Characterization of a metal-contaminated waste rock dump using field portable X-ray fluorescence (FPXRF) spectrometry

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Waste rocks dumps are chemically heterogeneous deposits piled up during mining exploitation over tens of years. They contain non-mineralized rocks and low-grade mineralization and are typically characterized by significant vertical and lateral heterogeneities in grain size, lithology, mineralogy and chemistry. Waste rock dumps are often sites of environmental concern because they commonly contain high levels of metals and metalloids which may be released to the circulating waters during weathering. Moreover, the metal leaching may be exacerbated, in sulphide-bearing waste rocks, by Acid Mine Drainage (AMD) processes.

With this work we investigated the chemical composition and the metal distribution within a sulphide bearing waste rock dump using a field-portable energy dispersive X-ray fluorescence (FPXRF) spectrometer (X-MET7500, Oxford Instruments) with a FP (Fundamental Parameter) calibration built-in by the factory. Confirmatory analyses were performed by means of ICP-OES and ICP-MS (AcmeLabs®, Canada).

The site chosen for this study is a small-sized dump (about 3500 m^2) from an abandoned Cu-sulphide mine (Rio Bansigo mine, eastern Liguria, Italy), which was extensively exploited from 1877 to 1935. We performed a superficial sampling (20 cm from topographic surface) by applying statistical methods based on a 15 m^2 sampling grid designed using the open source GIS software GrassGis 6.4. Moreover, four samples from the uncontaminated soils surrounding the waste rock dump were analyzed to determine the natural background of the studied area. The results, obtained with these different techniques, showed a good correlation for most of the detected elements. Regression analysis shows a near 1:1 correspondence between FPXRF and ICP for Cu and Zn and a good correlation for Ni, Mn, Cr, V and Pb. The only elements with significant statistical differences are those occurring in concentrations very close to the minimum detection limits of the FPXRF (Ba, Cd, Sn).

The analytical data were processed in GIS for spatial analysis in order to recognize the spatial relationships among the different variables. Thanks to the possibility of analyzing a large number of samples by means of FPXRF, very detailed contour maps were then drawn for each metals, which allowed to evaluate the metal distribution in the entire mine dump area and to recognize the presence of several hot spots.

Our results evidenced the feasibility of a detailed evaluation of the metal hazard within waste rock dumps using a field-portable XRF device, thus providing a powerful tool for quick decision-making in the field and reducing the need of off-site laboratory analyses. Moreover, the possibility to perform a large number of *in situ* analyses, in a cost-efficient and timely manner, allows the production of geo-environmental models and detailed mapping of metal distribution based on a geostatistical approach as well as the recognition of pollution hot spots.

Assessing environmental risks associated with sulfidic mine waste: a gold case study

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Acid rock drainage (ARD) poses one of the most serious environmental challenges associated with the mining industry. Formed through the oxidation of sulfide minerals in the presence of oxygen and water, ARD generation is further exacerbated by the regeneration of lixiviates by naturally occurring, iron- and sulphur-oxidising micro-organisms. In South Africa, ARD is most commonly associated with the coal and gold mining industries. Of particular concern is the number of historical and abandoned mines and the quantities of mining waste posing potential environmental hazards.

Management and prevention of this issue relies on accurate characterisation of the ARD generation potentials of waste samples. Classification of the ARD potential is achieved through the quantification of acid-generating and acid-consuming components present within a sample. This quantification is often completed sequentially from laboratory-scale screening tests through to kinetic field studies. In addition, mineralogical sample analysis is used to assist in the screening process and interpretation of experimental results. Initial laboratory-scale static ARD tests, however, are focused on primary oxidation of sulfide minerals within the sample and often fail to account for potential environmental impacts due to leaching of non-sulfidic constituents. In addition, the toxicity and concentrations of trace elements within samples is not included in the screening tests. This study aimed to assess the environmental risks associated with a sample of gold gravity tailings from a historical dump using mineralogical analysis and standard laboratory ARD screening tests.

Results from the static ARD characterisation tests indicated no net acid generation would result from sulfidic oxidation of the tailings sample. Biokinetic accelerated weathering tests and ARD potentials calculated based on mineralogy confirmed this result. Trace metal analysis of the leach liquors, however, showed a significant environmental risk associated with the release of As, Pb and U during laboratory tests. Other elements of potential environmental significance included Al, Cu, Zn and Ni. Mineralogical test work indicated uraninite and brannerite as the sources of soluble U, while metal sulfides accounted for the presence of Pb, As and base metals. In conjunction with these results, sequential chemical extraction experiments were performed to provide information on the distribution and potential availability of elements within the tailings sample. The findings from this study will be used to aid in the development of a more robust protocol for the characterisation of environmental risks associated with sulfidic mining wastes.