

Zinc Smelting, On-site Smelters, Retorts & Debris and Source Mines at Zawar

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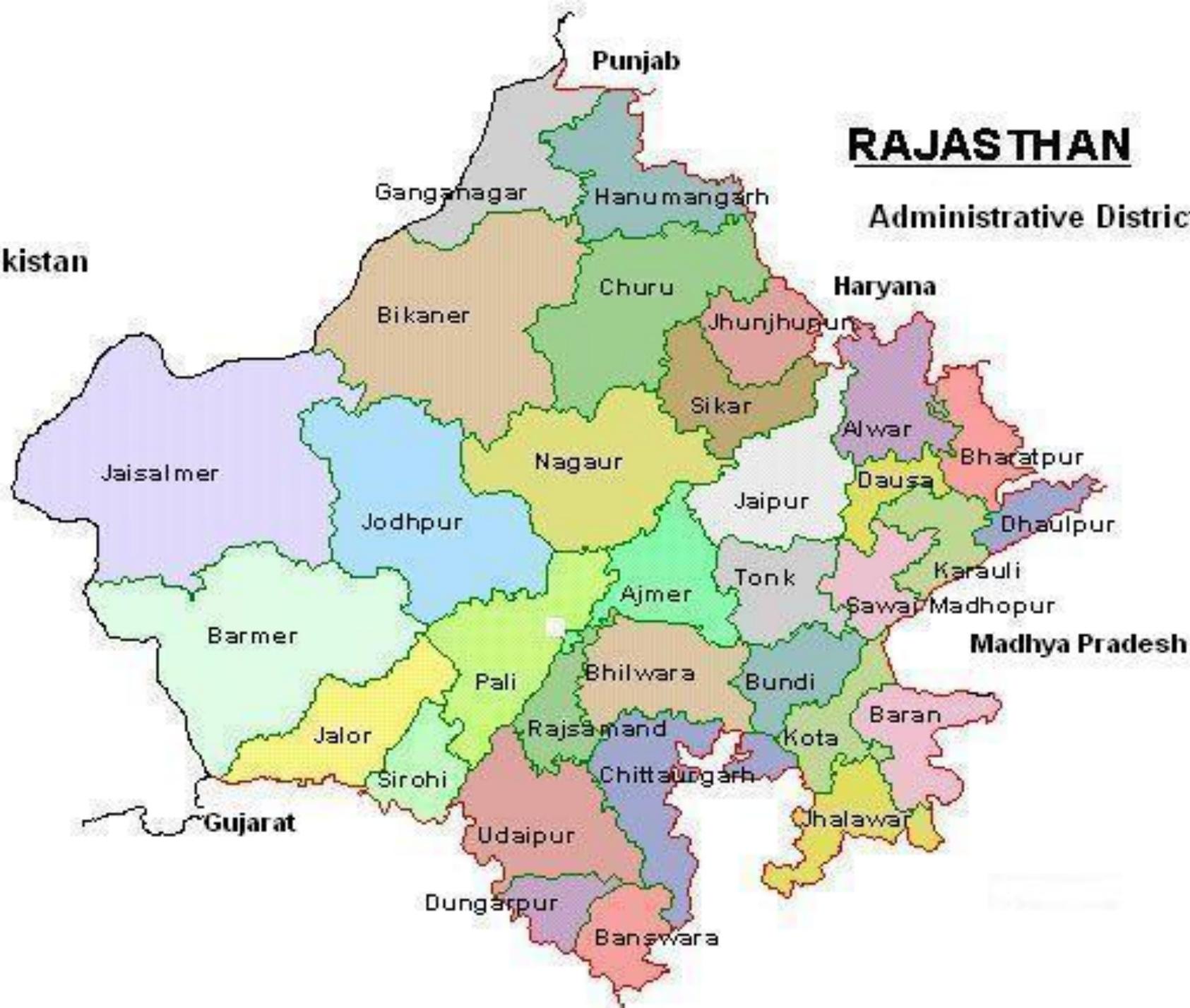
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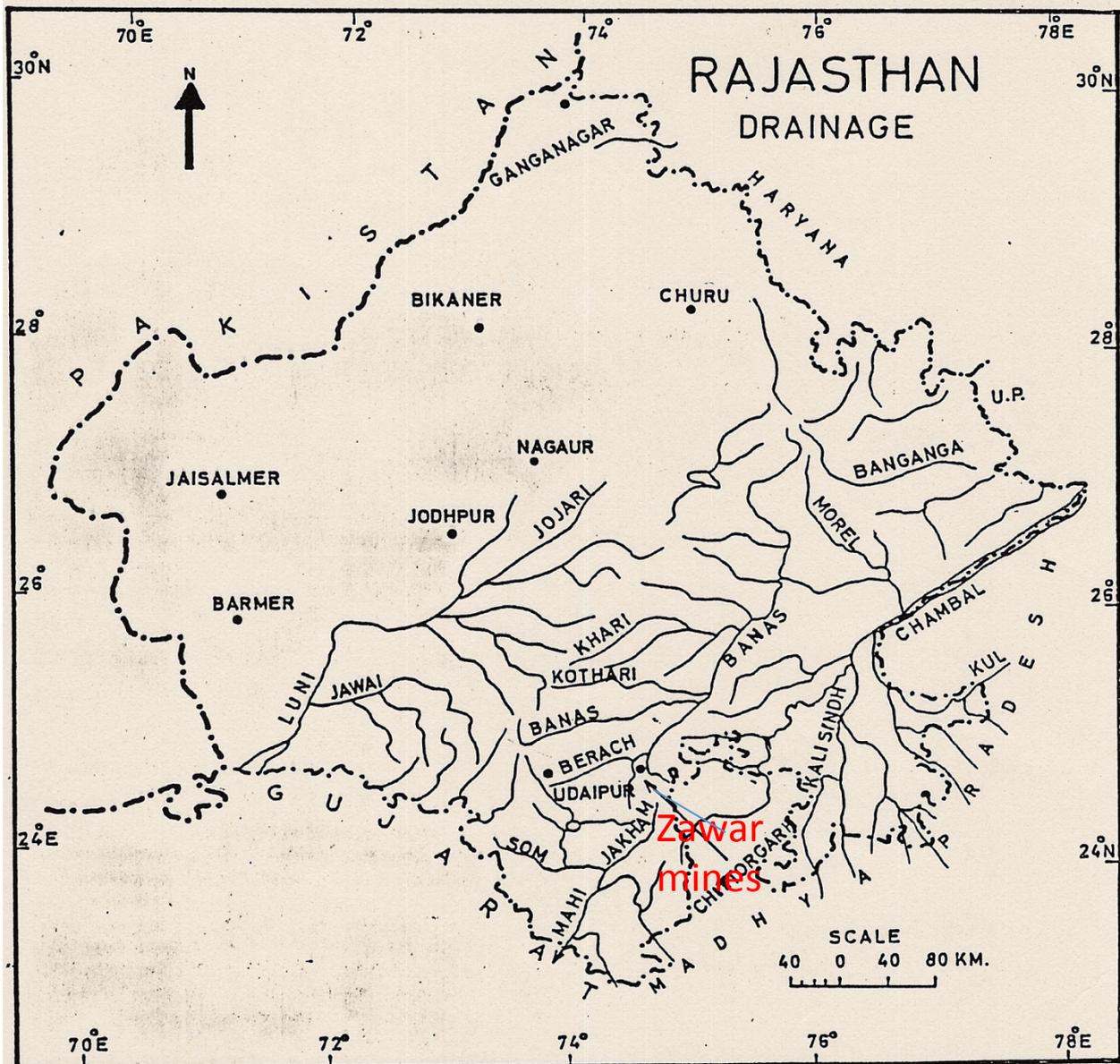
Industrial Heritage in India – knowledge, condition and
significance

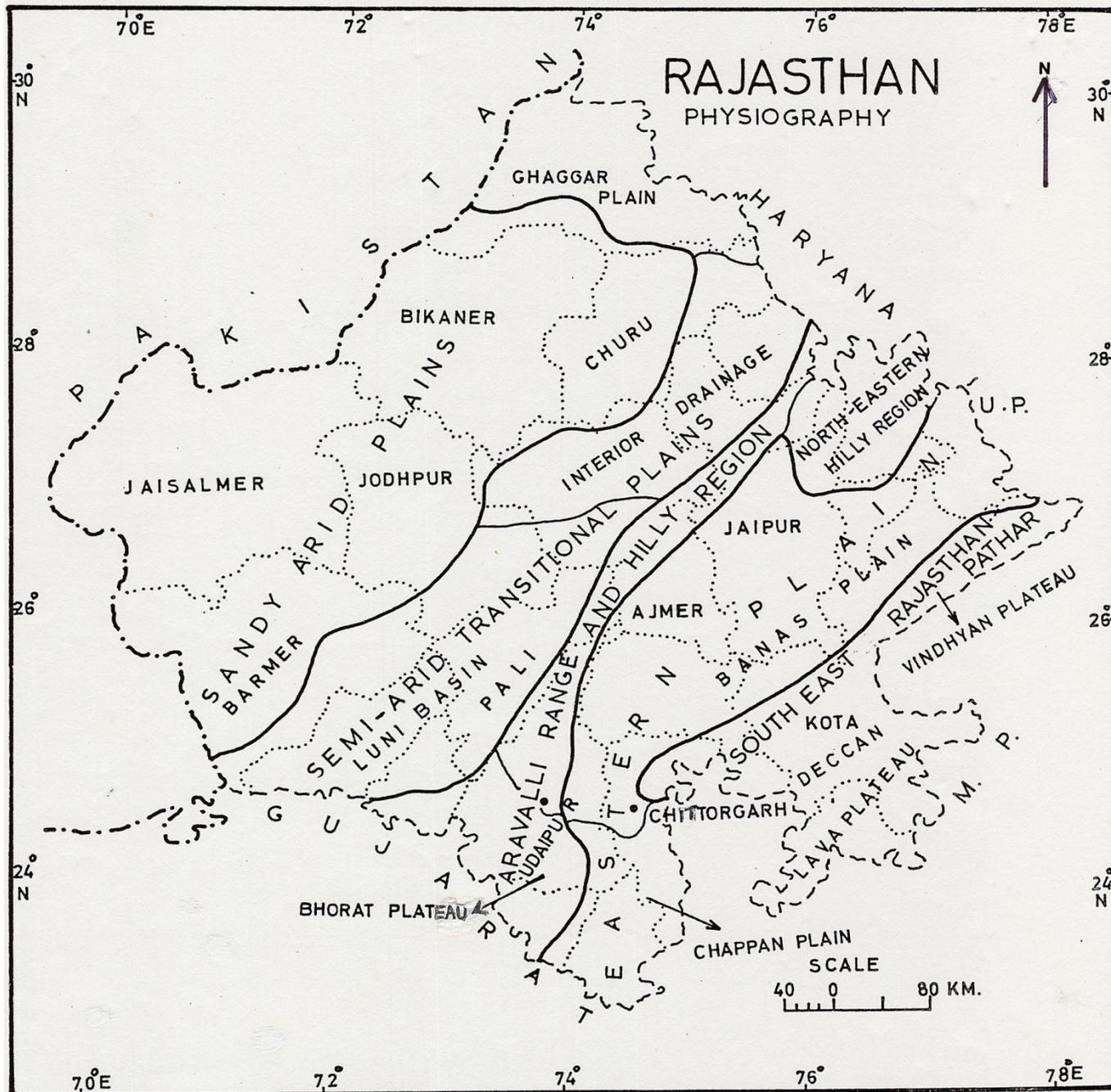
RAJASTHAN

Administrative Districts

Pakistan







- **Zinc** is a difficult metal to handle, but at Zawar **Zinc** was extracted and smelted from around the 14th century CE, and maybe earlier.
- The archaeo-metallurgical importance of Zawar has been described by H.V. Paliwal, K.T.M. Hegde, A.K. Biswas, Paul Craddock, Lynn Willies and L.K. Gurjar in various research papers and also by J.S. Kharakwal in his book titled "*Indian Zinc Technology in Global Perspective*, 2011



- The exact date of early mining activity in the Indian sub-continent is unclear, but it was known to the Harappan (or Indus Valley) civilization (circa 3200-2500 BCE).
- Evidence of ancient mines & metallurgical slag heaps and other debris may be noted in Rajasthan and adjoining areas of Gujarat, linked to certain mineral belts along the Aravalli Range.
- At least 145 localities have been identified with evidence of ancient mining and metallurgy.
- There are ancient mine openings and worked-out mine shafts on many hills in Mochia, Baroi, Balaria and Zawarmala, in the Zavar area of Rajasthan, where current mining is also on.

- The Zawar mines area (latitude 24°18'50"N & 24°22'47"N ; longitude 73°40'22"E & 73°45'08"E), 44 km from Udaipur in southern Rajasthan, covers an approximate area of 67 sq.km.
- The terrain comprises hilly lowlands and narrow valleys, between 90m to 300m above seal level in height.
- The area is one of the oldest lead–zinc-silver extraction areas in India. It stretches for at least 10 kilometers along the banks of River Gomati.
- Radiocarbon dating of wooden remains (ladder-ways, haulage scaffolds) found in the ancient mines at Zawar, indicate that during c.4th to 1st centuries BCE (Mauryan period) mining occurred in this region and nearby parts of southern and south-eastern Rajasthan.
- The mining and metallurgical industry apparently went into oblivion by the end of 7th Century and was re-started /discovered in the late 14th century. Vast quantities of lead, silver and zinc were extracted and smelted.

Hut on a mound of distillation retorts & possible furnaces debris



- The wider Zawar area has evidence of early mining activities – open cast and tunnelling - for ore containing lead-silver-copper. Mine shafts etc. and various material remains were reported in 20th century reports.
- The area also has physical remains of smelting retorts, on-site kilns, hill height debris mounds and modernized working mines from which zinc continues to be extracted & smelted.
- In the late 14th century, Mewar began to use its newly re-discovered mines of Zawar, which were part of a tract wrested from the Bhils of the Chhapan area. This helped in the economic prosperity of the kingdom.

- Vedic texts refer to the techniques of purifying the metals and use of gold, silver, copper, tin (tripu), lead and iron.
- Some of the over 90 chalcolithic sites ascribed to the Ahar Culture from south-eastern and southern Rajasthan have yielded evidence of copper smelting furnaces.
- Mining and the administrative network associated with it during the Mauryan period is described in the text, 'Arthashastra' (believed to be written by Kautilya, a.k.a. Chanakya, chief minister of Mauryan Emperor Chandragupta).
- This has information on ores, detailed instructions on mines organisation, and the system of revenue collection for mines and metals. The mineral resources of the earth were regarded as state property and were an important source of revenue for the Mauryan State

- In the Zawar area itself, remains of ancient mines, iron chisels and pestle-like hammers were noted in situ at ancient workings in the Mochia mine.
- Remains of wooden stairways, haulage scaffolds, and staging and drainage leets etc. also survive in many mines.
- Samples taken for radiocarbon (C14) dating from a scaffold and leet in the Zawar Mala mine have given C14 dates of 170 +/-60 BCE, and CE 30+/-50.
- The dates are comparable to other ancient silver/lead workings at Rajpura-Dariba and Rampura-Aguncha, located in the same sub-region.



- Radiocarbon dating of charcoal from piles of charcoal and wood recovered from the ancient mines and heaps of smelting debris at Zawar, Dariba and Agucha by the British Museum, London, has provided the main framework for the chronology, particularly for the early periods.
- Apart from these radio carbon dates, there are some known historical references to Zawar and other places, as well as some monuments in the vicinity of these areas especially the ruins of fort, dam and temples, whose dedicatory inscriptions (at some places) are clearly dateable.
- Together these elements enable a reasonably coherent picture of the development of mining & smelting industry in the area
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- The list of radio-carbon or C14 dates available is given in Table-1 that follows:
- *(After Craddock et al, 2000)*

Table -1 Radio-carbon dating of Zawar

Zawar (Mining)		Zawar (Lead Smelting)	
Sample No.	Age in Years (Before Present)	Sample No.	Age in Years (Before Present)
BM-2482	2150+/_110	BM-2485	1960+/_60
BM-2483	2180+/_35	BM-2487	1930+/_80
BM-2148R	2350+/_120	Bm-2488	1370+/_80
BM-2149R	2140+/_110	BM-2486	200+/_35
PRL-932	2140+/_100	BM-2484	100+/_45
PRL-933	1900+/_140	Zawar (Zinc Smelting)	
Sample No.	Age in Years (Before Present)	Sample No.	Age in Years (Before Present)
BM-2639	2040+/_70		
BM-2634	1340+/_100	PRL-935	840+/_130
BM-2381	2360+/_59	BM-2223	530+/_50
BM-2666	390+/_50	BM-2578	500+/_50
BM-2388	170+/_50	BM-2243	350+/_130

- Work in the Zawar mines area led researchers from the MS University Baroda, the British Museum, and Hindustan Zinc Ltd., Udaipur, and others, to conclude that an indigenous process of zinc smelting was known as early as the 14th-15th century CE.
- This predates zinc production in Europe.
- Analysing mining techniques, ore sources, and preparation of 'charge', zinc distillation process, and so forth, researchers believe that originally only silver and lead was worked at Zawar, with zinc smelting a later development.
- Zinc extraction and smelting at the Zawar mines developed into a major industry by the 16th century and continued to flourish until the late 18th century. This is attested by the vast slag heaps at Zawar Mata, 25 miles southeast of Udaipur, along with zinc retorts, disused furnace- sites etc. and remains of old structures and temples over a large area.

- C14 dates from Zawar indicate that Zawar Mala and Mochia mines, were worked from around the time of the Mauryan Empire. Lead slag heaps and suspected silver cupellation debris present at northern bank River Tidi near village Singhatwadai s more or less contemporary, and suggests that lead was the principal metal exploited 2000 years ago Silver was extracted from it. This is seen from the cupellation debris at Dariba, and Agucha, and the low silver content in the slag at these locations.
- Data suggests that during Mauryan times a well-organised mining & metal industry was in existence, and work on extracting and processing the ore happened in a systematic manner. A planned sequence of mining is noted at the Zawar Mala mine at Zawar, showing an ability to control drainage and ventilation several hundred metres below ground, and manage the water table in the South Lode.

(The recovery of 10 Lead metal ingots weighing 5kg each and a brass lamp during the digging of trench for foundation of house in the vicinity of Ahar archaeological mound tentatively dated to 3rd Century CE, is significant too).

- The Samoli Inscription details some of this activity in the 7th-8th centuries - noting the presence of eighteen *vaitalilokvikhyalatam*, (? mining engineers), who lived at 'Kupagiri' with apparently healthy and prosperous workers.

- Amongst all the mines of Zawar, the Balaria mine ore has a higher zinc / lead ratio (approximately 5 / 1) than any other mine. Cadmium and silver are associated with the sphalerite and the galena respectively.
- The ancient workings are mainly confined to the eastern limb and in the central hinge zone of the Zawarmala Mine fold while in the western limb the ancient workings are small and widely separated. Sulphide mineralisation occurs throughout the dolomite horizon but is confined to structural openings, i.e. shears and tensional fractures. The principal sulphide minerals are pyrite, sphalerite and galena with minor amounts of pyrrhotite and traces of chalcopyrite. Silver is found as thin films, flakes, foils and wires, concentrated along the fractures near pockets of crystalline galena.
- The Baroi mine is part of the Mandli, Baroi Magra and Zawar formation of the Tiri Series. Here lead is more abundant than zinc. The principal sulphide minerals are galena and sphalerite with minor amounts of pyrite, pyrrhotite, and traces of chalcopyrite. Dolomite, quartz and sericite are the main gangue minerals. Silver occurs in solid solution in the galena, and cadmium is associated with the sphalerite.

Older Mining Methods

- Judging from the presence of vast extent of ancient mines in the form of long open trenches, pits circular and rectangular shafts all along the top of the ridges in the area it seems that mining systems were developed in the latter half of the first millennium BCE at both Mochia Magra and Zawar Mala Magra. The absence of later working or collapse at the latter mine has resulted in the virtual intact survival of one of the most extensive and sophisticated ancient mining systems known anywhere. (Willies et.al. 1984 and Willies 1987).
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- Due to the intense folding, the ore bodies usually lie at a steep angle, and were followed down by the miners from where they outcrop on the top of the steep ridges, some 300 metres above the valley floor.
- Traces of early mining are visible along a total of at least 12 km of the ridges, including major excavations which form the tops of stopes, shafts for ventilation, access and haulage routes leading down vertically to intersect the inclined stopes, and also great opencast mines on Mochia and Balaria. The ore bodies were often several metres thick and many metres wide and thus great stopes developed following the ore down for a hundred metres and sometimes more into the hills.

- Survey by a British Museum team found that the mining was helped by fire-setting, evidenced by the rounded profiles of the galleries and supporting pillars the smooth surface of the rock showing few pick or chisel marks. Some of the rock faces still bear traces of burning, everything is smoke blackened and the floors are buried deep in charcoal, ash and burnt rock. At some faces, the method of fire setting could be observed.
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- The wooden stairways observed at ancient mines of Zawarmala are sufficiently broad for two people to pass without difficulty. The obvious implication of this is that an almost continuous stream of workers moved both up and down these stairways carrying baskets of ore and debris (gangue) and pitchers of drainage water; remains of both types of container are quite common in the mines, Much of the waste rock debris (deads) was carefully stacked back inside the galleries as they were worked out. Where the waste rock were stacked in the steeply sloping main stopes it was necessary to build retaining walls and stabilize with timbers set from floor to ceiling.
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- The water running down the stopes was collected in channels and by launders hollowed from tree trunks, which survive in quantity throughout the mines. With these much of the water was brought together for removal before it reached the bottom. The larger water clay pots found in the mine have a capacity of about five litres, and thus several hundred journeys up and down the ladder-ways would have been necessary each day in each gallery system just to drain the mines.

- The pottery included many vessels with straight flared sides, resembling small pudding basins or bases of larger vessels trimmed down. These were probably lamps. If filled with cotton waste and soaked in vegetable oil, they could have given light for several hours. Preliminary tests by Dr. John Evans of the North East Polytechnic College of London have confirmed that the clay walls of the vessel do contain vegetable oils which would seem to confirm their use as lamps.
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- From the observation made by British Museum team during its survey of ancient mines the team postulate that the mine developed in the following sequence. First a large number of small quarries and trial mines took out the richest and most accessible pockets of ore, and then the steeply dipping main ore bodies were mined by driving galleries down into them and extending laterally from them (underhand stopeing).
- Pillars of ore were left at frequent intervals to support the roof but after the main operations had ceased most of these were removed together with the remainder of the ore as the miners worked back towards the surface (retreat mining).
- Probably the final stages in the mining were the extensive surface quarries to remove the easily accessible but low grade ore. Such opencast operations are found all along the top of MochiaMagra, and a very considerable body of material must have been removed.
- Dates for the first three phases of mining at Zawar Mala all lie in the range 4th to 1st centuries BCE, and the dates from the underground working at Mochia suggest the 5th century BCE, but the opencast working above could be much later, as suggested by the one carbon date of 390 +/- 50, from the Mochia surface workings.

Ore dressing

- Just outside the mine entrances are the usual heaps of spoil-rock fragments of all sizes from dust through to boulders. Within a short distance of the mines (under a hundred metres) are more heaps of pea-sized rock fragments, and the very occasional hard stone pebble used as a hammer stone. These are apparently the remains of a beneficiation process. The general absence of stone tools suggests that most of the hammers were of iron. The ore would have been broken up into pea-sized pieces and the good ore selected by hand-picking.
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- The presence of small rounded pits on the rock surface near the mine openings /smelting sites along with vast heaps of crushed debris indicates that the mined ore was crushed, handpicked and later ground before smelting. These are visible at all the places.
- At Baroi hill hard silicious dolomite outcrop adjacent to ancient mine opening, a number of small to medium size mortar pits 10 to 30 cm in diameter and 15-30cm deep with rounded bottoms were observed. These were probably used for crushing and grinding to upgrade the ore before smelting



Smelting

- The problem with producing zinc from its ore arises due to its volatility (boiling point 907°C Centigrade), when using simple traditional simple shaft furnace, in which smelted metal settles down at the bottom ingot, whereas zinc ore produces zinc vapor which instantly get re-oxidized lost in the flue and is lost. Because of this zinc could not be isolated from its ore in Europe till 1736 CE. William Champion of Bristol, UK, first produced metallic zinc metal from ore.
- Zawar's ancient smelting method resolved this problem by smelting zinc ore through high temperature distillation and condensation technique using clay retorts.
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- In India various Zinc Smelting processes are described in Sanskrit texts like *Rasa-Ratnakar* (2nd Century CE), *Rasprakash-sudhaka* (12th Century CE), *Rasratnasammuchchaya* (13th Century CE). These texts recommend distillation and condensation techniques for extraction of mercury and zinc from their ores.
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- The archaeo-metallurgical Investigation at Zawar discovered intact ancient zinc smelting furnaces still containing their full charge of 36 retorts . The furnaces were used to carry out one of the most sophisticated pyrometallurgical operations in vogue in this part of world before industrial revolution in the West, a process which is still basic to all high temperature distillation & condensation operations. (Craddock et.al. 1985)

- Each furnace is in the form of truncated pyramid and 60cm in height. The exterior wall of it is made up of regularly arranged brick, the interior wall is much less regular and often large gaps in the brick work were clay and refractory fragments. The furnace is divided into two parts, a lower cooler chamber which is square in plan and separated by perforated plat/brick, from the upper furnace chamber.
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- The internal dimension of the furnace at its base is 660mm X690mm, being slightly wider across the sides with an entrance to the lower chamber. The area in the front of the furnace is paved with large flat bricks. The furnace discovered in the retort heaps in the old Zawar township is similar in design but longer in size, approximately 1100cm square at the base to accommodate bigger retorts.
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- The perforated plate consists of four identical 50mm thick perforated bricks perforated with regular pattern of large and small holes, fitting closely fitted together and resting on a projected ledge inner furnace wall at the sides with a single clay peg/pillar providing support in the centre. This form the plate on which the retorts rest and act as grate of the furnace. The large holes are to accommodate the condenser necks and smaller holes for the passage of air into the furnace and ash to drop through.
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- A complete retort is cylindrical in shape tapering at one end. The retorts are of two principal sizes; smaller retort is approximately 200mm in length and 80mm in diameter while larger one is 350mm in length and 120mm in diameter. The *Rasratnasamuchchaya* (13th Century CE) recommends a similar type of crucible to extract zinc from its ore.

- Before Zinc ore could be smelted it was necessary to drive off sulphur converting zinc sulphide to oxide. Absence of detectable amount of sulphur in the retort residue suggests that the ore was calcined before smelting.
- The calcined ore, and reducing agents and necessary fluxes such as dolomite, charcoal and salts or borax, were filled in the retorts. In many early smelting it was the practice to bind the ground ore and calcined ore into balls with some sticky organic material. The ore and fluxes in the discrete balls would stop the charge to from falling out of retorts when they were initially inverted in the furnace, and at the same time would facilitate escape of zinc vapor formed during the firing. The conical condenser head and neck was then firmly fixed and luted on the retort with clay , leaving no air gap. To get a clear route for zinc vapor to escape from the retort into condenser head, a wooden stick was used to push the condenser through the sticky charge. On heating the stick would char and dropout, leaving a clear central channel running through the charge into the condenser through which zinc vapor and carbon monoxide could escape into lower condenser chamber where zinc will condense as metal.
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- Filled retorts were loaded in an inverted position in the main furnace chamber. The retort rested on the perforated plate with the condenser necks protruding down into the cooler chamber below. The retorts were fired *in situ*, with charcoal over them. The condensed zinc dropped into the zinc collecting vessels (now missing) placed beneath.



ANCIENT TOOLS USED IN ZAWAR

- One of the works of alchemy, compiled in the 13th century, the *Rasaratnasamuchchya*, coincides with the large scale production of zinc at Zawar. Words such as 'rasaka' or 'kharpara' suggest the substantiation and use of zinc. Zinc was also used for 'bhasma' (powdery ash of metal), and for making 'yasada' or brass, which looked like gold. Hence, an appropriate name for zinc became 'jasada' or 'rasaka.' The eighth chapter discusses the 'koshthi' used for extraction of metallic content. The tenth chapter describes different types of "koshthi' or furnaces. 'Siddharasa, Angara, Gara and Patala Kosthi yantra". Of these, Gara Kosthi and Angara Kosthi types of furnaces seem approximate the ones found in Zawar.
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- KOSTHIKA YANTRA:
- It was a furnace with a width of sixteen *angulas* (fingers) and a length of one *hasta* (hand) and has a regular structure. It is used for extraction of *satva* (extract) from *dhatu* (ore). For this double chambered furnace, good quality charcoal was filled in the upper part of the furnace and sufficient air was blown through the lower opening.
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- GARA KOSTHI:
- This had a depth of 12 *angula* (fingers) and a diameter of one *pradesa* (4.5"). To construct and assemble this kind of a furnace, a ring like structure was made at the height of four *angula*. A circular earthen pot consisting of many holes was placed over the ring like structure. Charcoal was filled inside it and air was blown via *vakra nala* (bent pipe). This instrument was used to for separation and destruction of the associated metallic impurities from the ore.

ANGARA KOSTHI

- This type of furnace was meant to be quadrangular in shape and have a height of 22.5 inches.
- The length and breadth should be exactly half (11.25") of the height.
- It has to be well covered with a wall made of soil.
- Underneath this, was to be an opening of half *vitasti* (9") in one of the walls.
- Beneath this, came another opening of the size of one *pradesa* (4.5").
- Close both openings made in the wall with bricks and seal their joints.
- The furnace should be filled with charcoal and air is blown via two blowers.
- The upper chamber can also be used to fill in charcoal.
- The balls prepared for 'satva patana' were meant to be put in five numbers in one go. This instrument is called the Angara Kosthi and was used to extract metals from hard substances.

- The charge was prepared in the following way:
- Calamine was mixed and rubbed with turmeric, myrobalans, resin, salts, soot, borax, acid juices and one fourth of its weight of 'Semicarpus anacardium.'
- A tubulated crucible was smeared with the above mentioned mixture and set to dry in the sun. Its mouth was covered with another crucible inverted over it.
- Heat was applied to this apparatus.
- When the flame coming from molten calamine turned from blue to white in color, the crucible was held with a pair of tongs. (Change in color of flame ensures that smelting was over). Its mouth was bent downwards and it was thrown on the ground.
- Proper care was taken and precautions were followed to ensure zero damage to the tubular part. The essence and lustre of tin which was dropped was collected for further use. Another version of this process is given in the text from Ray(1956: 172).
- Equal parts of lac, barks of peepal (fig, ficus Religiosa) tree, turmeric, myrobalans, treacle, resin, rock salt, borax and 'kharpara' (zinc ore) were mixed together.
- This mixture was baked with cow's milk and ghee (clarified butter).
- Small balls were made out of this product and were placed into a 'vrantak moosha' (crucible or retort) and heated at high temperatures.
- The contents were poured into a slab of stone. The essence of 'kharpara' having an appearance of tin was used.

- A study of ancient mines, slag/retort heaps, archives and historical data and temple architecture suggests that between 10th and 16th centuries AD mining and extraction/ smelting thrived at Zawar, and the town and its surrounding area became a famous pilgrimage centre.
- Zawar and its surrounding area has several clusters of ancient temples, heaps of refractory material of zinc, remains of ancient residential structures, ancient mines, lead slag, water reservoirs, remains of ancient furnaces, and small medieval period garrison forts.
- Archival records note that there was a Sub-Treasury of the erstwhile Mewar State in the Zawar valley in late medieval times.

- In 1945 Mewar State leased out the mines to the Metal Corporation of India, a private company. In 1966 the mines were taken over by Hindustan Zinc Limited, a Public Sector Corporation. Hindustan Zinc is presently privately owned and is a Vedanta Group company
- Present methods are based on :- Stoping, mineral processing, crushing, grinding, flotation, dewatering, tailing disposal, dispatching of concentrates, smelting

- Until 1872, the lead and zinc mines at Zawar yielded a net annual revenue of Rs 2 lakhs.
- However, the famine of 1812-1813 was so severe that Mewar State was completely devastated and the Zawar mines, which had been worked since Rana Lakha's reign, were abandoned at the time, and never fully recouped.
- Furthermore, over time the level of water in the had increased and manual pumping of water from the mines eventually became exceedingly difficult. The State could not provide machinery for this.
- The situation changed in 1945, when Mewar State leased the mines to a private company known as the Metal Corporation of India. (The company worked the mines till 1966, when it were taken over by the Hindustan Zinc Ltd., a public sector company of the Government of India. In 1948 the mines produced 700 tonnes of lead concentrate and 1600 tonnes of zinc concentrate).

- Zawar mining and smelting technology apparently pre-dates other high temperature pyrotechnologies across the world.
- Acknowledging this, the American Society of Metals (AMS) , USA, declared Zawar as an Historical Landmark, placing a plaque at Hindustan Zinc Ltd at Zawar in February 1989.

American Society of Metals (AMS) 1989

Declaration at Zawar

“At this site are preserved the zinc retort distillation furnaces and remnants of related operations. The technical sophistication and application of scientific principles are unparalleled elsewhere in the medieval period.

The element of standardization and mass production foreshadow the industrial revolution. This is the earliest example of high temperature distillation operations...

The operation first supplied zinc for brass making used for fine instrument making in Europe, a forerunner of the Industrial Revolution”



Ramnath Temple, Zawar



Zawar, with its associated remains, has made a major contribution to the scientific and technological achievements of the world, and has potential for obtaining World Heritage Status.

The local mining technology and its in situ evidence deserved documentation, research & analysis, and protection. Zawar also is a valuable record of industrial heritage, and should be considered for listing on the World Heritage Site Tentative List for eventual inscription, and for being getting the highest level of national protection by the Government of India.

In August 2014 I had placed a Resolution before the 36th Meeting of Central Advisory Board of Archaeology 2014, calling for :-

National level (Archaeological Survey of India) protection for the archaeological and archaeo-metallurgical remains, including ancient mines, remains of zinc smelting, lead-silver-zinc ore extraction, retorts, furnace-remains etc., and associated activities, at Zawar (Rajasthan).

ANCIENT MINING TECHNIQUE	PRESENT MINING TECHNIQUE
1. Old underhand Stoping method used as the first level of mining.	1. New Transverse Sublevel Stoping used as the first level of mining.
2. Primitive tools were made use for example handmade retorts, earthen pots, condensers, clay plates, hammers, chisels, furnaces and other organic material.	2. Modern machines are made use of. Examples: crushers, grinders, ball mills etc.
3.Grinding and washing took place in manually dug pits.	3. Winnowing is done in running water, ball mills etc.
4. Trenches and tunnels were constructed to facilitate incoming and outgoing of water used for flotation.	4. New circuits and channels have replaced old tunnels.
5. Transportation of material was manually conducted; baskets and wooden stairs were discovered in the ancient mining sites.	5. Transportation of material is facilitated by modern conveyor belts, pipelines etc.
6. After mining, the lode was taken for smelting. Handmade retorts were used along with a wooden stick. This process took a long time to finish and tiny amount of zinc was left behind in the retorts.	6. Handmade retorts are no longer in use and machines have replaced them. Smelting takes place in mechanized furnaces. These machines save more time and energy. They are efficient and ensure negligible amount of wastage.
7. Retorts were non reusable and after using once for mining purposes, they were turned into building material for many homes.	7. In modern times, storage ponds have been made for decantation. The water is also recycled in flotation and frothing.

Identification Number	Site	Latitude	Longitude	Notes
Z/IH/01	<p>Ancient Mining sites in the present mining areas</p> <p>Mining areas :</p> <ul style="list-style-type: none"> i Zawarmala mine ii Balaria mine iii Mochia mine iv Baroi magra mine 	-	-	<p>Ancient mining sites visible on the surface:</p> <ul style="list-style-type: none"> a. Cave near the Chattri b. Maharana Pratap Cave in Zawarmala c. Cave near Hirankashyap Fort at Haran Mangri d. Mining caves near Baroi mine e. Near the pedestrian bridge of Shiv Temple f. Opposite Hanuman Mandir, Ashok Nagar
Z/IH/02	Bhattis/ furnaces	-	-	<ul style="list-style-type: none"> a. Near Ramanath Temple b. On hillock near Jain temples (main temple road)
Z/IH/03	Remains of retorts.	-	-	
Z/IH/06	Remains of the historical dam at Tidi river	24° 20' 47.92"	73° 41' 25.88"	

Monuments and Sites

S.No.	Identification Number	Site	Latitude	Longitude	Notes
1.	Z/BH/01	Zawar Mata Temple	24° 20' 41.80"	73° 41' 01.20"	Site is located near the Tidi river. Temple complex with five structures, a chattri and baoli. Front plaza also used for public gatherings.
2.	Z/BH/02	Shiv Temple	24° 20' 38.67"	73° 41' 02.87"	The site is located across the river opposite to Zawar Mata temple. It has a two built structure and a open space for yagya and worship. One is a temple complex, and another is for sadhus.
3.	Z/BH/03	Hindu temple	24° 20' 47.38"	73° 41' 02.18"	The temple is in the state of ruins with only the shikhar remaining over the garbha griha
4.	Z/BH/04	Jain Temple	24° 20' 57.46"	73° 41' 21.66"	Site is almost square in plan. Most of part is destroyed. Used by local people as cattle shade and as a storage. Inscriptions were found.

S.No.	Identification Number	Site	Latitude	Longitude	Notes
5.	Z/BH/05/A	Jain Temple Complex- Group of 5 temples	24° 20' 58.78"	73° 41' 23.07"	A complex with 5 temples within the site. The temple is in the state of ruins. An underground tunnel found connecting two temples.
	Z/BH/05/B		24° 21' 0.27"	73° 41' 24.28"	
	Z/BH/05/C		24° 20' 59.21"	73° 41' 25.78"	
	Z/BH/05/D		24° 20' 59.66"	73° 41' 26.17"	
	Z/BH/05/E		24° 21' 01.76"	73° 41' 24.74"	
6.	Z/BH/06	Hindu Temple on the banks of Tidi River	24° 20' 58.34"	73° 41' 29.72"	A single storey structure with garbha griha with shikhra. Ganesha statue is carved over the gate of garbha griha.
7.	Z/BH/07	Chattri	24° 21' 20.50"	73° 41' 27.75"	A flat roof supported on 4 columns, which creates a platform. Said to be the meditation place of Hiran Kashyap.
8.	Z/BH/08	Ramanath Temple	24° 20' 58.19"	73° 41' 43.01"	Ramanath temple has a style of vaishnav temple. 5 temple in the complex, and a water kund. 4 temples are situated on corner and a main temple. Inscriptions were found.
9.	Z/BH/09	Jain Temple (Complex of 2 temples)	24° 21' 0.75"	73° 41' 55.41"	Two structures identified. Only plinth remains for one of the structures, the other has the garbha griha with Shikhra on top.

S.No.	Identification Number	Site	Latitude	Longitude	Notes
10.	Z/BH/10	Jain temple(Complex of 2 temples)	24° 21' 0.47"	73° 42' 04.58"	Two temples located perpendicular to each other. Broken statues were found. The temples are in a state of ruin
11.	Z/BH/11/A	Jain Temple Complex	24° 21' 01.12"	73° 42' 09.55"	An old temple complex with decorative columns, mandapa, garbha griha, and a worship area. Inscriptions found on the beam of mandapa.
	Z/BH/11/B	(2 temples)	24° 21' 0.65"	73° 42' 09.46"	
12.	Z/BH/12	Jain Temple	24° 21' 01.25"	73° 42' 10.77"	The site is adjacent to prabal shanti vihara. 3 shikhara connected through a single structure below. The temple is in the state of ruins.
13.	Z/BH/13	Jain temple (Single Structure)	24° 21' 02.92"	73° 42' 12.88"	A single structure with Garbha Griha and Shikhara on top. The temple is believed to be a Hindu temple.
14.	Z/BH/14	Ganesh Temple, Gram Balaraiya	24° 21' 17.78"	73° 44' 26.66"	Located on a hillock. In the past, local people used to pray here for rains.
15.	Z/BH/15	Hanuaman Temple	24° 21' 28.42"	73° 43' 57.01"	Located in front of the Kendriya Vidyalaya. With RCC roof on top.
16.	Z/BH/20	Hirankashyap Fort at Haran Mangri	24° 21' 01.56"	73° 42' 30.71"	Site adjacent to tailing Dam. Site is believed to have 3-4 fresh water springs, the source of which is unknown.

S.No.	Identification Number	Site	Latitude	Longitude	Notes
17.	Z/BH/21	Fort currently used as school	24° 20' 52.77"	73° 41' 02.32"	The fort currently in the state of ruins was used as a school 8 years ago.
18.	Z/BH/22	Dharamshala near Ramanath Temple	24° 20' 59.14"	73° 41' 47.79"	Single storey structure across Ramanath temple. Currently used as a cattle shed by the residents.

- Extensive work on Zawar is required to cover the lacunae in knowledge about the areas full potential.
- Zawar is much more than just another site. Further archaeological work is recommended and a strong commitment to showcase the exceptional cultural value of this heritage.

Industrial Heritage

- The site is marked with archaeological and industrial sites of high significance like remains of Metallurgical activities. There are remains of old mine workings of mining of zinc, lead and silver in the area. The ancient zinc smelting site is located on the banks of river Tidi and is marked by immense heaps of slag and retorts. In the early 1980's a team including Hindustan Zinc, British Museum, and M.S. University, Baroda was constituted to investigate the remains of early lead zinc mining and smelting industry present in the Zawar.
- Extensive archaeometallurgical investigations were carried out during the period. The investigation led to excavate more than half a dozen smelting furnaces in the area by Craddock and his team. The investigation helped in understanding the ancient mining and smelting process of zinc.

The Nizhny Tagil Charter for the Industrial Heritage defines Industrial heritage as “heritage that consists of the remains of industrial culture which are of historical, technological, social, architectural or scientific value. These remains consist of buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure, as well as places used for social activities related to industry such as housing, religious worship or education.”(as per THE NIZHNY TAGIL CHARTER FOR THE INDUSTRIAL HERITAGE, July 2003).

- Zawar is definitely Industrial Heritage.
- Lets consider the next steps.....