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Mining in subarctic Canada: Airborne $PM_{2.5}$ metal concentrations in two remote First Nations communities

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HIGHLIGHTS

- High PM concentrations observed in remote First Nation communities in Canada.
- Good agreement between personal and central monitoring measurements of PM.
- Enhancement in K and Ni concentrations in Attawapiskat First Nation.

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ABSTRACT

Airborne particulate matter arising from upwind mining activities is a concern for First Nations communities in the western James Bay region of Ontario, Canada. Aerosol chemical components were collected in 2011 from two communities in northern Ontario. The chemical and mass concentration data of particulate matter collected during this study shows a significant difference in $PM_{2.5}$ in Attawapiskat compared to Fort Albany. Elemental profiles indicate enhanced levels of some tracers thought to arise from mining activities, such as, K, Ni, and crustal materials. Both communities are remote and isolated from urban and industrial pollution sources, however, Attawapiskat First Nation has significantly enhanced levels of particulate matter, and it is likely that some of this arises from upwind mining activities.

1. Introduction

Ambient air particulate matter (PM) is a heterogeneous mixture and a ubiquitous air pollutant that varies in size and chemical composition, depending on its sources and chemical transformations. PM can be directly emitted into the atmosphere (e.g., diesel exhaust, coal power plant emissions, mining activities), or formed through secondary chemical process (e.g., particle nucleation, condensation of gases on existing particles). Ambient aerosols are observed throughout the troposphere and they result from a combination of long- and short-range transport and local aerosol emission or generation processes. Therefore, identifying specific sources of aerosols can be difficult. Typical methods for source identification follow investigation of aerosol chemistry or morphology (Chan et al., 2009; Gao et al., 2004; Heald et al., 2005; Seinfeld and Pandis, 1998; Peltier and Lippmann, 2010; Peltier et al., 2011, 2008), back trajectory analysis (NOAA, 2007), or other modeling approaches (Ahmadov et al., 2012; Li et al., 2011; Shrivastava et al., 2011). In many cases, specific sources can only be estimated as aerosol provenance can be ambiguous.

A growing body of evidence has demonstrated a consistent increased risk for significant human health impacts associated with exposure to PM. Cardiovascular disorders and adverse pulmonary effects are often considered to be of most concern with respect to human health outcomes associated with ambient air exposure in Canada and the U.S (Hutcheson and Rocic, 2012; Allen et al., 2011; Delfino et al., 2010; Brook et al., 2010; Sun et al., 2009). However, the underlying mechanism(s) and major component(s) responsible for PM associated health effects are still poorly understood and need to be addressed. Recent animal studies and human historical data analyses suggest that redox reactive metals in PM (Verma et al., 2014; Lippmann and Chen, 2009; Lippmann et al., 2006) may play important role in PM associated health effects.

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The work presented here focuses on air pollution exposures in two First Nation communities subarctic Ontario (Mushkegowuk Territory), Canada (Fig. 1). The coastal portion of the Mushkegowuk Territory is populated by approximately 10,000 First Nation Cree (Native North Americans) who inhabit five remote communities: the First Nations of Moose Factory, Fort Albany, Kashechewan, and Attawapiskat on the western coast of James Bay, and Peawanuck (Formerly Winisk) on the western coast of Hudson Bay (Tsuji and Nieboer, 1999). Attawapiskat and Fort Albany rely largely on subsistence living with limited employment opportunities available to its residents. Neither community has year-round ground transportation to outside communities, though a temporary ice road is constructed each winter. Subsequently, vehicle use in these communities is relatively limited, with only a few hundred cars or trucks in Attawapiskat and less in Fort Albany. There are even fewer diesel vehicles in these communities. The residential areas of these communities are both approximately one square kilometer, and there are no moderate or heavy industrial facilities in either community. These remote communities require significant residential heating demands due to cold winter time temperatures, and this demand is usually met with electrical heat and/or wood burning throughout the winter. For much of the year, the only transportation option available to these communities is daily commercial air service.

The De Beers Canada Inc. Victor Diamond Mine, is a large open-pit mine on the traditional lands of the Mushkegowuk Cree and lies approximately 90 km west of Attawapiskat First Nation and 170 km northwest of Fort Albany First Nation. Concerns were raised by community members about particulate mine tailings and fugitive emissions arising from upwind mining activities. We hypothesize that open pit mining operations, mine fleet operation, and ore/mineral processing, contributes to the aerosol load in the community of Attawapiskat. Of particular concern for mine emissions are activities relating to mechanical crushing of geologic materials, which results in extremely large quantities of fugitive dust. Mine processes that involve mechanical crushing of materials typically emit significant quantities of larger dust particles (e.g. PM_{10}), with fewer – but non-zero – emissions of particles below 2.5 μm ($PM_{2.5}$). This, in turn, may be transported by prevailing winds to Attawapiskat and other downwind communities where exposures occur. PM generated by mining operations is a major concern and was identified as a potential hazard in the *Victor Mine Environmental Assessment* report (Environmental Assessment Agency, 2005).

The Attawapiskat kimberlite pipes were first identified in the 1980s as having a high potential for significant diamond yield (Whitelaw et al., 2009). Kimberlite pipes are complex geological formations that vary with chemical composition depending on

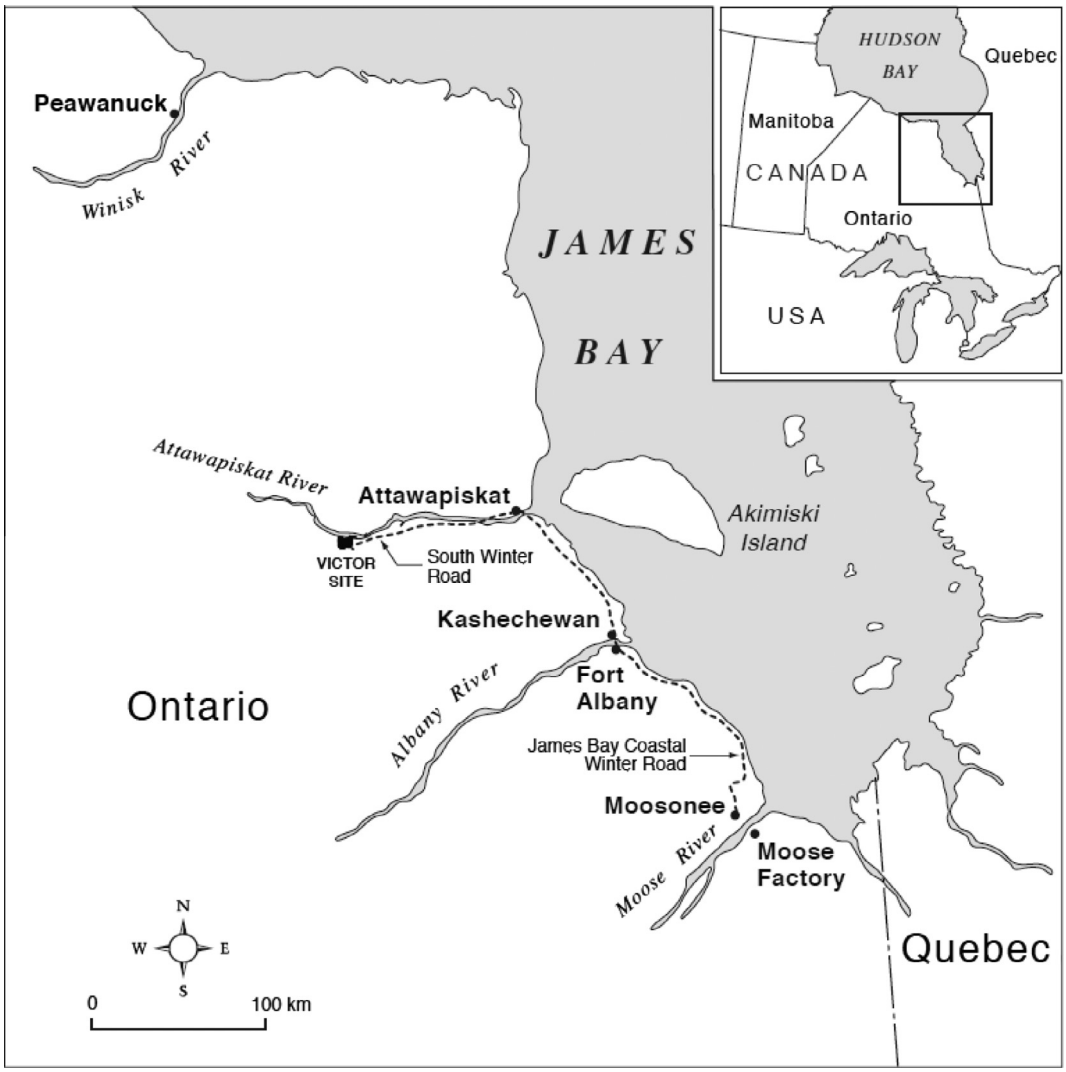

Fig. 1. Map of the James Bay region including locations of Attawapiskat and Fort Albany, First Nations, and Victor Diamond Mine.