



Editorial

Geochemical sampling for geological–environmental studies

Geochemical sampling involves collecting and analyzing various earth materials such as rocks, soils, sediments, water, vegetation, and gasses. Various geochemical sampling methods have traditionally been some of the most efficient of any methods used in mineral exploration. These methods have also been applied, however, to geological and environmental studies. Variations in chemical compositions of certain earth materials are descriptors of the environment in which those materials occur or from which they were derived. For studying certain environments, it may be obvious which earth materials must be sampled and analyzed for contents/properties of substances of interest; whereas for other environments, that may not be so. However, depending on (a) sound conceptual models of dispersion of chemical substances in different earth materials in various environments and (b) well-defined objectives for particular geological and/or environmental studies at certain spatial scales, only certain earth materials can be optimally sampled and analyzed for contents/properties of substances of interest.

It can be argued that rocks represent the ultimate sources of chemical compositions of various surficial materials. Rocks are a key sampling medium for geological and geochemical exploration of mineral deposits (Govett, 1983). However, in this special issue, Salaün et al. and Pichler et al. used rock geochemistry to study, respectively, volcanic hydrothermal activity and source of arsenic contamination in an aquifer system. To study ancient and active hydrothermal systems of a volcano in Guadeloupe, Salaün et al. sampled (a) unaltered rocks, (b) ash fall deposits (AFDs) associated with phreatic explosions and (c) debris-avalanche deposits (DADs) associated with flank collapse events. Because of the dynamic processes associated with the AFDs and DADs, samples from these materials represent different parts (including inner and deeper parts) of the volcano. However, as Salaün et al. describe, detailed geological mapping is vital to the study to link to every sample spatially and temporally to ancient and active hydrothermal systems. Salaün et al. then synthesized geological and trace element geochemical data, particularly incompatible element ratios and normalized rare earth element compositions, to reconstruct the spatio-temporal evolution of hydrothermal activity in the volcano. To determine the source of arsenic contamination in the Floridan Aquifer System (FAS), Pichler et al. studied the distributions of arsenic concentrations in solid drill cores and rock drill cuttings. Besides this main objective, Pichler et al. used different sampling strategies to assess which of them would be sufficient to achieve that main objective. The study identified pyrite in lithostratigraphic units comprising the FAS as the main source of arsenic contamination, and found that either interval or targeted sampling of rock drill cuttings seems to be a sufficient strategy for identifying the contaminant source.

As exemplified in the paper of Pichler et al., the presence of certain minerals (e.g., pyrite) can indicate the potential risk of environmental

contamination. However, other minerals are useful as indicators in geochemical exploration for certain types of mineral deposits (e.g., Gent et al., 2011) whereas other minerals are useful indicators of depositional environments of lithologic formations in which they occur. For example, evaporites (e.g., anhydrite) are important indicators for studying paleo-climate and paleo-depositional conditions because they are susceptible to changes in geographical conditions and chemical compositions of seawater. Isotopic geochemical data are ideally used to infer paleo-environmental conditions of evaporite formations (e.g., Kah et al., 2001; Longinelli, 1980). However, mineralogical and elemental geochemical data from evaporites have been used for paleo-climatic studies in arid regions (Smykatz-Kloss and Roy, 2010). This is further demonstrated by Bahadori et al. in this special issue. They synthesized lithologic interpretation of gamma-ray and sonic well log data, and statistical correlations and chemostratigraphic analyses of major/trace element contents of anhydrite samples collected from the evaporite members of the Gachsaran Formation. Bahadori et al. finally deduced that the Gachsaran Formation was formed in a sabkha lagoon basin that was likely closed to the open sea by a shallow barrier that somehow allowed seawater recharge into the basin.

Geochemical compositions of clastic sediments have been used as indicators of tectonic settings (e.g., Armstrong-Altrin and Verma, 2005) as well as provenance and weathering conditions (e.g., Roddaz et al., 2006). In this special issue, Bhuiyan et al. discuss the differences in major, trace, and rare earth element compositions of bar-top and channel facies sediments in the Brahmaputra–Jamuna River (Bangladesh) for provenance, tectonics and source weathering implications. The rationale for studying those samples was to understand (a) the influence of grain-size variations on sediment geochemistry and (b) the geochemical differences in sediments of the Brahmaputra River before and after the junction with Tista River. Bhuiyan et al. concluded that sediments in the Brahmaputra–Jamuna River (a) were derived from a quartzose-recycled orogen in an active continental margin and (b) were delivered from low- to moderately-weathered sedimentary source regions.

Like fluvial sediments, airborne sediments (or dusts) have been part of much of the geological history of our planet and interfere with biogeochemical cycles (Engelbrecht and Derbyshire, 2010). The major source regions of airborne dusts are in or around the extremely arid to semi-arid regions of the world (Prospero et al., 2002). In this special issue, Zarasvandi et al. studied the mineralogy and major/trace element geochemistry of airborne dusts in Khuzestan province (southwestern Iran) to deduce their plausible source region(s) and to explore the possibility that occurrences of airborne dusts are related to the prevalence of respiratory diseases in that province. Zarasvandi et al. conclude that (a) airborne dusts in Khuzestan are derived from dry lakebeds, alluvial deposits and deserts in neighboring countries to the west and (b) pores

of common health masks used in Khuzestan inadequately block fine airborne dusts, suggesting that airborne dusts are likely implicated in respiratory-related diseases in that province.

Plants take up nutrients and elements from soils or underlying substrate through their roots, and accumulate certain elements in their organs, such as roots, stalks, and leaves. Thus, if certain plants contain abnormally high concentrations of certain metals, they may indicate the presence of sub-cropping mineralization (Brooks, 1972). However, the success of a biogeochemical sampling for mineral exploration depends on knowledge derived from an orientation survey because the biogeochemical characteristics of plant species are site-dependent. In this special issue, Jung et al. investigated suitable accumulator and/or indicator plants for biogeochemical prospecting of epithermal-Au deposits in Korea, and they found that *Quercus aliena* (oriental white oak) appears to be the best sampling media for that purpose.

In the application of geochemistry to geological and/or environmental studies, it is not only the choice of appropriate sampling media that is important but also the choice of appropriate analytical procedure. In this special issue, Favas et al. used a seven-step sequential extraction procedure to study the mobility and retention behavior of trace metals in mine tailings and/or soils along four transects – one topographically above and three topographically below – a tin mine in Portugal. Samples of mine tailings pertain only to the three latter transects, which are located at different distances downslope from the mine. The ability of the seven-step sequential extraction procedure adopted by Favas et al. to distinguish associations of trace metal contents with organic matter, secondary sulfides and primary sulfides is, from an environmental perspective, highly desirable. The trace metal geochemical data obtained from the mine tailings and soil samples using the seven-step sequential extraction procedure described lend to assessment of risk associated with heavy metals in those materials.

The papers included in this special issue represent different knowledge fields, although they form a coherent collection under the theme of geochemical sampling. Nevertheless, the motivation to bring them together in this special issue of the Journal of Geochemical Exploration (JGE) is based on the following facts. A search of the JGE in ScienceDirect using the term 'debris avalanche' indicates that DADs have not been reported in JGE as a sampling media to study volcanic hydrothermal activity, as Salaün et al. have described in this special issue. The sampling media used by Pichler et al. are non-unique in studying sources of arsenic contamination in groundwater. However, their analysis for efficient sampling strategy is innovative and instructive. The topic of the paper of Bhuiyan et al. is well-covered in JGE; however, their analysis is unique in the use of both bar-top and channel facies sediments to achieve the objectives of their study. A search of the JGE in ScienceDirect using the term 'chemostratigraphic analysis', as Bahadori et al. have described, returns only eight papers. A search of the JGE in ScienceDirect using the term 'dust' returns only five papers, including that of Zarasvandi et al., with 'dust' in their titles. The topic of the paper of Jung et al. is also well-covered in JGE; however, more similar studies are needed to identify suitable accumulator and/or indicator plants for biogeochemical prospecting of certain deposit-types in different areas. The topic of the paper of Favas et al. is also well-covered in JGE; however, a search of the JGE in ScienceDirect using the term 'seven-step' returns only 14 papers, including that of Favas et al., which (likely) adopted a seven-step

sequential extraction procedure for analysis of geochemical samples. Thus, it is with hope that bringing together the seven papers in this special issue would inspire other researchers to adopt/adapt the geochemical sampling methods in studies similar to each of those papers and/or submit their papers on similar studies for publication in JGE.

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