India Was the First to Smelt Zinc by Distillation Process

By D.P. Agrawal & Lalit Tiwari

Zinc is a very interesting metal and was responsible for the innovation of utensils of mock silver and coins of mock gold. Because of the low boiling point (907°C) zinc is difficult to smelt. Brass (an alloy of copper and zinc) however is known from even 3rd Millennium BC in China, but brass can be produced from naturally occurring minerals containing zinc and copper. Pure zinc could be produced only after the mastery of distillation techniques, which have been described in our ancient chemical treatises. The mines of Rajasthan have given definite evidence of zinc production going back to 6th Century BC. Distillation process however was being used only from the 12th century AD, thus India is the first to produce zinc by distillation processes.

We are sure that the following story of early zinc production and lead about the ancient Indian chemists and metallurgists will be of interest to the students of history of science and technology.

Zinc is silvery white in colour, hard and brittle owing to its closely packed hexagonal crystal structure. In the 17th and 18th century Germans called this metal 'Caunterfeitum' or mock-silver because of its silvery white lusture. Its boiling point is 907°C. The main minerals of zinc in nature are calamine and sphalerite and mostly these occur in combination with the minerals of copper, lead, silver and iron. There is confusion about early occurrence of zinc and its extraction by the distillation process. The regular zinc production by distillation started in India around 12th century AD and in China it is not earlier then 16th century AD. As early as the 12th century AD, India produced the metallic zinc by the sophisticated distillation process at Zawar in Rajasthan. This technology of zinc manufacture is also described in several Indian alchemical works of the mediaeval period including the 13th century *Rasa Ratna Samuccaya*. The word used in this document to describe the distillation process involved is *tirakpatnayantra*, which translated literally, means "distillation by descending". Various zinc-smelting processes were also described in the Sanskrit works of medicinal chemistry and alchemy, viz., *Rasarnavam Rastantram* (500-100 BC), *Rasratnakar* (2nd century AD) and *Rasprakash Sudhakar* (12th century AD). In China zinc was first reported in the 16th century by the excavation in Gui-Zhan region of Yun-han, but the new research by the Chinese scholars gives a clear indication that zinc smelting began in China in the Jiajung period (1552-1566 AD) of the Ming dynasty. In 17th century China exported zinc to Europe under the name of *totamu* or *tutenag*. *Tutenag* possibly has its origin in the word *Tutthanagaa* maening zinc in South Indian languages.

Vijaya Deshpande (1996:276-279) claims that zinc extraction in India had definitely started by the 13th century AD at Zawar. The earliest literary evidence for the production of metallic zinc on a regular basis comes from India (Craddock 1987/88). There are references to burning a metal, *rasa*, to produce an eye salve, which should refer to zinc placing its use in the last centuries of the first millennium BC. The *Rasaratnakara*, which was probably compiled in its present form in the seventh or eighth century AD, is ascribed to Nagarjuna, the great Indian scientist who lived in the 14th century AD. It describes both the production of brass by the familiar cementation process and of metallic zinc.

Zinc mine at Zawar

Willie (1989) has described that the ancient mines at Zawar in Rajasthan are both open cast and underground. He has concluded that the host rock at Zawar is metamorphosed, sheathed hard and compact dolomite, except within the weathered zone. The abundance of charcoal waste and ash found on the floor of the old mine has indicated mining by fire setting method, which must have created acute ventilation problem inside the mine. The inner side of the mine was worked very methodically; the floor was kept clean and well lit by oil lamps placed at suitable distances. Clean drinking water was also put in large earthen jars. Transport of the ore, waste, timber and water must have been a major task and for this, good pathways were made with wood and stone. On the outer slopes of the hills ample evidence has been found about the techniques used for breaking and beneficiating the ore. The ore mineral was hand picked and broken, when necessary using stone hammers and slightly hollowed work stones. In the recent excavation of Zawar region several uncovered banks of furnaces were found. These furnaces were outlined in the *Rasa Ratna Samuccaya* and these are just like an industrial version, with banks of between three and seven furnaces and each furnace held 36 retorts (Craddock 1987:183-191).

Smelting process of zinc

There are few metals, which are produced by the reduction distillation technique, and zinc is one of them. Craddock et al (1985) have mentioned that distillation technology and apparatus were used in ancient times in India for the process of distillation of water, wine, mercury and zinc. The process used for the distillation of zinc in Zawar mines is unique because it is designed on the basis of downward distillation. After the sizing and beneficiation, the ore was mixed with charcoal dust and fired in to a heap to convert it in to oxide. This roasted ore was again mixed with more charcoal powder, salt and borax as flux and thoroughly mixed with cow dung and water, then made in to balls of 5 to 10mm diameter by hand rolling. These pellets were dried in sun and then filled into the brinjal shaped retorts. The retorts are of two sizes with capacity of 750 and 2000cc. In the excavation at Zawar region these retorts have been found. Each distillation unit had two parts, a lower condensing chamber and upper main furnace chamber. The lower chamber was square in plan and separated by perforated bricks from the upper chamber, which was in the form of a truncated pyramid. The internal dimensions of the furnaces (taken from furnaces 3 and 4) at the base were 660mm ´ 690mm, being slightly wider across the side with the entrance to the lower chamber. The division between lower chamber and the furnace proper was made by four of the perforated bricks (55mm thick), fitting closely together and resting (but not mortared) on a projecting brick ledge at the side with a single clay peg providing support in the centre. The use of a peg was necessary to reduce absorption to a minimum as the lower chamber, which contained the collecting vessels, was entered through just one small opening. Each of the perforated bricks had 9 large (35 mm diameter) holes to accommodate the condenser necks and 26 smaller holes (plus 9 shared with neighbouring bricks) for the passage of air into the furnace and for ash to drop through (Craddock et al, 1985: 45-52).

In this apparatus, at high temperature, solid charge was held in to upper inverted pot by sealing its mouth with clay and fixing a reed stick in the centre for the escape of gases etc. Another matching earthen pot was kept into a trough full of water. During the processing the upper inverted pot was heated by building a fire on a platform around it. On reaching the cherry red temperature (600ºC) the reed was charred and brunt off and the reduced metal vapours were forced downward into the condenser where it got deposited into liquid or solid metal.

Conclusion

The distillation technique of zinc and heating from outside was traditionally similar in both India and China but condensation method of zinc vapour was different. A rough and conservative conclusion suggests that perhaps 2,50,000 tonnes of zinc concentrates were extracted from some 2.5 million tonnes of ore in the total mined area before modern mining commenced. The Zawar industry is the most unusual phenomena of a fully-fledged technology with neither antecedents nor successors and apparently no contemporaries either, for even within India it seems unique.

References

Agrawal, D.P. 2000. *Ancient Metal Technology and Archaeology of South Asia.* New Delhi: Aryan Books International. Pp. 204-214.

Craddock, P.T. 1987. The early history of zinc. *Endeavour* 11(4): 183-191.

Craddock, P.T. 1987-88. The early history of zinc and brass. *Wiener Berichte uber Naturwissenschaft in der Kunst* 4/5: 225-45.

Craddock, P.T., I.C.Freestone, L.K.Gurjar, K.T.M. Hegde and V.H. Sonawane. 1985. Early zinc production in India. *Mining Magazine.* Pp. 45-52.

Craddock, P.T. and W.Zhou 1999. Traditional zinc production in modern China: survival and evolution. *BUMA conference Proceedings* Pp.85-96.

Despande, Vijaya 1996. A note on ancient zinc-smelting in India and China. *Indian Journal of History of Science* 31(3): 276-79.

Hegde, K.T.M., P.T.Craddock and V.H.Sonawane. 1984. Report on the Excavation of Ancient Zinc Smelting Furnace at Zawar, Rajasthan.

Prakash Bhanu.1997. Metal and metallurgy. In *History of Technology in India* (Ed.) A.K.Bag. New Delhi: Indian National Science Academy. Pp.136-143.

Sing R.D. 1997. Mining. In *History of Technology in India* (Ed.) A.K.Bag. New Delhi: Indian National Science Academy. Pp. 62-68.

Willies L.1984. Ancient lead and zinc mining in Rajasthan, India. *World Archaeology* 16(2): 222-33.

Willies L.1987. Ancient zinc-lead and silver mining in Rajasthan, India. *BULP Interim Report* 10(2): 81-123.