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Identification of environmental lead sources and pathways in a mining and smelting town: Mount Isa, Australia

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ABSTRACT

Lead (Pb) concentrations and isotopic compositions from soils, dusts and aerosols from public land and residential lots adjacent to the copper and Pb mine and smelter at Mount Isa, Australia, were examined to understand the sources and risks of environmental Pb exposure. Urban soil samples contain elevated Pb concentrations (mean 1560 mg/kg), of which 45–85% of the Pb is bioaccessible. The Pb isotopic composition of surface soils (0–2 cm), aerosols and dusts ($^{206}Pb/^{207}Pb$, $^{208}Pb/^{207}Pb$ range: 1.049, 2.322–1.069, 2.345) are dominated by Pb derived from the Mount Isa Pb–zinc ore bodies. Underlying soil horizons (10–20 cm) have distinctly different Pb isotopic compositions ($^{206}Pb/^{207}Pb$, $^{208}Pb/^{207}Pb$ range: 1.093, 2.354–1.212, 2.495). Surface soil-, dust- and aerosol-Pb are derived predominantly from smelter emissions and fugitive mining sources and not from *in situ* weathered bedrock. Remediation strategies should target legacy and ongoing sources of environmental Pb to mitigate the problem of Pb exposure at Mount Isa.

1. Introduction

The neurotoxic effect of lead (Pb) has been long established in the scientific literature and children are particularly at risk if exposed (Needleman, 2004). Children presenting with blood lead (PbB) levels well below 10 μg/dL have been linked with decreased Intelligence Quotient (IQ) and academic performance, as well as a range of socio-behavioural problems (Lanphear et al., 2000, 2005; Bellinger and Needleman, 2003; Canfield et al., 2003; Braun et al., 2006; Bellinger, 2008; Jusko et al., 2008; National Toxicology Program, 2012; Taylor et al., 2012a,b). Concerns have been raised about the impact of PbB levels in children across a number of Australian mining, smelting and port towns, including Broken Hill (Gulson et al., 1994a,b,c), Lake Macquarie (Gulson et al., 2004; Dalton and Bates, 2005), Mount Isa (Munksgaard et al., 2010; Taylor et al., 2010; Taylor and Schniering, 2010), Port Kembla (Young et al., 1992), Port Pirie (Baghurst et al., 1992, Taylor, 2012; Taylor et al., 2013), Rosebery (MCPHR, 1999) and Esperance (Gulson et al., 2009).

A survey by Queensland Health (2008) at the major mining centre of Mount Isa, north-west Queensland (Fig. 1), indicated that 11.3% of 400 local children sampled aged between 1 and 5 years of age had PbB levels above the generally applied risk of harm value of 10 μg/dL, as set by the Australian National Health and Medical Research Council (NHMRC, 1993, 2009). In contrast to other Australian mining and smelting towns, Mount Isa has only recently started to receive considerable attention regarding the environmental and human health impacts arising from mining-related activities (e.g. Taylor and Hudson-Edwards, 2008; Noller et al., 2009; Munksgaard et al., 2010; Taylor et al., 2009, 2010). Research of soil, air and water (including sediments) systems in and around Mount Isa has demonstrated a significant proportion of the urban area and riverine environment is contaminated with Pb and other metals and metalloids (Taylor and Hudson-Edwards, 2008; Taylor et al., 2009; Mackay et al., 2011; Mackay and Taylor, 2013). The combination of elevated Pb in soil (Taylor et al., 2010) and dust (Queensland EPA, 2008; Taylor et al., 2011), coupled to Mount Isa's semi-arid climate, provide environmental conditions that enhance the transmission of Pb into residential lots. This makes household dusts and urban soils a likely primary pathway and places Mount Isa children at a potentially significant risk of harm from Pb exposure.

This study seeks to identify the sources, pathways and relative risk of environmental Pb at Mount Isa via the analysis of the concentrations and isotopic compositions of Pb in soil, aerosol, rock and dust. The data generated from this research provides valuable information to guide local regulatory authorities in directing environmental remediation in Mount Isa. In addition, the methods and research design used in this study are of direct relevance to other

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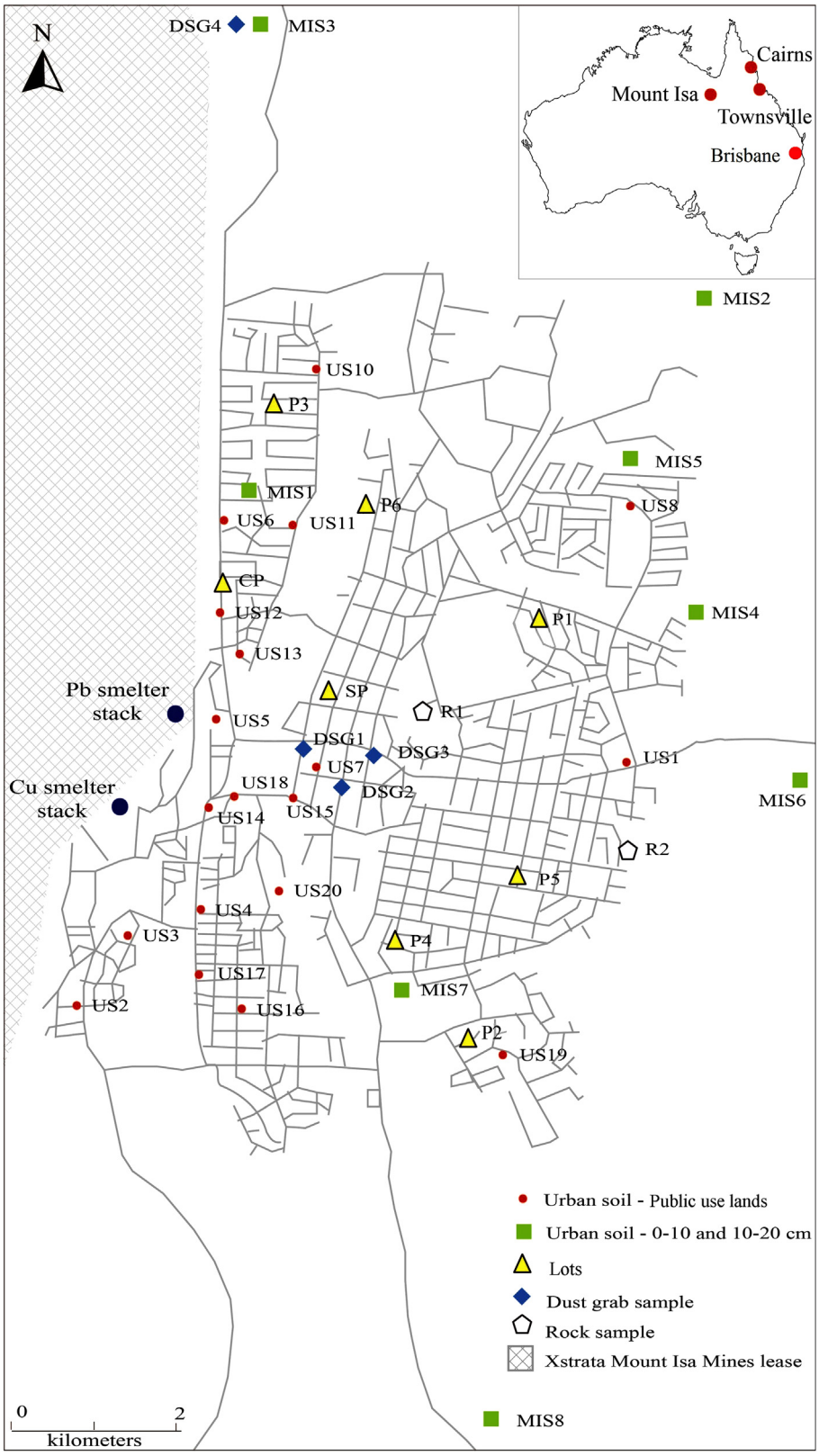

Fig. 1. Location map showing the sample sites for different environmental samples collected and analysed from Mount Isa. Aerosol samples collected as background indicators from the cities of Cairns, Brisbane and Townsville are also shown in the inset along with Mount Isa.