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Foreword

Geochemical and isotopic record of anthropogenic activities – Thematic issue dedicated to Jean Carignan (1965–2012). Part 1: Radiogenic isotopes and elemental geochemistry

Anthropogenic activities are today one of the major factors controlling the evolution of our environment with major consequences on all Earth surface compartments: atmosphere, oceans, continents and biosphere. Such consequences accelerated with the industrial revolution, but probably started much earlier as they are related to the demographic evolution and the settlement of various human communities during the last millennia. They are presently reaching unequal effects all over the globe.

Defining precisely present-day and past impacts of anthropogenic activities and forecasting their future impact requires tools to assess their specific effects on our environment. Elemental geochemical and isotopic tools developed in the geosciences appear to be particularly useful for tracing anthropogenic activities.

Today research in this field is in full growth due to the fact that the scientific issues it addresses are important societal issues. It is also related to the fact that novel research prospects become achievable thanks to the recent analytical developments of instruments such as MC-ICPMS, nano-SIMS, etc. All of these studies lead today to novel orientations whose scientific potentialities but also their usefulness as decision-making tools should be better known and popularized. It is one of the goals of this thematic issue of *C. R. Geoscience*, which assesses the impacts of anthropogenic activity on the environment. The issue gathers 19 papers by colleagues specializing in geochemical and isotopic tracing tools and methods. The papers demonstrate how diversified are the approaches and geochemical tools used in a rapidly developing field, which combines classical geochemical tools with novel geochemical tracers such as the so-called "non-traditional stable isotopes".

This issue is divided into two volumes: the first one gathers radiogenic and elemental geochemistry approaches, whereas the second one is devoted to the use of stable isotopes, including both traditional (C, H, O, N, S) and non-traditional isotopes.

This first volume is comprised of ten papers, the first six of which use Pb isotopes as tracers of anthropogenic sources to the environment as well as tools for metallogenic exploration. The paper by Kyser et al. (2015) demonstrates the usefulness of Pb isotopes in surface media to "distinguish anthropogenic sources from undercover uranium sources." The second paper, by Stevenson et al. (2015), points out how Pb, Sr, and Nd isotope systematics in marine sediments help understanding ocean current changes and sedimentary dynamics of the Arctic Ocean. The following four papers present several case studies demonstrating the usefulness of Pb isotope studies to identify the source of anthropogenic Pb in continental ecosystems. Négrel et al. (2015) show the potential of such studies at the scale of a volcanic basin. The next two articles clearly demonstrate how geochemical monitoring helps assessing the evolution of anthropogenic impacts on the environment and human health. For instance, Petit et al. (2015) show a comparison between blood Pb isotope analyses of two populations from the same region and sampled 30 years apart. They illustrate the impact on humans of measures taken to reduce Pb atmospheric pollution level, while showing the need to take into account other sources of Pb and also the human Pb metabolism to correctly interpret the presented results. Cloquet et al. (2015) point out that lichens can be useful biomonitors of atmospheric Pb pollution levels and source appointment in a given region. On the other hand, Hoàng-Hóa et al. (2015) show how passive samplers can help monitoring a geochemical atmospheric evolution at relatively small time

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Fig. 1. Jean Carignan (1965–2012).

scales. In addition, this article shows the usefulness of Pb isotopes coupled with Nd and Sr isotopes to decipher the evolution through time of the various sources of atmospheric dust at a local scale. The following three articles present examples of other isotopic and geochemical tools for identifying both the source and fate of anthropogenic products in the environment. Gogot et al. (2015) show the potential of the infrequently used Os isotopes as tracers of atmospheric emissions generated by aluminum smelters. Merschel et al. (2015) and Hissler et al. (2015) highlight how rare-earth elements patterns and geochemical "anomalies" in some elements of this chemical family can trace anthropogenic chemical fluxes. This first series of ten papers closes with the work by Pédrot et al. (2015) demonstrating how helpful are geochemical observations at smaller and smaller scales ranging from micrometric to nanometric for studying the biochemical processes that control pollutant mobility in the environment, such as in this case study. All these papers, as well as those presented in the second volume of the thematic issue (see Chabaux et al., 2015), clearly demonstrate how dynamic the field of isotope geoscience is, and how the various geochemical tools can be applied to tackle a variety of environmental issues.

We would like to dedicate the two volumes of the thematic issue of *C. R. Geoscience* to our colleague and friend Jean Carignan (1965–2012). Jean (Fig. 1) was among the pioneers of non-traditional stable isotope applications to the environmental geosciences, during his too short scientific career.

A few years ago, we initiated, with Jean, the idea of putting together contributions about this topic in a thematic issue of *C. R. Geoscience*. However, Jean's disease and then death put a stop to our project. Today we are proud to have honored this initiative and to have been able to finalize this volume thanks to the participation of many of Jean's friends and colleagues. We warmly thank all of them as well as those who reviewed the manuscripts[1]. We are convinced that the present thematic issue will make a lasting contribution to popularizing the development of geochemical tracer studies for environmental issues, which Jean had set his heart on. It will probably render the most proper tribute to Jean's work.

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