RAJASTHAN'S ALCHEMICAL LEGACY: A STUDY OF ANCIENT CHEMICAL PRACTICES

Dr.Binay Barman, Assistant Professor,Department of History, Saldiha College, Bankura, W. B.
Email. binaybarman123@gmail.com
Sudip Sahana, Assistant Professor, Department of Chemistry, Saldiha College, Bankura, W. B.

ABSTRACT:
The origin of chemistry in India dates back to ancient times, with early applications in various practical arts, including:

1. Ceramics: Manufacture of decorated earthenware and porcelain.
2. Construction: Production of burnt bricks.
3. Ornamentation: Creation of glass beads.
4. Metallurgy: Development of alloys.
5. Medicine: Formation of Ayurvedic remedies. These ancient chemical processes laid the groundwork for India's rich chemical heritage, influencing the development of Rasayan (Indian alchemy) as well as Ayurveda. Chemical industries displayed excellent artistry, indicating that the craftspeople were well-versed in the underlying chemical processes. However, it is unlikely that knowledge of theoretical chemical principles has advanced significantly. However, the ideas of atoms and chemical combinations were developed as a result of philosophical conjectures by ancient Indian thinkers regarding the cosmic genesis and nature of matter. These ideas were not, however, corroborated by experimental evidence. The pre-Harappan, Harappan, and post Harappan eras can all be used to study the beginning and evolution of chemistry in ancient India.

Various ancient monuments in Rajasthan are connected to early chemistry, particularly in the areas of medical alchemy and metallurgy. One notable example is the Zawar region, which is near Udaipur and is renowned for its antiquated methods of smelting zinc that date back to the 1st millennium CE. Early chemical understanding is demonstrated by archaeological evidence of sophisticated furnaces and distillation equipment for the extraction of pure zinc, a difficult process requiring high temperatures and exact control. In addition to being employed in regional crafts, zinc from Zawar was also traded extensively. The ancient copper mining and smelting complex at Khetri, which dates to the 2nd century BCE, was another significant location of ancient Rajasthan.
This research article explores the little known chemical processes of ancient Rajasthan that influenced the metallurgical and alchemical traditions of the region.

ANCIENT CHEMICAL HISTORY IN INDIA:
Significant knowledge about chemistry, metallurgy, and medicine may be found in post Vedic literary and technological works. In this regard, the Kautilya, Caraka, and Susruta treaties are incredibly rich. Despite being primarily a work on politics, Kautilya's "*Arthasastra*"[1] (c.4th century BCE) served as a foundation for numerous ancient Indian scientific disciplines.
This text discusses the ores of gold, silver, copper, lead, tin, mercury, and iron, as well as the extraction of their metals and the creation of their alloys. It describes how gold and silver are worked and how silver is purified by heating lead and silver in a skull, a method that is a little like the current cupellation process. Additionally, it describes a wide range of stones, including pearls, emeralds, sapphires, rubies, diamonds, coral, and opals. There is also a discussion on the makeup of various liquors.
The '*Carak-Samhita*' [2] and '*Susruta-Samhita*' [3] are two seminal medical texts from ancient India (c.1st century A.D.), favorable way of remarkable chemical insights and pharmacological expertise. The

Caraka-Samhita mentions minerals such as pyrites, sulpher, rust of iron, orpiment, sulphate of copper, sulphate of iron, and realgar.

The use of coral, lapis lazuli, conch shell ashes, iron and copper calces (oxides), and antimony sulphide are all mentioned in the book. Iron, copper, and other metals are said to be killed-that is, their sulphides are formed -when they are roasted with sulfur. Distillation has also been used to prepare a variety of fermented liquors and nearly anhydrous substances.

The '*Susruta-Samhita'* provides a through explanation of the properties and manufacture of caustic alkali and alkali carbonates, as well as how an acid neutralizes an alkali. The level of detail in the description is so flawless that it could nearly be physically transferred to a contemporary chemistry textbook. A weak form of alkali carbonate was boiled with a lime solution to create caustic alkali.

The oxide of tin, lead, copper, silver, iron, and gold-made by burning the metals with minerals like red ochre and alum earth – were suggested by Susruta as medications. He was aware of the toxic nature of arsenic compounds like orpiment and white arsenic. Susruta explained a simple technique called '*ayaskrti*' that involves burning metals with saltpeter, common salt, and magnesium sulphate to create metallic oxides or oxy-salts. Susruta mentions mercury merely in passing once or twice, suggesting that it was not well known in his day.

References to chemical composition and decomposition by more or less primitive processes of calcinations, distillations, steaming, fixation, etc., are frequently found in the writings of the ancient Indian medical schools that originated with Caraka and Susruta. Caraka established ideas of chemical combination and compound creation based on Samkhya philosophy. He made a distinction between chemical compounds and mechanical mixtures, and Susruta followed Caraka in this regard. A more thorough explanation of the chemistry of digestion can be found in Vagbhata's "*Astanga hrdaym-Samhita*"[4], a medical book written considerably later than the Caraka-Samhita. The latter covers a variety of gold, silver, copper, iron, tin, and lead formulations.

INDIAN CIVILIZATION AND USE OF CHEMICALS:

In Baluchistan (now in Pakistan) and surrounding regions of Sind, copper artifacts and burnt clay specimens have been discovered, demonstrating that the people who lived there between the fourth and third millennia BCE established the groundwork for chemistry in India. It has been demonstrated by excavations at Mohenjo-Daro in Sind[5] and Harappa in Punjab[6] that the inhabitants of the Indus Valley Civilization (c.2500-1800) were adept at using a variety of chemical processes. Item discovered include bricks, water pots, vessels, jars, faience, terracotta, jewelry, metal tools, seals, and glazed and painted polychrome pottery. Glaze was created by combining a fusible silicate (a sodium silicate created by agents such as ferric oxide and certain kinds of copper ore. It's interesting to know that glazed originated in India.[7]

Between 200 B.C. and 150 Ad, foreign travelers demonstrated the widespread availability and export of copper in India. Along with iron and lead that arrive at Carmanian port on their route to the Persian Gulf, Pliny mentions copper as one of India's main products. The author of Periplus of the Erythreansea further supported this by listing copper as one of the goods exported from the port of Barygaza (Broach). In order to sell the metal to the Persian Gulf and West Asia via sea, it may have been extracted in the area surrounding Aravallis and the transported by road to Broach (ancient Barygaza).

Although copper has been utilized and recognized since pre-Harappan times, it has been challenging to identify the ancient copper sources. Agrawal[8] and Hegde[9] have attempted to identify the proto-historic mining regions in the absence of 14C dates by comparing the chalcolithic artifacts with trace impurity patterns of known ore deposits. These investigations suggest that both the Chalcolithic and Harappan cultures took advantage of the Khetri belt.

In order to directly date the old workings; attempts have recently been conducted to gather organic samples. Here we list every 14C date that has been measured thus far for historic copper workings. Despite the fact that none of the 14C dates (Table 1) shown here are from the proto-historic era, they offer fresh chronological support. We can now definitively determine the age of some mining regions for the first time. The evidence of the ancient workings, their historical context, their socioeconomic influence, and their chronology will all be briefly covered below.

Table-1

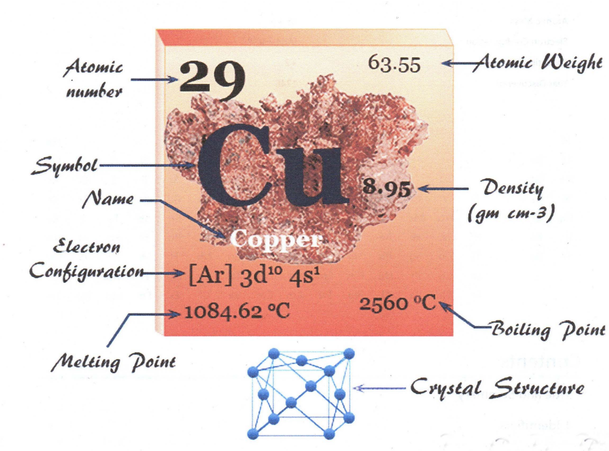
^{14}C dates of Ancient Copper Workings

Sample No.	Site	Date in yrs. B.P. $_{T1/2}$ = 5739 yrs.	Locus	Sample From
TF – 1117	Dariba Mines, rajasthan, District Udaipur	2310±105	Depth 64 m, Layer 436	G.S.I., Udaipur
TF – 1221	Kumbaria, Dist. Banaskantha, Gujrat	535±90	Dumps behind Jain Temples, Kumbaria	G.S.I., Ahmedabad
TF - 1222	"	905±85	"	"
PRL – 53	Ambamata, Dist. Banasakantha	2110±200	12 m distance in No. 3 west Drive of the underground mine	Mineral Exploration Corporation Ltd., Ambaji
PRL – 66	"	850±100	Bore hole No. 100, N-W zone of Ambamata deposit	G.S.I., Ahmedabad
TF – 805	Bandjomatto Hill, Dist. Guntur, A.P	900±80	From contact of dolomite-phylite of Cumbum stage of Nallamallai series	Hindustan Opper Ltd., Bollapalle
TF – 806	"	655±90	"	"
TF – 373	Mailaram, Dist. Khammam, A.P	535±90	One km. west of Mailaram from a slag beap, 1 m depth	G.S.I., Hyderabad

Table I: courtesy D. P. Agarwal

The 14C dates from the ancient copper workings in Rajasthan, Gujarat, and Andhra Pradesh are listed in the Table 1. Since the dates stretch back to around 360 BC, at the 14C dates indicate that the earliest mining activities found at Dariba mines in Rajasthan. It is intriguing to note that the Dariba mines have been worked since the Mauryan era, if not before. Mauryan-Sunga era also saw the exploitation of Ambrama mines. Mining activity was evident in Kumbharia (Gujarat) during the eleventh and fifteenth century AD. The mines in Andhra Pradesh's Agnigundala region date back at least 900 years.

Copper-Cu. Copper is a chemical elements or reddish-brown transition metal of group-11 or IB of the Periodic Table with the symbol Cu and Atomic number 29. It is soft, tough and lustrous metal with high thermal and electrical conductance. Copper helps in the formation of hemoglobin (an oxygen carrier) in animal body.



Copper symbol Analysis: B.B., S.S.

The Aravalli region contains large concentrations of chalcopyrite copper ore. Among the key locations for the region 'sore resources are Khetri, Babai, Singhana, Dariba, Devbari and Kotri. The ore deposits in Khetri, Singhana, Bairat, and Babai are linked to prehistoric metal smelting and mining.[10] Large piles of copper slag from ancient copper ore workings have been discovered at close to Rohira[11] in Sirohi, Gujrat, which borders the Banaskantha district.Ancient copper workings have also been discovered recently in the former Danta state.[12] These workings stretch more than alkalimeter along the top of a ridge that runs northwest from Ambamata and parallels the road to Mount Abu. Actually, there are signs of copper mining and smelting close to Dariba (Bikaner) and Dariba (Udaipur). It seems that the term "Dariba" was typically used to refer to old metallurgical and copper mining camps.

COPPER BELT OF ANCIENT RAJASTHAN:

According to archaeological data, Rajasthan had several thriving towns near copper ore regions throughout the Historic period (c. 300 BC- 400 AD). Among the most significant ore these are Bairat. Rairh, and Sambhar near Jaipur; Nagari near Chitogarh; Nagar near Tonk; and Pushkar near Ajmer. According to the early epigraphs, foreign and Indian tribes lived in Jodhpur, which lies on the edge of the Thar Desert, between 500 and 600 AD. Numerous copper artifacts, particularly coins, from Bairar, Rairh9, and Sambhar demonstrate how widely copper was employed for decorations, household items, and other purposes.

Zinc:

History of Zinc: In the ancient world, zinc ore was first used to make cementation brass in India and elsewhere. This was accomplished by reducing the ore in situ while copper powder was present. The copper power absorbed some of the zinc vapor that was produced (b.p.913 C) to create brass with a zinc content of no more than 28p.c. The ores that were utilized were calamine, a carbonate, and sphalerite, a sulphide. Zinc oxide, often referred to as pompholyx and spodos in Europe and tutiya in Persia, was rapidly formed from zinc vapor and utilized as a raw material to make cementation brass. By condensing the vapor in a reducing atmosphere before it could be oxidized, only Indians were able to recover zinc as a metal.

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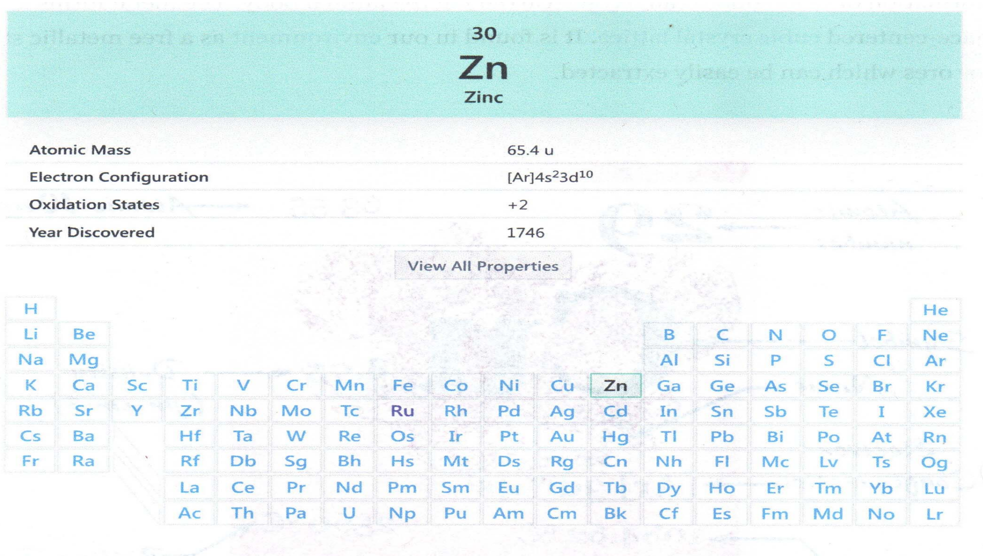
The Greek physician Dioscorides and the Roman Pliny wrote of calamine (from the Indian port of Kalyan, which exported brass), pompholyx, and spodos (zinc oxide). According to Dioscorides, the white, light, flying in the air purer pompholyx-known to the Persians as a covering for the roof and the walls of the furnace used to make brass and was also used as a medication. In the ninth and tenth centuries AD, Persian authors detailed different types of tutiya. Abu Dulaf declared that since the Indian variety is created from tin vapor, it should be chosen. "Metallic zinc is to be understood here, almost certainly", said Craddock, quoting this.

"Upon extraction from its ore, zinc is a volatile mineral or half-ripe metal. It is less malleable and less fusible than tin and it is brighter. It transforms copper into brass, just like lapis calaminaris does, because this stone is actually just infusible zinc, which might be referred to as a fusible lapis calaminaris because they share the same characteristics. It sublimates into the furnace's fissures, where the smelters often break it out"[13]

Zinc in Ancient Rajasthan: Rajasthan is the only state in India where there is variable proof of zinc melting. Mining different kinds of ores has been practiced since the Bronze Age (it is may be fourth millennium BCE) in the Ganeshwar-Jodhpura cultural complex in the north of Rajasthan and the Ahar culture in the south, according to Agrawal and Kharakwal.[14] According to Hooja and Kumar[15] more than five thousand copper-bronze artifacts from the 4^{th} to the 1^{st} millennium BCE have been produced by these two cultural complexes. Furthermore, a few copper arrowheads were found at the Bagor Mesolithic site in the district of Bhilwara. It is to be noted that the only known ancient zinc smelting site in India is Zawar (24' 27' N; 7 3' 41' E), which is located in the Aravalli Hills approximately 38 km south of Udaipur, Rajasthan. Massive slag and retort piles along the whole Tiri valley at Zawar signify a lengthy history of zinc smelting.



Zinc symbol analysis: B. B, S.S.

Early zinc mining and smelting is also demonstrated by Zawar, a small retort heap two kilometers south west of the Kaya, and old mine working. It is the contribution of the Zawar mineralization to the northwest. However, considering the condition of the counters, it can be safely assumed that these remaining parts are of a similar era even though they have not been thoroughly examined. Kaya is located about fifteen kilometers south of Udaipur town and six kilometers north of Zawar. Early traces of metallic zinc can be found in the Athenion Agora and Taxila, which date to the fourth and second centuries BCE, but there is no proof that these sites were regularly used for production. But the new brasses found in Senuwar provide compelling evidence that metallic zinc was unquestionably produced in India in the early Historic period. One explanation could be that zinc was no longer considered a rare metal Zawar offers the earliest known proof of pure zinc since the distillation method was employed to create in the 9th century A. D.

In the words of Hooja[16], the Bhil tribes of southern Rajasthan are considered to be the local inhabitants and make liquor using a traditional down-word refining method. Remarkably, zinc was also produced in Zawar using the distillation process. Furthermore, the Bhils of Zawar were able to distill pure zinc until 1840, according to Brooke. Therefore, the Bhil clan of southern Rajasthan is unquestionably responsible for developing outstanding solutions and heaters for the refining of zinc.

CONCLUSION:

Archaeological discoveries and literary imagery reveal that the ancient residents of Rajasthan shown extraordinary proficiency in the use of chemicals. They demonstrated a sophisticated understanding of the chemical processes by using minerals dyes, alkalis, and acids for metallurgy and textile dying. Their scientific knowledge is further demonstrated by their methods for casting bronze, casting pottery, and creating glass. A combination of utilitarian and therapy purposes is reflected in the medical applications of chemicals documented in Ayurvedic scriptures. This inventiveness in chemical produces left an enduring legacy of scientific invention in ancient Indian history, beginning not only the local industries but also Rajasthan's trade link with other regions.

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