) admiring to the edges of the little cells. They were no doubt connected with the coining apparatus of the Arabs. I take it that these slabs of clay were first heated upon a furnace to prevent the sudden chilling of the copper poured into them, and when filled and all surplus copper run off, each hollow contained a pellet of uniform size and weight. These were then placed between the dies and struck by a heavy hammer"[1].

Copper Plates.

3.16 Another use of copper in ancient India was in the preparation of copper plates usually for the purpose of making land grants by kings to Brahmins and others. These copper plates, as is well-known, together with ancient coins, are the most authentic sources of the allbut-forgotten history of ancient Hindu India. The Koshmba and Tirodi plate of Balaghat made of pure copper, some of them weighing several pounds (Kilogram). One of the earliest copper plates is the Sohgaura plate discovered in the village of Sohgaura, district Gorakhpur in the Uttar Pradesh, the inscription being in Maurya Brahmi characters of 320-230 B.C. The metal of the plate,' however seems to be an alloy of copper. The Sue Vihar inscription of Kanishka (first century A.D.) and the Taxila plates are also amongst the earliest of copper plates discovered in Northern India[2]. Sometimes the inscriptions are engraved on several plates or sheetst of copper and Mr. Vincent A. Smith writes "the length of individual inscriptions is illustrated by the fact that an important record recently brought to light (in Southern India) is engraved on *thirtyone sheets of copper* fastened together on a massive ring[3] ". These copper plates appear to have been in general use amongst kings up to the thirteenth century in Northern India-, but several copper plates dated so late as the eighteenth and nineteenth centuries appear in the collection of the Asiatic Society of Bengal.

Copper Utensils.

3.17 It has already been pointed out that such an ancient medical authority as Shusruta mentions the use of copper utensils.

3.18 Manu also mentions tie use and purification of copper vessels. Megasthenes mentions that "vessels of Indian cooper set with precious stones contributed to the brilliancy of the public ceress during Chandra Gupta's reign." Copper vessels from ancient times have been held by the Hindus to be sacred and almost all utensils meant for use in religious ceremonies such as *Jajvcs* and *pnjdhs* are invariably made of copper even at the present day. Even archaeological specimens of ancient copper utensils are available. One remarkable ancient copper ghoti or lota, was found by Major Hay in 1857 in the village of Kundla in the Kangra district, Punjab. It has been described by Sir George Bird wood in -his Industrial Arts of India and referred to by Mr. Vincent A. Smith in his History of Fine Arts in India and Ceylon. The vessel looks like a modern *lota,* but there is an inscribed scene running round it which represents Prince Siddhartha (afterwards Buddha) going in a royal procession in a chariot drawn by four horses accompanied by horses, elephants and musicians. From the mode of the inscription of this legend Bird wood regards the vessel to be a specimen of copper-work of the 3rd century A.D., but Mr. Vincent A. Smith regards it to be a specimen of the first century B.C. At any rate this copper *lota* is an authentic ancient specimen of Hindu art in copper utensil making.

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(1) Henry Couseus, Arch. Surv. Ind., Annual Report, 1903-4, p. 137.
(2) A catalogue of copper plates in the Asiatic Soeietv of Bengal has been published by Mr. R. D. Banerjee, Journ. As. Soc. Beng., 1910, 485,
(3) Early History of India, p. 405.

Copper Caskets

3.19 Copper was also used in ancient India in the shape of caskets for the preservation of relics inside the foundations of stupas and monasteries. One of the earliest copper caskets is the newly discovered casket of king Kanishka near Peshwar. The metal, however, is not pure copper but an alloy of the same metal several such ancient copper caskets has been discovered.

3.20 From the foregoing account of the ancient specimens of copper articles found in different parts of India it is evident that copper was used in ancient India at least from 1000 B.C. in a variety of ways. The discovery of the Gungeria find of copper weapons weighing as much as one third of a ton bespeaks of considerable production of copper in India in pre-Christian times. The discovery of the big copper bolt in the Rampurwa Asoka pillar of the 3rd century B.C. Lends confirmation to the same story. As time went on, the production of copper in India seems to have been on the increase, as the colossal copper image of Buddha cast in the 5th century discovered in Sultanganj or still more the gigantic, copper statue of the same deity at Nalanda no less than 80 feet high described by Hiuen-Tsiang fully testifies. Copper has ever been from the 2^{nd} or 3rd century B.C. one of the three metals used for coinage. It found an added application in the preparation of copper plates from per-christian times for inscribing deeds of land grants by kings. Utensils made of copper, owing to the peculiar sanctity attached to it by the Hindus, have been used in India from remote times specially in the performance of religious ceremonies. As wires, copper and brass have from early times been used in the construction of stringed musical instruments for which India has always been famous.

3.21 Geological evidences also point out to the native production of copper in ancient India. These will be dealt with latter on, but it will be sufficient to note here that evidences of copper smelting and copper slag as well as sites of mines have been discovered in many places throughout India showing that a prosperous copper industry existed in India from pre-christian times down to the Moghul period

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CHAPTER IV.

Alloys of Copper— (i) Bronze.

4.1 The principal use of copper, besides in coinage, lies, as is well known, in making alloys. We would now proceed to give here a short account of the various alloys of copper used in ancient India, the most important being *rih* or pittala (brass) and *Kamsya* (bronze) That *Kamsya* meant bell-metal, also used in making gongs and other articles, is evident from a passage in Amarkosha's lexicon (6th century) A. D. in which *Kamsya-fala* is mentioned as one of the many musical instruments prevalent in ancient India[1]. Bell-metal contains a greater .percentage of tin than bronze.

Kautilya's Arthashastra mentions an alloy called *" triputaka"* made of 2 parts of silver and 1 part of copper.

4.2 The proportion in which copper and tin were melted together to form *Kamsya* is given in the Rasaratna-samuchchaya (13th century) in which we find that eight parts of copper and two parts of tin were used in making the alloy and that bronze made in Surat was excellent[2].The original Sanskrit equivalent for brass was *riti* the word *pittala* being subsequently adopted for it. Brass was prepared in India at first by heating copper with calamine and carbonaceous substances. It was, however, prepared by heating copper and zinc in the 13th century.

Alchemical works make mention of an alloy of five metals called *vartalauha* produced from *Kamsya,* copper, brass, iron and lead.

4.3 A number of alloys of copper were used in India during the Moghul period of her history. We find mention of several alloys of copper in the Ayeen Akbari. Kamsya or " sefaidru" was a composition of four seers (3.73242 kilogram) of copper and one seer (.933105 kilogram) of tin melted together, the proportion of copper and tin being the same as in Rasaratna-Samuchchya. *Rowee* was an alloy of copper and lead being made of four seers (3.73242 kilogram) of copper and one and a half (04665325 kilogram) self; of lead. Brass, *herinj* or *peetal* was made of two seers (1.86621 kilogram) of copper and one and a half seers of ruh-i-tutia. *Seem Suckhteh* was an alloy of silver, lead and copper, being of deep colour and very bright and was used in silvering. " His Perfect Majesty" Emperor Akbar was the inventor of another alloy of copper viz. " *cow elputter*" compounded of two seers (1.86621 kilogram) of bronze and one seer of copper, being a " very elegant and beautiful composition[3]".

4.4 We would now proceed to give a more detailed description of the history and methods pf preparation of the two most important alloys of copper viz. bronze and brass.

Bronze.

4.5 Bronze does not appear to have been known during the Vedic age, as it is not mentioned in any of the Vedas. It is, however, certain that it was an article of common use in the 3rd century B. C. It is mentioned in both the medical treatises of Charaka and Shusruta as well as in Kautilya's Arthashastra. Shusruta gives directions for drinking water in bronze vessels (besides those made of gold, silver, crystal or earth). The lawgiver Manu gives directions for the purification, amongst others, of brass and bronze vessels.

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(1) वंश्यादिकन्तु शुषिरं कांस्यतालादिकं घनम्—Amarkosha, Swargabarga, 179.
(2) अष्टभागेन ताम्रेण द्विभागकुटिलेन च।
विद्रुतेन भवेत् कांस्यं तत् सौराष्ट्रभवं शुभम्। Rasaratna—Samuchchaya,
(3), Gladwin's Ayeen Akbari, Vol. 1, p. 40.

4.6 Then again from the large quantities of ornamental bronze articles excavated at Tinnevelly in the Madras Presidency it appears certain that bronze was known in Southern India at a very remote time. It is to be noted, however, that these bronze articles were either used as household utensils or for ornamental purposes and along with them were associated weapon made of iron.

4.7 Bronze continues to be designated as *Kamsya* in Amarkosha's lexicon, though the latter stands for bell-metal also. .Both brass and bronze came to be regarded as alloys by the thirteenth century find that the author of *Rasaratna-Samuchchaya* while classifying metalswrites that "brass, bronze and *Vartalauha* are three alloys."

The Bronze Age.

4.8 In Europe and especially in Eastern Europe a bronze age. Intervened between the Stone Age and the Iron age, but so far as India is concerned, available evidence is absolutely insufficient to establish an Indian bronze age. Mr. Vincent A. Smith in his article entitled "the copper age and bronze implements in India" and in the supplementary essay[1] already referred to has collected a list of the very small number of bronze implements hitherto discovered in India. Only six authentic Indian bronze implements are known, whilst the number of copper implements discovered in India is nearly 500 as has been stated before. These six specimens comprise one flat celt, one so-called sword, one spear-head and three harpoon heads. These are undoubtedly made of bronze and the results of analysis are given below:—

	Copper	Tin
1. A flat celt discovered at Jabalpur in 1869, unfortun ately soon lost but analysed.	86.7	13.3 percent.
2. One bronze sword or rather spear head, length 28$\frac{3}{4}$″", purchased by Sir Walter Elliot from persons in India. Locality not known.	95.68	3-83,,
3. One spear-head presented in 1837 to the British Museum, supposed to come from Etawah.	Looks like bronze but has not been analysed.	
4. A fine harpoon-head presented by Sir Alexander Cunningham to the National Museum, Dublin,Said to have been found somewhere India.	Ditto.	
5. A harpoon found by a Berwick man while fishing in the Tweed near Norham castle and evidently of Indian origin although it is difficult to explain how it Found its way to England. Probably it was brought home in modern times by some sailor.	91.12	7.97
6. Another harpoon-head closely resembling the specimen No 5 found along with the sword or spear head mentioned above (No. 2).	93.18	6.74 per cent.

(1) Vincent A. Smith, Indian Antiquary, 1905, p, 240, and 1907, p. 53.

4.9 The percentage of tin in the sword is only 3.83 and might be due to accidental admixture but the celt from Jabalpur contains 13.3 percent of tin and is undoubtedly a true bronze, whilst in the case of the other two specimen's analysis shows a fair percentage of tin. The percentage of tin in ancient European bronzes ranges from 5 to more than 18 percent[1]. The number of bronze implements found in those parts of Europe in which a bronze age undoubtedly existed is very large, but it may reasonably be contended that one or two bronze weapons of doubtful origin are not sufficient to prove the existence of an Indian bronze age.

4.10 In the supplementary paper referred to above Mr. Vincent A. Smith quotes Dr. Furer who states that "numbers of ancient metal arrow-points are found in the soil around Bithur said to be relics of the time of Ramchandra[2]. Presumably all these Bithur specimens are made of copper and not bronze, but no analysis of these specimens has been made. A similar collection of "metal arrow-heads" has been made in the great *jhil* or swamp in the village of Parior (Oudh), but they also seem to be made of copper and not bronze, though no analysis has been made of the specimens. It seems undoubted that the available specimens are not enough to establish an Indian bronze age. The reason why India missed. Appears to be that as the use of iron was known from Vedic times the use of bronze as implements was not necessary. I agree in holding that the prevailing idea of the eastern origin of the Bronze Age must be dropped and as a matter of fact eastern countries like China did not also pass through a bronze age. It would interest readers to learn incidentally -the extent of area in Europe in which the Bronze Age really prevailed. Canon Greenwell, the veteran archaeologist writes "Indeed it cannot be said that there was ever any real development of a bronze cultivation, except in Western Europe. Assyria and Egypt certainly did not possess one; nor can Greece, the Islands of Asia minor be said to have brought it to any high pitch, though there are splendid specimens such as the Mykenac blades. Still there is nothing like the fine swords, spearheads were. so abundant in the United Kingdom. Denmark, France Switzerland and Italy. Hungary did not develop it certainly, but further east and south it never reached to any height nor have many bronze weapons have. been found in these countries. Spain, too, is very poorly represented, which as it had much traffic with the Eastern Mediterranean, seems to point to the bronze culture not having come through that channel[3]."

Ancient specimens of Indian bronze.

4.11 As regards ancient archaeological specimens of bronze, India has nothing to boast of in comparison with the colossal bronze statue of Apollo in the Roman Palatine Library or the still more famous bronze Colossus of Rhodes, one of the Seven Wonders of the World, though in iron India was unique[4].

4.12 But the use of bronze for the purpose of ornamentation was not unknown, as can be gathered from the remarkable discovery of ancient bronze articles at Tinnevelly in the Madras Presidency whilst excavating the ancient pre-historic burial sites in which it abounds[5].

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(1) Evaus, Brouze Implements, p. 419.
(2) Monum. Antiquary, N, W. P. and Oudh, p. 168.
(3) Quoted by Vincent A. Smith, Indian antiquary, 1907. p. 54.
(4) The sculptor of the Rhodes colossus which was a bronze statue of the sungod Helios was Chares, a native of Lindus. The work occupied him for twelve years and the statue was a gigantic one being 70 cubits high Having stood near the harbour for 56 years it was thrown down by an earthquake about the year 224 B. C. The enormous fragments were sold in 656 A. 1). By the Saracens, who conquer the country, as old metai to a Jew who had to employ as many as 900 camels to carry them away
(5) Annual Report, Archaeological survey of India, 1902-3 these articles and iron weapons have been referred to in the "Iron in ancient India/'

Bronze articles were found along with iron swords, daggers and weapons and are of superior workmanship and do not include any bronze weapons. The bronze articles included ornamental vase stands, bowls, jars and cups of different patterns with ornamental bowl lids. Bronze bangles, necklaces, ear ornaments and diadems were also found. Two circular tubes of similar shape resembling scent bottles and a number of sieve cups and perforated strainers for straining rice were also found. These utensils and ornaments show how bronze, on account of its colour, was regarded as a highly prized article in ancient India.

4.13 In India besides being used as art ware, bronze was also used in casting statues of various gods and goddesses. The Eastern school of bronze-casters of Bengal in the eight or ninth century was famous and it was from this school that Nepal and Tibet obtained their knowledge of bronze casting. Lama Taranath, the celebrated Tibetan historian of Buddhism, is of opinion that "the Naga productions of Nagarjuna' time were rivalled by the creations of Dhiman and his son Bitapala, natives of Varendra (Bengal) who lived during., the reigns of Devapala and Dharmapala (8th and 9th centuries). Both father and son were skilled alike as painters, sculptors and bronze founders. Bitpala, who remained in Bengal, was regarded as the head of the Eastern school of bronze-casting.[1] several excellent specimens of this Eastern school of bronze-casters in the shape of statues have been collected in the Archaeological Section of the Indian Museum.

Manufacture of Bronze.

4.14 As regards the method of manufacture of bronze, its two constituents copper and tin were known in India from very remote times. Though neither is mentioned in the earliest of the Vedas, both are mentioned in the White Yajurveda and the Brahma as. came to be used by the third century B.C., it appears that the two metals, which were known from a much earlier period, were at that time molten together to form the alloy. Recipes as to the proportion of the two metals used are, however, not found in the earlier works. As has already been noted, we find that the author ' the *Rasaratna-samuchchaya* of the 13th century mentions that bronze was made by melting together eight parts of copper and two parts of tin. The same proportion was observed in the manufacture of bronze in Emperor Abkar's time as may be learnt from the Ayeen Akbari[1].

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(1) Vincent A. Smith, History of Fine Art in India and Ceylon,

(2). A Greek manuscript of about the 1 1th century in the library of St. Marks, Venice, also gives the composition of bronze as made from 1 lb (16oz) of copper and 2oz. of tin, the proportion being the same as used in ancient India.

CHAPTER V.

Copper in Ancient India.

Alloys of Copper— (2) Brass.

5.1 The next important alloy of copper is brass. The time when brass was first used in India has still been an open question, but if we would have recourse to archaeological evidences such a date can be fixed with a certain amount of precision. Brass articles of the 1st century B.C. or A.D. have been found on excavation of ancient stupas. General Ventura executed operations for the examination of the stupas at Manikyalaya in 1830. Three deposits were obtained of which the third, at a depth of 64 ft.,(19.5072 cm) consisted of a copper box enclosing a brass cylindrical box cast and beautifully turned on the lathe. The lid of the brass casket was found on cleansing to be inscribed. From the inscriptions on the various articles of this deposit and the accompanying Indo-Scythian coins the great tope at Manikyalaya has been indentified to be a mausoleum of the Indo-Scythian King Kaniskha (1st century B.C. or A.D.)[1]. Another inscribed brass urn of the same date as the former has been discovered in a tope about 30 miles (48.28 kilometer) west, of Kabul in the district of Wardak. This urn which in shape and size approaches closely the ordinary water-vessels in use in India to this day, was orginally thickly gilt and its surface has in consequence remained well-preserved.[2] As regards coins, both brass and bronze were used in ancient India for coinage. Circular punch-marked brass coins of Dhana-deva and Arya-Varma of Ajodhya (circaist century B.C.) have been found. Brass coins of kings of several other dynasties living at that time have also been collected.[3] From these archaeological and numismatic evidences it is clear that brass was in common use in ancient India as early as the first century B.C. It was known in India probably a few centuries earlier as it is mentioned in the famous Aurvedic treatise Charak-Samhita (circa thirntury B.C.) along with gold, silver, copper and tin.[4] The same medical treatise makes mantion of brass in another place along with gold, silver, tin and bronze [5]. The word in both the places is " riti " probably derived from " harita " or yellow, though the word " harita " was used in vedic literature as a synonym for gold which is also yellow. The same word in found in Manu's Institute[6] in which the lawgiver gives directions for the pruification of utensils made of copper, iron, bronze, brass, tin and lead vessels with ashes, acid water and water. It therefore appears that brass was known in ancient India as early as the third century B.C. and was certainly in general use in the first century before Christ.

5.2 Turning to later times we may compile something like a history of the alloy from literary as well as archaeological evidences. The alloy continued to be designated as "riti." In Amarkosha's Lexicon and in Varahamihir's famous astronomical compendium *Brihut-savihita*, both works of the sixth century, it is designated by the same word. The modern name "pit ta la" (पित्तल) seems to have originated at a later date, for example we come across the latter wrord in the Rasaratna- Samuchchaya, an alchemical work of the thirteenth century, in which brass is designated as "pittala and divided into two classes "ritica"and " kakatundi."[7]

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1. Wilson. Asiatic Researches, Vol. X VII, p. 601; Cunningham, Jouin. As. Soc. Beng., 1854.
2. Prinsep's "Indian antiquities/' edited by Thomas, Vol. 1, p. 162.
3. See Vincent A. Smith's "Catalogue of coins in Indian Museum."

4 सुवर्णरजतताम्राणि त्रपुरीतिमयानि च—Charak-Samhitā, Sutrasthān, V. 26.

(5) सुवर्णरूप्यत्रपुताम्ररीतिकांस्यलोहजभवेषु दन्तैः:—Charak-Samhitā, Siddhi-sthān, III. 4.

(6) ताम्रायःकांस्यरैत्यानां त्रपुणः सीसकस्य च ।
शौचं यथार्हं कर्त्तव्यं क्षाराम्लोदकवारिभिः । Manu, V. 114.

(7) रीतिका काकतुण्डी च द्विविधं पित्तलं भवेत्—Rasaratna-samuchchaya, V 192.

The gigantic brass bell at the Siwe Dagon Paya in Myanmar.

Ancient specimen of Indian Brass.

5.3 As regards ancient specimens of brass of known date, mention has already been made of the brass casket and urn discovered in stupas of the 1st century. Brass along with bronze was very largely used in making statues of gods and goddesses in the middle Ages. An inscribed brass statue of Buddha 30 cm high and 13.5 cm. wide of the sixth century has been discovered in a dharamsala at Fatehpur a village 20 miles (32.1369 kilometer) due west of Kangra-kot.[1] Another inscribed brass statue of a large size of about 11th century discovered in Bengal has been preserved Lin the Dacca museum. But the most remarkable and gigantic work of brass has been described by the Chinese traveler

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1. Annual Report, Arch. Surv. India, 1904-5, p. 107.

The famous Minguin bell in Myanmar.

Hiyuen-Tsang who saw near the famous Nalanda convent "a Vihara of brass built by Siladitya-raja. Although it is not yet finished yet its intended measurement when finished (to plan) will be 100 feet"[1] (30.48 meter) Though the statement of the Chinese traveller is not explicit as to whether it was 100 feet high or wide, this entire vihara or monastery made of brass by Raja Siladitya (also known as King Harshavardhan who ruled from 606-647 A.D.)'[2] of the seventh century, when completed, would undoubtedly have been a magnificient example of the skill of the ancient Indians in brass-work.

5.4 It is needless to make any detailed mention of the smaller images of Hindu and Buddhist gods and goddesses made of brass from the middle ages down to our own times, as they may be counted in their thousands in Indian temples and Hindu household throughout this land and in Tibet. As a matter of fact brass has been very largely used, as has already been pointed out, in making images of idols for worship in medaeval and modern India.

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1. Beal's Buddhist Records, Vol. IT. p. 174; Beal's Life of Hiuen-Tsang. 119.
2. Vincent A. Smith, Early History of India, pp. 325, 336, 338.

5.5 But Myanmar has pre-eminently been the land of brass. From the middle ages and specially from the eighteenth century Myanmar has been famous for gigantic brass statues of' Buddha and brass bells which adorn Burmese temples. Though brass and bronze bells are indispensible ornaments of Indian temples, yet in size and dimensions they are insignificant in comparison with Burmese bells. The gigantic brass bell at Siwe dagon Faya constructed by the Emperor Simby Shin in 1775 weighs 41 tons (37194 kilogram) . The celebrated Minguin bell in Upper Myanmar, the second biggest bell in actual use in the world, cast by the Emperor Bodow Paya in 1790, is 16 ft. (4.8768 meter) in diameter and weighs 88 tons. (79832.3 kilogram) An idea of its height may be obtained from the fact that it is difficult for three men standing on each other's shoulders to reach the top of the bell from its bottom.[1]

Brass and bronze guns and cannon of the Moghuls.

5.6 In the "Iron in ancient India" (p. 43) an account has been given of the wrought iron guns and cannon used since the Moghul period of Indian history. The Moghul guns and cannon were also- made by casting brass and bronze. Babar, the first Moghul Emperor and the first to introduce guns into. India, mentions in his well-known memoirs the casting of a copper gun under the direction of Ustad Kuli Khan. Babar writes "Around the mould they had erected eight furnaces for melting the metal (copper). From the foot of each started a channel which ended in the mould. As soon as I arrived, the holes to allow the flow of metal were opened. The fused metal rushed into the mould like boiling water. After a time, before the mould was full, the fused metal from the furnaces began to flow very slowly, either because their size or the amount of material had been wrongly calculated. Ustad Kuli Khan, in a state that cannot be described, wished to fling himself into the very midst of the melted copper. I made much of him, ordered him a robe of honour and then succeeded in calming him. A day or two afterwards when the mould had cooled down, it was opened. Ustad Kuli Khan, overwhelmed with joy, sent me word that the bore of the piece had no fault and that a chamber could easily be made in it. The body of the cannon was then uncovered and a certain number of artificers were set to finish it, while he busied himself with the preparation of the chamber."

5.7 With the advance in the knowledge of the technique of srunmanu facture, the size of the guns increased enormously and the materials used were chiefly wrought iron and brass or bronze. The iron guns which were often as long as 30 ft. (9.144 meter) were chiefly made by welding together a large number of wrought iron rings 'placed side bv side. The wejding was done in many cases so perfectly as in the case of the Murshidabad gun manufactured at Dacca during Emperor Jehangir's time that the weld lines were completely invisible. As regards brass guns we know from Bernier's account of his travels that early in Aurungeb's reign there were in the field with the emperor seventy pieces of heavy artillery mostly of brass. Many of these were so gigantic and heavy that 20 yoke of oxen were often required for drawing them.

5.8 Amongst the notable brass guns of the Moghuls may be mentioned the great gun of Agra" which was an enormous howitzer about 14 ft. (4.2672 meter) long and $22\frac{1}{2}$ inch (57.15 cm) in the bore into which men could easily enter crouching It was lying near the bank of the Jamuna outside the fort. Its weight was 1049 cwts or 1469 Mds and its value, as old brass, has been calculated to be about Rs. 53400 but if serviceable, one lacand sixty thousand rupees[2].

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1. The largest bell in actual use in the world is the Moscow bell in Russia, which weighs 128 tons. Another bell at Moscow named " Tsar Kolokog" is bigger than this, but as it cracked in the furnace it seems never to have been hung or rung. It weighs about 180 tons.
2. Irvine's "The army of the Indian Moghuls."

The famous bronze cannon "Maliki-i-Maidan" at Bijapur.

5.9 Many of the Moghul guns and cannon were captured later on by the English. At Agra, for instance, Lord Lake captured a fine *72* pounder of brass as well as 76 brass and 86 iron guns of different kinds, mortars, howitzers and gallopers. At Delhi Lord Lake captured 68 guns, mortars and howitzers, many being made of brass which was cast in India.

5.10 But the most important Moghul gun made of an alloy of copper is the famous "Malik-i-maidan " or " Monarch of the plain " which has justly been characterised by Meadows Taylor and Furgusson as " the largest piece of ordnance in the world." A piece of the metal of which - the gun is composed has been analysed and has been found to be bronze having the following percentage composition.

Copper	…….	**80.427**
Tin	…….	**19.573**
		100.000

Though its length is 1 4'-3" and therefore only half of the length of many of the iron guns of the Moghuls, its diameter is enormous and is as much as 4'-10" at its mouth. Its full dimensions are given below: — j

Length	…	$14' - 3''$
Diameter at mouth	…	$4' - 10''$
Diameter at nozzle	…	$4' - 5''$
Diameter at bore	…	$2' - 4\frac{1}{2}''$

5.11 It is now resting on the walls of Bijapur and resembles an enormous howitzer into whose belly a man standing almost erect can easily walk. The surface of the gun had been chased after casting and the muzzle worked into the shape of the head of a dragon having open jaws with small elephants between. It was cast at Ahmednagar in 1548 during the reign of Sultan Burham Nizam Shah and the place where it was cast can still be seen. The casting of such an enormous bronze howitzer as much as five feet (1.524 meter) in diameter reflects the greatest credit on the workers who manipulated the enormous amount of the alloy in casting it. It is needless to make any detailed mention of the smaller brass guns many of which are still to be found in different parts of India. Some of these called Isa Khan's guns cast in the 16th century have been discovered in Bengal. One piece of the metal of one of these guns has been analysed which gives the composition of brass as used in India in the 16th century. The result of analysis is as follows[1] :—

$$\begin{array}{ll} \textbf{Copper} & -\mathbf{87.72} \\ \textbf{Zinc (and iron)} & -\mathbf{13.82} \\ \textbf{Tin} & \underline{-\mathbf{1.83}} \\ & \mathbf{99.874} \end{array}$$

Chemistry of Brass.

5.12 We would now proceed to consider the chemical composition of brass and the method of its preparation in ancient India. The European history of the chemistry of brass is sufficiently well known. Aristotle (4th century B.C.) described the preparation of a kind of copper which was obtained by heating copper with a kind of earthbound on the shores of the Black Sea. Pliny (1st century B.C.) describes the preparation of *aurichalcnm* by heating copper with cadmia' or calamine (zinc carbonate). Brass continued to have been manufactured in Europe up to the end of the eighteenth century by heating copper with calamine and charcoal or coal, though "in England there is good evidence of the manufacture of brass with zinc at the end of the 16th century for Queen Elizabeth by patent granted to William Humphrey and" 'Christopher Schutz the exclusive right of working calamine and making brass." As regards its chemical composition, it was Kunkel in Europe, who at the end of the 17^{th} century recognized it to be an alloy.

5.13 So far as India is concerned, it would appear that the knowledge of the chemical composition of brass as an alloy and of its preparation from metallic zinc as distinguished from calamine was more advanced in India than in contemporary Europe, because metallic zinc was prepared in India several centuries earlier than in Europe.

Earlier discovery of zinc in India than in Europe.

5.14 Zinc appears to have been prepared in India, as has been stated above, at a much earlier period than in Europe. In Europe "the word zinc is first found in the writings of Paracelsus (16th century) who has pointed out that zinc was a metal." According to W. Hommel, however, "the name zinc is erroneously attributed to Basil Valentine and the discovery of the metal to Paracelsus, for the identification of zinc as the metal from blende was only accomplished by Homberg in 1695." [2]

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1. H. E. Stapleton, Journ. As. Soc. Bengal, 1909, 369.
2. Roscoe and Shcorlemmer, Treatise on chemistry, Vol. II, pp. 6 4 3—644.6

5.15 It would even appear that the acquaintance of European alchemists with zinc began when it was being imported from India or at any rate from the East Indies by Dutch merchants in the 17th century, as Libavius "who was the first to investigate the properties of zinc more exactly, although he was not aware that the metal was derived from the ore known as calamine" stated "that a peculiar kind of tin is found in the East Indies called caloem. Some of this was brought to Holland and came into his hands."[1]

5.16 In India, zinc appears' to have been extracted from calamine (Sanskrit " *rasaka.* " or *" kharpara")* by heating it in a covered crucible with substances rich in carbon at least as early**y* as the 7th century. We find the description of a process of the extraction of "essence of calamine*"* in the alchemical work of the 7th* century named Rasaratnakar, ascribed to Nagarjuna which gives the following recipe—calamine is macerated, amongst other things, with carbonated alkali lac, soot and borax and then heated in a covered crucible in a furance when an essence of the colour of tin is obtained.[1]

5.17 In this process carbonated alkali and the carbon obtained by the destructive distillation of such carbonaceous substances as lac . supply the reducing agents in the extraction of zinc from calamine. In later alchemical treatises the covered crucible is provided with a tubulure so that the completion of the reaction may be ascertained when the blue flame at the mouth of the tubulure suddeniy changes to white owing to the volatilisation of zinc. The description of the distillation of zinc in tubulated covered retorts or crucibles in *Rasaratna-Samuchchaya*,, *Rasaprakash sudhakar* and other alchemical treatises of the 12th and 13th centuries are "so exact that it will bear repitition in any text-book of metallurgy." We give below the description of the process as given in Rasaratna-samuchchaya[2]:— Rub calamine with turmeric, the chebulic myrobalans, resin, the salts, soot, borax and one fourth its weight of semicarpus anacardium and the acid juices. Smear the inside of a tubulated crucible with the above mixtuie and dry it in the sun and close its mouth with another inverted over it and apply heat. *When the flame issuiug Jiom the molten calamine changes /row blue to ivhite,* the crucible is caught hold of by means of a pair of tongs and its mouth held downwards and it is thrown on the ground, care being taken not to break its tubulure. The essence possessing the luster of tin which is dropped is collected for use." The chemical reaction that takes place in the above process is easily understood and is the same as takes place in the modern process of the extraction of zinc

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1. क्षाराम्लैश्च भान्त्राम्लैः रसकं भावितं बहु ।
ऊर्णालाक्षा तथा पथ्या भूलताधूमसंयुतम् ॥
मूकमूषागतं ध्मातं टङ्कणेन समन्वितम् ।
सत्त्वं कुटिलसङ्काशं पतते नात्र संशयः ॥

Rasaratnākar.

2. हरिद्रात्रिफलारालसिन्धुधूमैः सटङ्कणैः ॥
सारुष्करैश्च पादांशैः साम्लैः संमर्द्य खर्परं ।
लिप्तं वृन्ताकमूषां शोषयित्वा निरुध्य च ॥
मूषां मूषोपरि न्यस्य खर्परं प्रधमेत् ततः ।
खर्परे प्रहृते ज्वाला भवेन्नीला सिता यदि ॥
तदा सन्दंशतो मूषां धृत्वा कृत्वा त्वधोमुखीम् ।
शनैरास्फालयेद् भूमौ यथा नालं न भज्यते ॥
वङ्गाभं पतितं सत्त्वं समादाय नियोजयेत् ।

Rasaratna-Samuchchaya, II, Ray, History of Hindu Chemistry, Vol. I, p. 49.

5.18 In the first place calamine is converted by heat into zinc oxide, which when heated with soot and carbon obtained by the Destructive distillation of carbonaceous substances such as lac is converted into metallic zinc whilst carbon monoxide is evolved which burns at the mouth of the tubulure with the characteristic bluish flame. When the reduction is complete and the zinc vaporises, the bluish flame is replaced by the white flame of burning zinc vapour. At that time the molten zinc is poured out from the crucible by holding its mouth downwards.

5.19 Similar descriptions are to be found in other alchemical works of this and later times, showing that by the 13th century the process was quite common, though it must be conceded that the process was discovered as early as the 7th century, if not earlier.

5.20 The Indian process of distillation of zinc described above is thus an anticipation by several centuries of the old English process termed ‘distillation of zinc per descensum’, in which “the mixture of ore and coal was heated in curcibles closed at the top, but having a pipe leading from the bottom stopped by a wooden plug. The latter was quickly carbonised, thus becoming porous and allowing the vapour of the reduced zinc to pass down the tube where it was condensed.” [1] In the Indian process the molten zinc is poured out.

5.21 Zinc was recognised as a metal for the first time under the designation of its modern name, *Jasada,* as pointed out bv Dr. Ray,in the lexicon ascribed to king Madanapala Written about the year 1374 A.D.[2] But this fact was not universally recognised until the sixteenth century. Sarangadhar, the well-known alchemist has not mentioned zinc in his list of nine metals. Rasendrachintamni, Rasakalpa, Nityanatha’s Rasaratnakar and other alchemical works of this period do not mention zinc in the list of metals. It is only in the works of the sixteenth century that zinc finds a permanent place in the list of metals. Dhatukriya, Bhabaprakasha and other alchemical works of this century mention it in the list of metals and the Ayeen Akbari also mentions “ruh-i-tutia ” (essence of (white) tutia) or zinc as one of the seven metals. It must therefore be acknowledged that though zinc was universally distilled in India by the 13th century and its metallic nature recognised by Madanpala in the fourteenth century, it was not until the sixteenth century that it was universally recognised as a metal. Even in this respect India’s knowledge of the metallic nature of zinc was more in advance than in contemporary Europe as “the identification of zinc as the metal from blended was only accomplished by Homberg in 1695-”[3]

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1. Roscoe and Schorlemmer’s Treatise on Chemistry, Vol. II, p. 645.

2. जसदं वङ्गसदृशं रितिहेतुश्च तन्मतम्—Madanpāla-Nirgghantu.

3. It is often remarkable how truth is arrived at by different peoples through almost identical channels of surmises and mistakes. We have already pointed out that in India a good deal of confusion existed regarding the chemical nature of zinc from the fourteenth to the sixteenth century. In Europe also “the exact nature of zinc and its ores continued doubtful during the seventeenth century. Glauber, it is true, stated that calamiue was an ore of zinc, but Lemery, so late as 1675, believed that zinc was identical with bismuth, and Boyle often employed the names zinc and bismuth indiscriminately for the same substance.” Then again, in India there was a good deal of confusion for a long time regarding the equivalents for zinc and its ore calamine (rasaka or kharpara). Both the equivalents of calamine ‘are used to designate the ore as well as the metal. In Europe also “ the word zinc occurs in many subsequent authors and sometimes it is employed to denote the metal, at other time*! The ore from which the metal is obtained.” It would be rash to suggest from the similarity in the development of the ideas regarding the chemical nature of zinc that Europe borrowed them from India. It often happens that different countries often arrive at a particular truth after pursuing a similar train of reasoning.

Recognition of brass as an alloy.

5.22 It has already been pointed out that in Europe Kunkel at the end of 17th century recognized brass as an alloy. In. India, however, this fact must have been recognized as early as the 13th century as it has been mentioned as such in alchemical works of this century. Yasodhar, author of Rasaprakash-sudhakar writes *"saurastra,* brass and *vartalanha* are three alloys (misralauha)."[1] The' author of Rasaratna-samuchchaya also says bronze, brass and varta are the three *misralauha."*[2] That brass came to be regarded as an alloy four centuries earlier than in Europe need not cause surprise as zinc itself was distilled, as shown before, several centuries earlier in India. Bhavmisra, the author of *Bhavaprakasha* (16th century) writes that brass is a semi-metal *(updhatu)* of zinc and copper, [3] as it is derived from these two metals.

5.23 Though the alchemical works of this century make mention of brass as an alloy, they however Ho not definitely state that it was an alloy of zinc It has only been mentioned as an alloy of zinc in alchemical works of the sixteenth century such as Bhabprakash, Dhatukria and others.[4] The reason for this is not far to seek. It is owing to the fact that zinc was not generally recognised, as has already been pointed out, as a metal before that century. As has already been mentioned, though Madanpala was aware of its metallic nature in the fourteenth century, zinc was not universally recognised in India as a metal until the sixteenth century. It may therefore be contended that though brass was distinctly recognised as an alloy in the thirteenth century, it was distinctly recognised *as an alloy of zinc* in the sixteenth century. Even then India can lay a priority of claim of the discovery of the chemical nature of brass by at least a century, as it was at the end of the seventeenth century only that Kunkel recognised brass as an alloy and Holmberg recognized "zinc as the metal from blende".

Manufacture of brass from zinc.

5.24 From the fact that brass was designated as an alloy by the thirteenth century, it might follow that at least from that time onwards brass was manufactured in India by melting the two metals But as zinc was not generally recognised as a metal, and as brass was not generally recognised as an alloy of zinc before the sixteenth century, we cannot be certain of the fact that brass was manufactured in India directly from its constituent metals before that century.

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1. स मिश्रलोहत्रितयं सौराष्ट्ररीतिवर्त्तकाः ।

Rasaprakāsh-sudhākar.

Saurāstra here evidently means bronze as the best bronze was obtained from Surāstra (Surat). cf. "कांस्यं तत् सौराष्ट्रजं शुभम्" (Rasaratna-samuchchaya). Its other and more common meaning viz. alum is ɛvidently out of place here.

2. मिश्रं लोहं त्रितयमुदितं पित्तलं कांस्यं वर्त्तं—Rasaratna-samuchchaya, V. 1

3. रीतिरप्युपधातुः स्यात्ताम्रस्य यशदस्य च—

Bhābaprakāsha.

4. रीतिरप्युपधातुः स्यात्ताम्रस्य यशदस्य च—Bhāprakāsha.

शुल्बखर्परसंयोगे जायते पित्तलं शुभम्—Dhātukriyā.

शुल्बजासत्त्वसंयोगे नारीधातुस्तु जायते—Ibid.

5.25 It is true that zinc was first distilled in India, as has already been stated, as early as the seventh century so that it may be presumed that brass was manufactured directly from zinc from that time onwards, but as direct evidence on that point is lacking the point cannot be urged with sufficient emphasis. Again we might be permitted to assert that brass was manufactured in India directly from zinc from the thirteenth century (i.e. at least three or four centuries earlier than in Europe) as it was recognised as an *alloy* at that time, but as the fact of its being prepared directly from the metals copper and zinc has been openly mentioned only in works of the sixteenth century and later (see before), it is safest to conclude that brass was undoubtedly manufactured in India directly from zinc from the sixteenth century onwards. Even then India was ahead of Europe in this respect by a century, as in Europe brass was manufactured directly from zinc not earlier than the last part of the seventeenth century.

5.26 Prior to this, brass must have been manufactured from7 calamine as in Europe. We have a recipe in Rasaratnakar (7th century) for the conversion of copper into a gold-like substance meaning evidently brass, by heating copper, calamine and organic substances in covered crucibles.[1] This recipe is quoted almost bodily in the alchemical Work Rasaranava (12th century). The organic substances on being heated in covered crucibles evidently supplied the carbon necessary for the reduction of calamine.

5.27 Though brass has repeatedly been mentioned in alchemical works of the 13th century and later as an alloy, the proportions in which copper and zinc were mixed have not definitely been mentioned. From the Ayeen Akbari, however, we learn that during Moghul time's brass was manufactured by melting two seers of copper and one and half seer of ruh-i-tutia or zinc*

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1. किमत्र चित्रं रसको रसेन ।
• • • भावितः ।
क्रमेण कृत्वाम्बुधरेण रञ्जितः
करोति शुल्वं त्रिपुटेन काञ्चनम् ॥

Rasaratnākar, I, 3

***Both Blockman and Gladwin evidently made a mistake in rendering ruh-I tutia (essence of calamine) as " a kind of native pewter," as it is mentioned as one of the seven metals, (the other six metals being gold, silver, copper, tin, iron and lead) and not as oue of the alloys. The word is a evidently Persion translation of the sanskrit word *rasaka-svattwam* (रसकसत्त्व) or ja-svattwam (जासत्त्व) meauing"essence of calamine."**

CHAPTER VI.

Matters of 'Chemical interest relating to be copper.

Compounds of copper.

(a) Copper Sulphide.

6.1 Two compounds of copper were known in ancient India in the pure state—the sulphide and the sulphate.

6.2 Of these the sulphide appears to have been first prepared artificially by Vrinda (circa 900 A.D.) under the name of *parpatitamram* in the following manner— " sulphur, copper and the pyrites are to be pounded together with mercury and subjected to roasting in a closed crucible."[1] The formula for this preparation, however, says Dr. Ray, does not occur in the Poona edition of Vrinda's work but it is to be found in the Kashmir manuscripts under *Rasayanadhicar*, so that the passage might be an interpellation. It is, however, certain that Chakrapani (circa 1060 A.D.) prepared the compound in a pure state under the name of *tamarajoga* Chakrapani writes "take a thin leaf of Nepalese copper and embed it in powdered sulphur. The substances are to be placed inside a saucer-shaped earthenware vessel and covered with another. The rims are luted with sugar or powdered rice-paste. The apparatus is heated in a sand-bath for three hours. The copper thus prepared is grounded and admixture with other drugs."[2] " Killed copper " mentioned in later alchemical works was prepared by first making copper amalgam by mixing copper with mercury and then heating the amalgam with excess of sulphur in a crucible when the mercuric sulphide sub time off and the sulphide of copper is left behind. The roasting is repeated several times with sulphur in order to complete the conversion of copper into the sulphide.

(b) Copper Sulphate.

6.3 Blue vitrol or copper sulphate is designated in Sanskrit by the work *tutthwam* (तुथ्यम्) from which the Persian word tutia" is evidently derived. It was known in ancient India from the 3rd century B. C. as it has been mentioned in the Charaka and the Sushruta where it is used as an ingredient of external applications for the treatment of ulcers, leprosy, &c.

Copper sulphate works in Rajsthan (Ball's Economic Geology of India).

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1. Ray, History of Hiudu Chemistry, Vol. 1. p. 32.
2. Bay, History of Hindu Chemistry Vol. I. p. 34,

6.4 It would be noted in this connection that not only tuttliwam but kashha or green vitriol also has been mentioned in these works showing that the difference between these two kinds of vitriols was recognised in ancient India at a time when the ancient Greeks and Romans were ignorant of it. It was also known in later times as *mayurtutthwam and sasyalca* (मयूरतुत्थम् and सस्यक).

6.5 That blue vitriol yields copper on heating with organic substances and borax in closed crucibles was discovered in India in the 12th century, as we find the following formula in *Rasaniava*—" Take blue vitriol and one-fourth its weight of borax and soak the mixture in the oil expressed from the seeds of pongamia glabra for one day only and then place it in a covered crucible and heat in the charcoal fire — by this process an essence is obtained from it of the beautiful appearance of coccinella insect."[1] This formula is repeated in Rasaratna-samuchchaya which also prescribes that when blue vitriol is heated in a closed crucible with lime juice and borax, its essence in the form of copper is obtained.[2]

6.6 In the Bhavaprakash (16th century) blue vitriol has been designated as a semi-metal (उपधातु) of copper as it is derived from copper. Dr. Ray remarks on this passage that "the nomenclature is in wonderful agreement with that adopted nearly two centuries later by Boerhave (1732 A.D.)."

6.7 As regards the actual method of manufacture of blue vitriol in ancient India very little is known and no description of the process is to be found in alchemical works. As blue vitriol, however, is mentioned in medical works composed as early as the 3rd century B.C. it is very likely that it was obtained as a natural product or a bye-product in copper mines. An indigenous process of manufacturing blue vitriol along with ferrous sulphate and alum still survives in various parts of Rajsthan where these sulphates are obtained by dissolving shales in water and crystallising from the solution obtained. The process was thoroughly examined and described by Colonel Brooke.[3] Ball in his Economic Geology of India writes— "In 1864 there were twenty of these factories at Khetri and about double the number at Singhana. The broken shale from copper mines which contains the salts is placed in earthen *gharas*, together with the crusts from the refuse heaps of previous lixiviations and water is added. The *gharas* as are arranged on ledges prepared for the purpose on the heaps of refuse.

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1. सस्यकस्य तु चूर्णं तु पादसौभाग्यसंयुतम् ।
करञ्जतैलमध्यस्थं दिनमेकं निधापयेत् ॥
मध्यस्थमन्धमूषायां ध्मापयेत् कोकिलत्रयं ।
इन्द्रगोपाकृति चैव सत्त्वं भवति शोभनम् ॥
Rasaratna-Samuchchaya, II, 133—4.

2. निम्बुद्रवाल्पटङ्काभ्यां मूषामध्ये निरुध्य च ।
ताम्ररूपं परिध्मातं सत्त्वं मुञ्चति सस्यकम् ॥
Rasaratna-Samuchchaya, II, 135.
Ray, History of Hindu Chemistry, Vol. I, p. 47.

3. Brooke. .Journ. As. Sou, Beng., XXXIII , p. 525.

6.8 "Each charge of shale is exposed to three changes of water and itself is changed from one *ghara* to another till it has taken up the sulphates from seven different steepings. It is then of a thick dirty bluish color and is taken to the boiling house where it is boiled in earthen *gharas* when sufficiently concentrated it is left to cool and then sticks being introduced the blue vitriol crystallises on them. The mother liquor is then poured off and again boiled and on the addition of saltpetre the alum crystallises at the bottom of the vessel. The residual sulphates still in solution are allowed to crystallise out by exposing the mixture to the sun."

6.9 In later times copper sulphate appears to have also been prepared by the action of sulphuric acid (*daha-jala*, lit. burning water) on metallic opper. We find the following recipe in the alchemical work Dhatukriya (16th century)—" *tutthcam* (blue vitrol) is obtained by the action of sulphuric acid on copper."[1] Sulphuric acid was obtained originally in the 13th century in India as an "essence of alum or green vitriol " by the distillation of these substances. The distillationof alum and green vitriol is described in Rasaratna-samuchchaya.[2] The word *dahajala* as an equivalent for sulphuric acid is evidently of later origin.[3] This process of preparing copper sulphate by the action of sulphuric acid on copper was discovered in Europe by Glauber in 1648, so that India can claim priority in the matter of the discovery of this reaction by nearly a century.

6.10 Of the other compounds of copper, the chloride and the oxide were incidentally prepared by heating copper with common salt and the metal respectively but not as separate compounds.

Copper Flame.

6.11 Every student of Chemistry knows that copper or compounds of copper when presented to the flame colour the flame blue. This fact is recorded in the Rasaranava (12th century) which states—'copper flame is blue". (शुल्ब नीलनिभा)

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1 ताम्रदाहजलैर्योगे जायते तुत्थकं शुभम् ।
Dhātukriyā.

2. Rasaratna-samuchchaya, II, 54 and 05.

3. Dr. Ray has evidently failed to interpret the meaning of this passage correctly, lie has rendered the passage as follows —"Copper in combination with the burning water gives rise to *tuttha* (green vitriol)." This interpretation is evidently meaningless owing to the rendering, possibly through oversight, of '*tuttha*' as green vitriol instead of blue vitriol or copper sulphate. The synonym "burning water" for sulphuric acid is very apposite and reminds one of the synonyms of " aqua fo r tis" for nitric acid and " aqua regia" for nitro-muriatic acid. That sulphuric acid was used for dissolving metals is independently shown by the following passage in Yasodhara's *Rasaprakasa-sudhakara*—"the essence of alum is to be used for treating (dissolving) metals and not as a medicine (तत् (तुवरी) सत्त्वं धातुवादार्थं चौषधं नोपपद्यते)."

CHAPTER VII.

METALLURGY OF COPPER

Copper mines in Ancient India.

7.1 At this great distance of time it is almost impossible to locate precisely the places in India in which copper mines originally existed. Nevertheless the existence of copper slag in many parts of India amply testifies to the fact that copper smelting was an important industry in ancient India, though at the present moment it has fallen, as in the case of almost every other scientific industry, into the hands of the most backward communities.

7.2 From geological and literary evidences the author has come to the conclusion that copper smelting was carried on extensively in ancient times in the Singhbhum and Hazaribagh District of Jharkhand, in various parts of Rajsthan, Nepal and some parts of Southern India though it was not unknown in other parts of the country. Copper was also imported into India from foreign countries. We would proceed to put forward the available evidences bearing on the subject, though it must be conceded that such evidences are more or less casual and not of a systematic nature.

7.3 As regards ancient copper mining and copper slag in the *Singhbhum District*, is still working copper mines, Ball, the well-known geologist writes—" Indications exist of mining and smelting having been carried on in this region from a very early period and the evidence is available , perhaps 2000 years ago, mining was initiated .and abundant testimony to the fact that copper mining was carried there on an extensive scale in ancient times. He reported that signs of numerous mines and deposits of copper slag were a bund any visible in the hills west of Asanabani, in Badia, in Masanboni, in the hills west and north-west of Surda, in the Sideshor hills south-west of Ruma.

7.4 Turning to the *Hazaribagh district* near the Singhbhum district geological evidences point unmistakably to ancient copper mining on an extensive scale. There is a place in this district which' is known as Baragunda, " so called from the fact of its being the site of 48 (baragunda) ancient copper mines." Ball says—" the excavations which mark the position of these ancient mines are situated along a line of outcrop of metamorphic rocks which form a ridge, about a kilometer long, between the villages of Parsabera and Baragunda." He containues — "we are not in possession of any information as to who the ancients were who made the numerous excavations at Baragunda of which ample evidence is still to be seen. These workings extended all along the outcrop and from their over-lapping in places it would appear that the deposit was not limited to one line of strike. Though in some cases the samples show that the ore occured as a constituent of the schist, others seem to justify the conclusion that there are one or more distinct lodes parallel to the bedding.''[1]

1. Ball's Economic Geology of India, pp. 254, 255,

7.5 From the discovery of large quantities of copper implements at Gungeria in the Balaghat it would appear that in prehistoric times copper smelting was extensively carried on in the Balaghat, for it is very unlikely; judging from the lack of facilities of transport which must have existed at such an early period of Indian civilisation, that such large quantities of copper and silver. Were imported either from abroad or from other parts of India, though as a matter of fact such a hypothesis would be more or less a conjecture. We are, however, on some solid grounds regarding the copper of the Sultangunj Buddha statue. From the copper slag and raw copper found in the vicinity it would appear that both the smelting as well as the casting operations was done in the locality. Although Copper deposit in Malajkhand and Budbudda of Blaghat is world known but no evidence is available regarding the use of copper ore.natural or native copper would be important, as free copper is not frequently found in nature. During my study I noticed that it is said about one of the source of Copper is so called Malechha mukham region which is out of Indian territories. It is impossible to bring the Copper ore from forein countries due to lack of communication and transportation. In my opinion the axact word is Malajkhand which is in Balaghat district and big source of copper ore. There is evidence regarding ancient mining also.

Ores of Copper.

7.6 We would now proceed to identify the ores of copper which were used in India for smelting purposes. The principal ores mentioned in alchemical literature from which copper was extracted are *Makshika* and *Vimala* meaning pyrites and copper glance respectively. So far as the former is concerned, two varieties of pyrites were known in India as early as the third century B. C. as Shushruta mentions two varities of the mineral, golden and silvery. The one was originally known by the word *tapya* as it was obtained near the Indian River Tapi. Later on the one pyrites were designated by the word makshika which was divided into two classes' *hema* - *mahsliika* (golden pyrites) and *taramahsliika* (silvery pyrites), according to their respective colours evidently meaning copper and iron pyrites respectively, as copper pyrites is much more yellow than iron pyrites. Recipes are given in many alchemical works such as Rasaratnakar, Rasarnava and Rasaratna-samuchchaya for the extraction of copper from golden pyrites. But as regards their chemical composition a good deal of confusion appears to have existed even in the sixteenth century, as we find in Bhavaprakash that " golden pyrites contain a little gold' and the silvery pyrites a little silver."[1] It is very likely that the colours have misled many to the supposition that the two varieties of pyrites actually contained gold and silver. Makshika is described to have been obtained in the river Tapi and also in the land of the Kirats, the Chinese and the Yavanas. Golden pyrites were obtained in Kanauja '

7.7 As regards *Vimala* it is difficult to identify it, which is described to be of three varieties according to their colours— golden, silvery and bronze-like. They are described as rounded and having angles and facets and would yield copper when heated with borax and organic substances. The description would tally in many respects with copper glance, a variety of copper pyrites which does not contain iron sulphide.

7.8 The minerals malachite as well as reel copper ore were known as green and red ores of copper and are mentioned in Kautilya's Arthashastra.

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1 किञ्चित् सुवर्णसाहित्यात् स्वर्णमाक्षिकमीरितम् ।

Bhābaprakāsha.

Metallurgy of Copper.

7.9 A connected history of the metallurgical operations used in the extraction of copper is extremely difficult to make out, as the description of the processes of extraction of copper is extremely meager in alchemical literature. It has already been pointed out that copper pyrites and copper glance were the two copper ores commonly mentioned in alchemical works and recipes have been given in these works for the extraction of copper from these ores. No furnaces, however, are described, the operations being conducted in crucibles. A few such recipes for the extraction of copper from *Makshika andVimala are given below:—*

7.10 (1) *Makshika or* pyrites—the following receipe is given in both Rasarnava and Rasaratna-samuchchaya :—" *Makshika* repeatedly steeped in honey, oil of the seeds of *riciuns communis* urine of the cow, clarified butter and the extract of the bulbous root of *musa sapientum* when gently roasted in a crucible yields an essence in the shape of copper."[1]

7.11 (2) *Vimala or* copper glance—the following formula for the extraction of copper from *Vimala* is given in Rasaratnakar, Rasarnava and Rasaratna-samuchchaya :—" *Vimala* digested with alum, green vitriol, borax and the watery liquid extracted from moringa pter, musa sapientum and finally roasted in a covered crucible in combination with the ashes of schrebera s wiet yields an essence in the shape of ckavdrarka (literally copper of gold-like lustre)." [2]

7.12 Another formula for extracting copper from *Vimala* is found in Rasaratna-samuchchaya " *Vimala,* rubbed with borax, the juice of *atrocarpus lakoocha* and the ash of *schrebera swiet* when roasted in a covered crucible yields an essence of the appearance of gold."[3]

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1 क्षौद्रगन्धर्वतैलाभ्यां गोमूत्रेण घृतेन च ।
कदलीकन्दसारेण भावितं माक्षिकं सकृत् ।
मूषायां मुञ्चति ध्मातं सत्त्वं शुल्बनिभं मृदु ॥

Rasárnava, VI, 12—13.

Rasaratna-Samuchchaya, II, 89—90.

2 विमलं शिग्रुतोयेन काङ्क्षीकासीसटङ्कणैः ।
वज्रकन्दसमायुक्तं भावितं कदलीरसैः ॥
मोक्षकक्षारसंयुक्तं ध्मापितं मूकमूषगम् ।
सत्त्वं चन्द्रार्कसंकाशं प्रयच्छति न संशय ॥

Rasaratna-Samuchchaya, II, 103—4.

3 सटङ्कणलकुचद्रावैर्मेषशृङ्ग्याश्च भस्मना ।
पिष्टो मूषोदरे लिप्तः संशोष्य च निरुध्य च ॥
षट्प्रस्थकोकिलैर्ध्मातो विमलः शीतसन्निभः ।
सत्त्वं मुञ्चति तद्युक्तो रसः स्यात् स रसायनः ॥

Ibid, II, 101—2.

The translation of the passages is as given in Rây's History of Hindu Chemistry, Vol. I, p. 46 and 47.

7.13 The chemical action that takes place in the processes given in the formulae mentioned above for the extraction of copper from its ores in covered crucibles is apt to be lost in the wilderness of names of various plants which evidently supply the carbon by destructive distillation when heated in covered crucibles. The carbon, borax and the alkali carbonates supply the reducing agents for the conversion of the ores into metallic copper.

7.14 It would be difficult to say whether such processes as described above were actually used on a large scale for manufacturing purposes in copper mines, though it is evident that they were used as laboratory methods on a small scale as covered crucibles are mentioned. From the existing archaeological and mineralogical evidences elaborated In previous chapters it is evident that copper was extracted in India from their ores in sufficiently large quantities from the third century B. C. when the Asoka pillar copper bolt was manufactured down to the Moghul period when large brass guns were cast, and that for that purpose the extraction must have taken place in big furnaces and not in small crucibles. Unfortunately literature on this subject has all perished by the ravages of time, and exact descriptions of the furnaces employed as well as of the metallurgical processes themselves are wanting at this great distance of time. Fortunately however copper smelting is still carried on in different parts of India, as has been already mentioned, in Khetri, Singhana and other places in Rajsthan and in Nepal and Sikkim Himalayas, and judging from the conservatism of the people it is to be presumed that the industry was carried on for many centuries in a like manner though certainly not on such a poor scale. It has already been pointed out that the scientific and industrial spirit has been waning in India from the 12th or the 13th century, and by the middle of the 16th century the emasculation of the spirit of industry and inquiry has become almost complete owing to decadent national vitality, and most industries have in consequence gradually been relegated by that time into the hands of the illiterate and the least advanced sections of the Indian community. The metallurgical skill displayed by the ancient Indians in the forging of the gigantic iron pillars of Delhi and other places, the iron beams of Konarak, Puri and Bhubaneswar was certainly of a very superior order, but descriptions of the furnaces, which were certainly of no mean dimensions, used in forging the-e beams and pillars and of the actual process of the extraction of iron, which must have been effected in very large quantities, have been lost in the obscurity of the distant past. Old processes, however, both of copper and iron smelting still continues, though on an infinitely smaller scale, amongst the aboriginal and the least advanced communities' of India. These processes are important as relics of a bygone industry which produced in the past articles of value which still attract the unstinted admiration of competent judges and experts.

7.15 We would therefore conclude by giving short descriptions of these indigenous processes of manufacturing copper as they existed about three quarters of a century ago and in fact are still existing in India in Rajsthan, Nepal and other places :—

7.16 *Rajsthan*—Capt. Ball can in his "Gleanings in 'science- (Vo. Ill, p. 380) gives a descript tion of the native process of manu facturing copper in Singhana as it existed in 183 1 and Col. J. C. Brooke in 1864 gives an account of the same process in Khetri with diagrams and plates.[1] Their accounts may be summarised th us :—

7.17 The principal ores in Singhana and Khetri were copper pyrites. They were pounded with hammers weighing 16 to 20 lbs. on stone anvils. The crushed ores were then mixed with cow-dung, made into balls and dried in the sun. The ores were first roasted and then mixed with charcoal and iron slag as flux. There are hillocks of iron slag in these places showing that iron was also smelted here at one time in very large quantities.

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1. Co). J. C. Brooke, Journal Asiatic Soc., Beng., Vol. xxxiii, pages 519—529 For a fuller description of furnaces and processes consult Percy's Metallurgy p. 390 and Ball's Economic Geology of India, p. 260.

Indian blast furnace for smelting copper (Ball’s Economic Geology of India).

The furnace was made by piling on one another three or four concentric clay or fire clay cylinders with arrangement at the bottom for two nozzles of two ordinary hand bellows ured for driving a blast of air. The height of a furnace would not exceed 30 (76.2 cm) or 40 inches (101.6 cm) and its external diameter 15 inches. (38.1 cm) During a day of nine or ten hours 3 maunds charcoal, $2\frac{1}{2}$mds. Roasted ore and 2 mds. Iron slag was consumed. The slag was drawn off and the molten copper remained at the bottom and removed next day. It was then re-melted in an open furnace under a strong blast of air and then cast into ingots of refined copper.

7.18 *Sikkim Himalayas*—The description of copper manufacture in Sikkim Himalayas given by Mr H.F. Bland ford of the Geological Survey of India and quoted in Percy’s Metallurgy published in 1861 does not differ materially from the description given by Col. Boilcan and Col. Brooke of the Rajsthan copper works. The workmen are all Nepalese who, as references in alchemical works already quoted show, were adepts in copper manufacture. Mr. Blandford's observations may be summarised thus:—

7.19 The ores are picked, crushed, powdered, subjected to several washings and then become ready for preliminary smelting. The washed ore consists of copper pyrites, mundic and gangue principally quartz and hornblende. The furnace is formed of refractory clay and is in the form of a truncated pyramid. It is generally 18 inches (45.72 cm) deep and there are arrangements at the bottom for a blast of air with two bellows consisting of inflated goat skin.

7.20 *Smelting*— The furnace is filled with lighted charcoal which is raised to its full heat and the washed ore thrown in the furnace. The bellows are worked by hand until the fused *“ regains''* forms a small pool at the bottom covered with a layer of fused slag. The crude metal is removed when cooled.

7.21 *Roasting*. — The crude metal is then kneaded with cow-dung into small balls, dried in the sun and roasted in a shallow furnace formed of a ring of slag cakes placed on edge.

7.22 *Refining*. — The roasted metal is afterwards refined in the first furnace, charcoal completely reducing the metal. The refined copper is collected at the bottom and removed as cakes when cooled weighing four (1.81437 kilogram) or five pounds (2.26796 kilogram).

7.23 This traditional Indian method of the extraction of copper is akin in principle to the modern blast furnace method of smelting copper first described by Agricola in the middle of the sixteenth century whilst writing about the working of the Mansfield copper works. The Mansfield process has been perfected by Herresh off and others and the chemistry of the modern process is almost identical with that of the traditional Indian method. For the sake of comparison the principle of the modern method is being quoted below—" the roasted ore, mixed with coke or anthracite, and the slag from a later process, which consists chiefly of iron silicate with a little copper, is introduced at the top of the furnace, the air being forced through tuyeres. The products, which consist of 'matte' and slag accumulate in the bottom of the furnace and then overflow continuously into the 'fore-hearth.' This matte is usually reduced to metallic coooer in a 'converter,' the resulting metal being refined in reverseratory furnaces."[1]

7.24 It would thus appear that the old Welsh or English process of copper smelting in reverberatory furnaces which requires a very large number of calcinations and roasting had no counterpart in .India, the Indian process being conducted in blast furnaces.

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1. Roscoe and Scholemmer, Treatise on Chemistry, Vol. IJ, p. 409.