



## Temporal and Spatial Variations of Geo-Environmental Parameters in Soil, Rock and Groundwater Samples of the Northern Calcareous Alps in Austria

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The objective of this poster is to present geochemical analyses of groundwater, soils and rocks in the Northern Calcareous Alps, to characterise their temporal dynamics and spatial variations and to study environmental processes such as buffering and sorption in soils and mineralization of groundwater travelling through soils and rocks.

The study area is situated in Upper and Lower Austria between the rivers Enns and Ybbs/Schwarzois and covers approximately 590 km<sup>2</sup>. Geological formations predominantly consist of carbonate and siliciclastic rocks of Triassic, Jurassic and Cretaceous age and quaternary moraines and terraces. Land use ranges from agriculture to forestry and, to a lesser extent, industry and tourism.

Over the last ten years groundwater samples taken from all main geological formations have been analysed for major and minor ion content as well as for trace element concentrations (HEINRICH et al., 1995 & 2000; DECKER et al., 1998; PFLEIDERER et al., 1999). Complementary rock and soil samples were taken in order to correlate their chemical composition with hydrochemical facies and to follow the flux of chemical substances resulting from atmospheric deposition, soil formation, rock dissolution and groundwater discharge into surficial waters (PIRKL, 1999).

Field measurements of springs sampled on a monthly basis include readings of electrical conductivity, water temperature, pH-value, redox potential oxygen content, and discharge. Chemical analyses quantify the concentration of Ca, Mg, Na, K, SO<sub>4</sub>, HCO<sub>3</sub>, Cl, F, NO<sub>3</sub>, (major ions) and H<sub>2</sub>SiO<sub>3</sub>, Cd, Cr, Cu, Pb, Zn, Al, Fe, Sr, Mn and Li (trace elements). Rocks samples from all main geological formations were analysed with respect to SiO<sub>2</sub>, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, MnO, MgO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>, CO<sub>2</sub>, SO<sub>3</sub>, (major oxides) and Ba, Sr, Co, Cr, Cu, Mo, Ni, Pb, Sr, V and Zn (trace elements). Soil samples were analysed in four ways:

- extract of water-soluble substances.
- exchangeable cations after dissolving the sample in lithium chloride.
- substances mobilised through weak acid after dissolving the sample in hydrochloric acid and
- total content after dissolving the sample in nitrohydrochloric acid (aqua regia extract).

Field observations of soil profiles include vegetation, morphology (slope and aspect), thickness and pH of individual soil horizons.

A homogeneous, well-documented, geo-referenced data set exists now in digital format describing major chemical parameters and trace element concentrations in all main rock and soil formations and springs within the study area. For soil and groundwater, multiple sampling allows for time series analysis over long periods. The poster illustrates results of

- rock sample analyses specific to geological formations;
- soil samples for particular morphological, geological and vegetation conditions and
- time series of groundwater samples of natural springs in various hydrogeological settings.

Methods to assess temporal and spatial variations include univariate, bivariate and multivariate statistics such as principal component analysis and discriminant analysis. Rather than modelling spatial variations within one unit (kriging within one rock type, soil type or aquifer), the methods are used to sufficiently describe, and distinguish between, populations of different units. Results show that detailed sampling strategies are needed to characterise the geochemical setting of the study area and to reveal long-term trends within the data.

Preliminary interpretation of results indicate high temporal variations in trace element concentrations of groundwater samples, good correlation between main water chemistry and lithological composition of the respective catchment areas, and moderately high heavy metal contents in sediments with terrigenous influence. Soil formations on these rocks show risks of acidification.

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