



Lalit K. Gurjar M.Sc.

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This obituary is to record the passing of L.K. Gurjar M.Sc. on 31st March 2022. He was sometime Deputy General Manager (Geology) at Hindustan Zinc Limited (HZL) and an active participant in the major international archaeological programme researching early metallurgy, in particular the great Mauryan and Medieval silver, zinc and lead mines at Zawar, Dariba and Agucha in the Aravalli Hills of Rajasthan. This account of his life will concentrate on the archaeological and historical aspects of his career in geology and metallurgy, as is appropriate for a historically orientated journal such as the *IJHS*.

Lalit was born in Nathdwara, renowned for its Krishna temple, approximately 40 km from Udaipur on the 17th April 1951, the eldest son with three brothers and two sisters. Whilst still a teenager, the family moved to Udaipur where he began his college studies. After receiving his B.Sc. in science, Lalit moved to the Maharaja Sayajirao University of Baroda at Vadodara, specialising in geology, for which he received his Masters degree in the first division.

He started his professional career in geological exploration with the Rajasthan Public Service to take up his job as a Gazetted Officer with the Directorate of Mines and Geology. Wishing to broaden his experience both of a wider range of geological materials of economic significance and also of the geology of India generally, he joined the Oil and Natural Gas Corporation (ONGC). Whilst with them, he was posted to many parts of India including Assam and Kashmir. Lalit was keen to further expand his experience and in 1973 he joined HZL, specialising in the mining geology and exploration of metals. This was to form the basis of his work deepening into a life-long research interest. An important part of his work was conducted at the long established zinc mines at Zawar some thirty km south of Udaipur. More specifically, his investigations with his colleague Dr. N.N. Singh at the

Zawar Mala mine defined a number of potential ore bodies, thereby prolonging the life of the mine. These deposits lay beneath the extensive and very complete early mining operations, awakening Lalit's interest and giving him familiarity and experience with early mine systems generally which were to prove invaluable in the later archaeological exploration and excavation both at Zawar and the other HZL mines (Fig. 1).

From Zawar he moved back to Udaipur with his family, including his wife, Pramila and children, Praveen, Sandeep and Kalpana (Fig. 2) to the HZL headquarters. There he now had additional responsibilities to contribute to the company's geological and exploration data management scheme, working on conceptual models for identifying potential deposits suitable for exploration on a global scale. He also became associated with the prestigious Grass-Root Exploration project of HZL in Ajmer for the identification of base metals including the GEOTEM, airborne electro magnetic survey system. Lalit concluded his official career at HZL as Deputy General Manager (Geology) after some 35 years in service. However this did not terminate his association with HZL which continued with consultancy work, not just in India but also in Oman, and with others, notably in Nigeria. There he carried out feasibility studies at the lead/zinc deposits at Abakaliki in the south east of the country, once again where there was abundant evidence for earlier working going back into the distant past.

As already noted Lalit's acquaintance and interest in the evidence of ancient metallurgy had begun long before at Zawar with its abundant evidence of the mining and smelting of zinc ores and this interest was to develop in the later part of his career, first at Zawar and then throughout India, and continued through his retirement.

The British Museum in conjunction with the Archaeology Department of the Maharaja Sayajirao University of Baroda had been interested in the evidence at Zawar including the great heaps of zinc smelting retorts and together with HZL, set up a joint archaeological research project. This was to survey and excavate the remains to establish the age and technology of the interesting and

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Fig. 1 Lalit inside one of the extensive galleries at Zawarmala Magra in 1982, mined for zinc in the Mauryan period, and almost perfectly preserved. (P.T. Craddock photographer)



Fig. 2 Lalit with his daughter, Kalpana at home in Udaipur in 1982. (P.T. Craddock photographer)

scientifically advanced processes carried on there, arguably the first transition from laboratory technology to a successful commercial process anywhere in the world. It should be made clear that right from the start HZL were not just involved of necessity because they operated the mines, but as active partners with a keen interest in researching the history of their properties. This involvement commenced right from the inception, in the design of the project, through supporting and to a large degree running the actual excavations, followed by the long post-excavation work including scientific analysis through almost four decades. Through the good offices of Mr. H.V. Paliwal, Director (Mining) at HZL, Lalit was assigned to the project as the company's day to day contact working directly with the field teams, including those from Baroda under Prof. K.T.M. Hegde, Dr. L. Willies of the Peak District Mining Museum, Derbyshire and the



Fig. 3 Setting up the archaeological project at Zawar in December 1982. From the left, Prof. K.T.M. Hegde, Dr. L. Willies, H.V. Paliwal and Lalit is on the right. (P.T. Craddock photographer)

British Museum (Fig. 3). His overall intelligence, organising ability and enthusiasm for the project were immediately apparent. In the first instance, he was in charge of the logistics of the project, organising the often considerable labour force, transport, accommodation, equipment etc., but this rapidly expanded into helping to choosing the actual sites for recording or excavation both above and underground, based on his knowledge of the mines. Lalit was also closely involved with the more academic post-excavation research and publication.

From the start he made discreet but effective contributions to our programme based on his practical understanding of the realities of working at Zawar. This is well exemplified by the occasion when I had organised a day's field walking over about 20 km of very rough ground. This turned out to be far too ambitious and at the end of the day with the light fast fading we were on the roadside still about 10 km from home. In the days before mobile 'phones this was potentially serious, when suddenly apparently out of nowhere a HZL bus appeared. Lalit explained that he had had his doubts from the beginning, but did not want to interfere, so instead had privately arranged for a company vehicle to be on standby at the point where he estimated we would likely to be at the end of the day.

Lalit also carried out some excavations of the furnaces at Zawar himself, and in one of the furnaces found a hoard of freshly minted silver coins minted at Ahmadabad in 1593 CE which, as well as their intrinsic importance, enabled the furnaces to be closely dated.

The excavations extending over several seasons through the 1980s generated large quantities of materials, ores, furnace fragments, retorts, crucibles and slags, that required scientific examination to establish the parameters of the process's involved. This scientific work was carried out jointly at the British Museum Research Laboratory and at the HZL laboratories, with Lalit overseeing the HZL scientific programme.



Our investigations at Zawar showed that there had been two major periods of activity, first during the Mauryan period in the late first millennium BCE and then again in the Medieval- Post-medieval period from the 14th through to the later eighteenth century, and moreover that these endeavours were very different. In the later operations there can be no doubt that the principal activity was the production of zinc metal by distillation and condensation in retorts. However the earlier evidence was much more difficult to interpret. Certainly there were no retorts, and at the other contemporary major mines in the Aravallis, described below, the same lead/zinc/iron sulphidic ores were worked for their silver content. Was this also the case at Zawar? Here Lalit's detailed and expert knowledge of the ore deposits and their mineralogy was invaluable and showed that not only that the overall silver content of the Zawar ores was very low but that the exploitation had been in the zinc-rich deposits rather than the lead-rich areas where any silver-rich lead ore could have been expected. This tied in very well with the conclusions drawn from the scientific study of the somewhat enigmatic remains of the smelting process, and together the mining and smelting evidence showed that in the Mauryan period Zawar had been producing zinc oxide. Although there were contemporary accounts in the Greek literature of the processes for the production of zinc oxide, Zawar is the only site in the world where evidence of this process has been identified and excavated. The zinc oxide would have been used in the production of brass by the cementation process (Craddock et al. 1989) and also for pharmaceutical uses, the familiar calamine lotion.

Following our success at Zawar, establishing the true age of the mines and the nature of the processes carried on there, H.V. Paliwal and Lalit suggested that we should investigate the other mines operated by HZL in the Aravallis, which also had extensive remains both above and below ground. These were at Rajpura Dariba and Rampura Agucha, where in the company of Dr. S.M. Gandhi, we were able to show that these mines were producing silver on an enormous scale during the Mauryan period, and supplying much of the silver required for the punch-marked coins.

Lalit's interests and expertise extended well beyond geology and science, with a good understanding of Indian history and culture including knowledge of Sanskrit (Fig. 4). Many of the temples at Zawar have dedicatory inscriptions which Lalit was able to read and translate directly. As such Lalit became both an adviser and contributor to the prestigious *History of Technology in India*, edited by K.V. Mital and published by the Indian National Science Academy.

Latterly, Lalit extended his archaeometallurgical interests to other Indian industries and crafts. These included the remains of the crucible steel industry at Konasamudram in Telangana State and to recording of some surviving traditional Indian metal crafts. The latter included

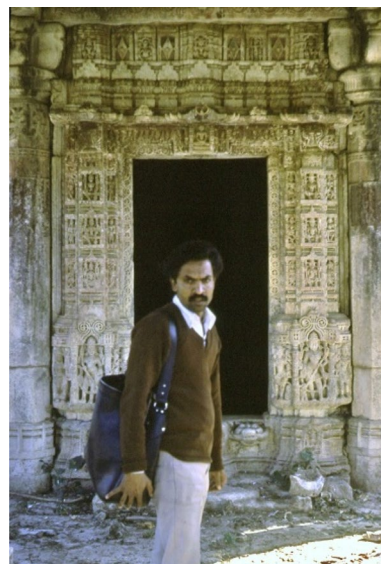


Fig. 4 Outside one of the many temples at Zawar in 1985. (P.T. Craddock photographer)

the production of the Bidri ware artefacts cast from an alloy with about 95% of zinc as well as the production of special high tin bronzes in the south of India. These included bronze mirrors cast from a high-tin ($\alpha + \delta$) eutectoid alloy and the metallurgically very different wrought and quenched high-tin β bronzes used for curd dishes, cymbals and gongs etc.

Lalit attended and contributed to a number of international conferences including the '2000 Years of Brass and Zinc' meeting held under the auspices of the British Museum and the Historical Metallurgy Society at Bristol in 1985, and at the British Museum in 2005, as well as many meetings and conferences within India itself, such as the International Mining conference of the Society of Geoscientists and Allied Technologists, held at Bhubaneswar, Odisha in 2007. These meetings in turn generated written papers in the conference reports, and contributions to many other papers, above all to the production of *Early Indian Metallurgy*, the main monograph bringing together the work of the whole project on the lead, silver and zinc mines of the Aravallis, published in 2017. In this Lalit was the lead author in the geology and history chapters, and contributed to others.

Lalit had hoped to translate this into Hindi, but sadly this was not to be as ill health, notably kidney problems, curtailed his activity in later years. But without his dedicated work through the planning, excavation and subsequent research the whole project would never been carried through, much less published. With this he made a major contribution revealing the extent and range of India's science and technology through more than two millennia.



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