Contribution of soil studies to geochemical mapping: the example of Emilia-Romagna alluvial plain

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A reliable estimate of the pollution status of soils requires that natural metal concentrations for different soil types (pedogeochemical values) be established accurately (ISO/DIS 19258). Advances in sedimentological and soil research in Emilia-Romagna provide today the opportunity to examine distribution of pedogeochemical contents of selected elements within a mixed pedological and sedimentological framework, through integration of geochemical data with detailed soil characterization.

The pedogeochemical mapping project of Emilia-Romagna alluvial plain at 1:250,000 scale represents the first step toward a new type of soil-oriented, geochemical map. Pedological and geochemical analyses of 300 soil samples collected within depths of 120-130 cm west of Secchia River enable precise identification of the pedogeochemical contents of selected heavy metals as a function of sediment provenance, facies association and soil maturity.

Sediment supplied by Po River and its major western tributaries (Trebbia, Nure and Taro) is characterized by remarkably high natural concentrations of Cr and Ni, reflecting erosion of ultramafic complexes in the related drainage basins. In contrast, significantly lower Cr and Ni contents are recorded where the drainage basins are ophiolite-free (e.g., Tidone, Parma and Secchia). Spatial distribution of Cu, Zn and Pb does not reflect major differences in sediment provenance, but is instead a function of changes in grain size (depositional facies) and degree of soil weathering. Increasing soil evolution invariably results in Ti, Zr, V, Fe_2O_3 and Al_2O_3 enrichments. In contrast, Ca and Sr are strongly depleted in highly mature soils, in response to leaching processes.

A realistic view of the pollution status of the Emilia alluvial plain can be obtained by matching the pedogeochemical contents measured at 120-130 cm depth against metal contents recorded in the corresponding topsoil units (20-30 cm). Despite very high concentrations, locally exceeding the maximum values permitted by law, nickel and chromium generally do not show enrichments due to anthropogenic disturbance. In contrast, a diffuse (although moderate) soil contamination is observed for copper, lead and zinc throughout the alluvial plain.

Pedogeochemical maps should provide all necessary information to assess in an unequivocal way legislation limits and levels of concern for potentially toxic heavy metals. In this respect, a combined use of different analytical techniques is essential for a correct evaluation of metal distribution in soils. X-ray fluorescence determinations provide a reliable estimate of total metal concentrations in soil samples, and are suggested here as the most efficient method to delineate pedogeochemical contents. Owing to partial metal dissolution following aqua regia digestion methods, ICP-MS determinations on the same samples invariably provide lower values than XRF analyses (around 80% for Ni, but only 45% for Cr). Assessing permitted levels of heavy metals in soils should thus address this issue.

This project shows that detailed soil studies constitute a priority for geochemical mapping of Quaternary deposits, and that identifying a geochemical signature for specific soil types and sedimentary facies is essential to obtain reliable information on natural metal distribution. An appropriate sampling strategy, including detailed soil characterization, is recommended to adequately represent the remarkable variability in terms of sediment provenance, grain size and soil maturity. Soil-oriented geochemical maps represent a novel, more efficient alternative approach to conventional geochemical mapping based upon geostatistical methods alone. In particular, the

pedogeochemical map of Emilia alluvial plain constitutes a powerful tool to assess the anthropogenic impact on alluvial plains, which can be of use for legislative purposes and for planning strategies for environmental protection.