

Pre-industrial Metal Anomalies in Ice Cores: A Simplified Reassessment of Windborne Soil Dust Contribution and Volcanic Activity during the Last Glaciation

ROBERTO OYARZUN,¹

*Departamento de Cristalografía y Mineralogía, Facultad de Ciencias Geológicas, Universidad Complutense,
28040 Madrid, Spain*

JAVIER LILLO,

*Escuela Superior de Ciencias Experimentales y Tecnología, Universidad Rey Juan Carlos, Tulipán s/n,
28933 Móstoles (Madrid), Spain*

JUAN CARLOS SÁNCHEZ-HERNÁNDEZ,

*Laboratorio de Ecotoxicología, Facultad de Ciencias del Medio Ambiente, Universidad de Castilla-La Mancha,
Avenida Carlos III s/n, 45071 Toledo, Spain*

AND PABLO HIGUERAS

*Departamento de Ingeniería Geológica y Minera, Escuela Universitaria Politécnica de Almadén,
Universidad de Castilla-La Mancha, Plaza M. Meca 1, 13400 Almadén, Spain*

Abstract

A major issue regarding pre-industrial accumulation of heavy metals such as Cu, Pb, Zn, or Hg in ice cores relates to the source(s) of the metals. We investigate the two possibilities that have been generally advocated for the origin of metal anomalies: (1) increased amounts of windborne dust during particularly cold periods; and (2) volcanic activity. We analyze the time span 35,000–14,000 yrs BP, which is characterized by extreme temperature deviations (ΔT : -2.1° to -9.8°C). Our findings show no definitive relationships between climate, dust, and metal contents, at least during the colder episodes. Thus, although dust deposition undoubtedly adds metals to the ice, it not clear whether climate can fully account for a direct relationship between these variables. In order to study the volcanic hypothesis, we analyze the case under a double perspective: (1) large explosive episodes related to acid magmatism; and (2) quieter mafic volcanic activity. Although the first one can introduce huge volumes of metal-rich aerosols to the stratosphere during single, catastrophic events, the latter is more continuous, accumulative, and far richer in sulfur. However, inasmuch as metals build volatile species with sulfur and halides, the chloride-rich character of the acid volcanism could easily compensate for its deficiency in sulfur. Thus, we suggest that the volcanic activity, via quiescent degassing and eruptive episodes, may account for an important part of the heavy metal contents present in the ice cores.

Introduction

ICE CORES ARE well known for being one of the best archives for information of the past climatic and environmental changes (e.g., Nordic Arctic Research Programme, 2004). However, the origin of pre-industrial metal concentrations measured in either Antarctic or Greenland ice cores is a matter of controversy. The two main proposals for metal enrichment call for either: (1) increased amounts of

windborne dust during particularly cold periods (e.g., Batifol et al., 1989; Hong et al., 1996, among others); or (2) volcanic activity (e.g., Matsumoto and Hinkley, 2001; Pyle and Mather, 2003; among others). Although these possibilities are not mutually exclusive, their relative importance remains as an open question. Moreover, if we analyze the volcanic option, we face again multiple possibilities. For example, there are good reasons to believe that large explosive eruptions have played an important role in altering the environment at a global scale via large-scale introduction of aerosols to the atmosphere

¹Corresponding author; email: oyarzun@geo.ucm.es