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Plumb Unlucky: Anthropogenic Lead Exposure During Unmitigated Industrialization in 18th and 19th Century England

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Human modifications to natural environments include the extraction and transformation of resources through mining of ores for metals and minerals with which we have created innovative technologies and established complex societies and economies. One of the most frequently exploited elements in this regard is lead, which has been mined since before Roman times. To explore the physiological manifestations of social and structural inequality experienced in unmitigated anthropogenic environments, we examined lead exposure between individuals from two archaeological collections of adults from England during that country's Industrial Revolution (c. 1760 AD to 1850 AD). Here collections represent English populations that inhabited different positions within the spectrum ranging from agrarian/rural to industrialized urban societies, which allowed us to evaluate the nuances of lead exposure. These collections fall within the mid-range of industrialization: the more rural and agrarian town of Barton-upon-Humber (n = 40), and the more urban industrial town of South Shields (n = 54). The concentration of lead in individuals' remains was first measured to assess anthropogenic versus geogenic exposure, and a suite of lead ($^{206}/_{204}$ Pb, $^{208}/_{206}$ Pb, $^{207}/_{206}$ Pb, and $^{206}/_{207}$ Pb) and radiogenic $^{87}Sr/^{86}Sr$ isotope ratios were measured to examine the potential sources of exposure. Individuals' lead concentrations ranged between 1.17 µg $g^{-1}$and 128.18 µg g^{-1}, significantly greater than the lead concentration found in the geological background (0.7 µg g^{-1}). The individuals from Barton-upon-Humber also had significantly higher concentrations of skeletal lead (mean 49.35 ± 39.01 µg g^{-1}) than the individuals from South Shields (mean 27.02 ± 19.78 µg g^{-1}) ($p = 0.020$). When individuals were compared by collection, we found statistically significant differences ($p < 0.001$) with respect to their Pb isotope ratios. Contrasting lead with Sr isotope systematics from the surrounding soil and skeletal samples in both sites allows us to track mobility within the geological context. We identified several locations throughout England, including coals, galenas, and ore deposits both near and far from each respective collection. Our findings suggest a far-reaching network in the sourcing of mined lead used in the common household heat source of coal as well as in industrial goods.