Identification of Sources of Lead in Children in a Primary Zinc–Lead Smelter Environment

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We compared high-precision lead isotopic ratios in deciduous teeth and environmental samples to evaluate sources of lead in 10 children from six houses in a primary zinc–lead smelter community at North Lake Macquarie, New South Wales, Australia. Teeth were sectioned to allow identification of lead exposure *in utero* and in early childhood. Blood lead levels in the children ranged from 10 to 42 µg/dL and remained elevated for a number of years. For most children, only a small contribution to tooth lead can be attributed to gasoline and paint sources. In one child with a blood lead concentration of 19.7 µg/dL, paint could account for about 45% of lead in her blood. Comparison of isotopic ratios of tooth lead levels with those from vacuum cleaner dust, dust-fall accumulation, surface wipes, ceiling (attic) dust, and an estimation of the smelter emissions indicates that from approximately 55 to 100% of lead could be derived from the smelter. For a blood sample from another child, > 90% of lead could be derived from the smelter. We found varying amounts of *in utero*–derived lead in the teeth. Despite the contaminated environment and high blood lead concentrations in the children, the levels of lead in the teeth are surprisingly low compared with those measured in children from other lead mining and smelting communities. *Key words:* **children, environmental samples, isotopes, lead, smelter, teeth.** ***Environ Health Perspect* 112:52–60 (2004). doi:10.1289/ehp.6465 available via *http://dx.doi.org/* [Online 25 September 2003]**

It is well recognized that in the past, processing of lead–zinc and zinc–lead ores in smelters has resulted in widespread contamination of the environment and has severely affected the health of the community, especially young children. Despite the introduction of emission controls through regulatory guidelines of, for example, lead in air, mining and smelting operations may continue to contaminate the environment and humans (Esterman and Maynard 1998; Hilts 2003; Hunter Health 2003; Morrison 2003a; Van Alphen 1999).

Legal action has been instigated by community members against lead processing companies. Such was the case in a class action involving some 600 people from Port Pirie, South Australia (location of the largest lead–zinc smelter in the world), and North Lake Macquarie, 120 km north of Sydney, Australia (Gordon 2002; Pasminco Ltd. 2000a).

Although smelters and/or mines are the obvious point sources in these communities, other lead sources may be present and may contribute to elevated blood lead concentrations, especially in children. For example, on the basis of total lead concentrations, Kimbrough et al. (1995) suggested that lead in paint together with the condition of the house accounted for 12% of blood lead variance in children from a community in which a smelter had closed. Similarly, in the Broken Hill mining community, New South Wales (NSW), Australia, high-precision lead isotopes demonstrated that paint and gasoline were contributors to blood lead in families, although the dominant source was lead derived from the local ore bodies (Gulson 1996; Gulson et al. 1996a, 1996b).

In response to requests for assistance from members of the North Lake Macquarie community and pediatrician Graham Vimpani, we have undertaken lead isotopic analyses of environmental and biologic samples, collected over a decade, to determine the sources of lead, especially in the teeth of children. In some cases, the parents were concerned that their children may have been exposed *in utero*. In this article we present the results of these investigations, which illustrate the potential of the lead isotopic fingerprinting method in determining lead sources in such communities but, because of funding constraints, are neither systematic nor exhaustive.

Materials and Methods

Setting/history. The community of North Lake Macquarie is located approximately 120 km north of Sydney, NSW, Australia, and consists of three suburbs (Boolaroo, Argenton, Speers Point), with approximately 1,600 households. Three junior schools for pupils 5–12 years old are located in the area.

A primary zinc–lead smelter, Cockle Creek Smelter Pty. Ltd., is located within this community (Figure 1) and is currently operated by Pasminco Ltd. The smelter began production in 1897, ceased operation in 1922, resumed again in 1961, and closed in September 2003. It produces zinc, lead, and sulfuric acid as major products.

In 1991, an investigation was undertaken by the Hunter Area Public Health Unit. This consisted of measurements of blood lead in children 1–13 years old in Boolaroo and Argenton, along with measurements of lead in soil, household dust, and paint. The results showed that 6% of children 1–4 years old had blood lead levels > 25 µg/dL and 84% had blood lead levels > 10 µg/dL (Galvin et al. 1993).

There was a significant relationship between the higher blood lead levels and proximity to the smelter, with the exception of slag (glassy smelter residue) infills (Galvin et al. 1993; Unpublished data). In addition, the soil survey (202 samples) reported lead values ≤ 21,460 ppm in First Street, directly opposite the smelter, with decreasing values away from the smelter. Furthermore, there was widespread use of slag as landfill, mainly in recreational areas, with levels ≤ 6,000 ppm Pb as far as 2 km from the smelter and one value ≤ 15,210 ppm Pb, 1 km from the smelter (Galvin et al. 1993). Although the metals in slags are considered to be safely contained within the glassy matrix (e.g., Body et al. 1988), Morrison (2003b) has shown that the fine fractions of the Cockle Creek slags have a very high bioaccessibility.

After disclosure of the results of the Hunter Area Public Health Unit investigations, a Community Consultative Committee was formed that later became known as the Lake Macquarie Environmental Health Coordination and Liaison Committee.

In 1992, decontamination work was undertaken at the Boolaroo school. At the same time, the local government body instituted a

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