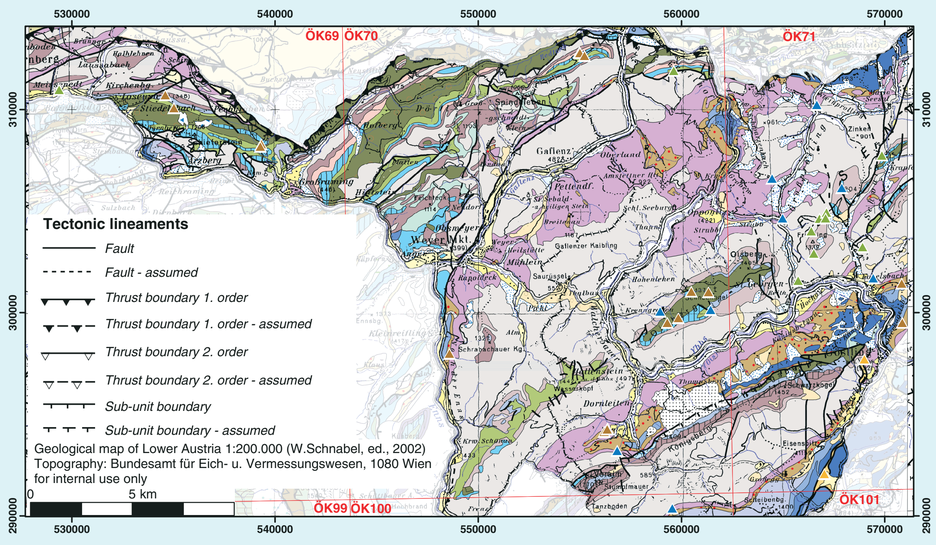
TEMPORAL AND SPATIAL VARIATIONS OF GEO-ENVIRONMENTAL PARAMETERS IN SOIL, ROCK AND GROUNDWATER SAMPLES OF THE NORTHERN CALCAREOUS ALPS IN AUSTRIA

Geological Map

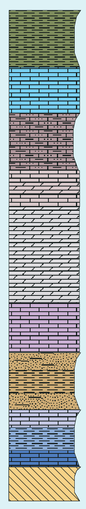


▲ **sandstones & marls** ▲ **dolomites**

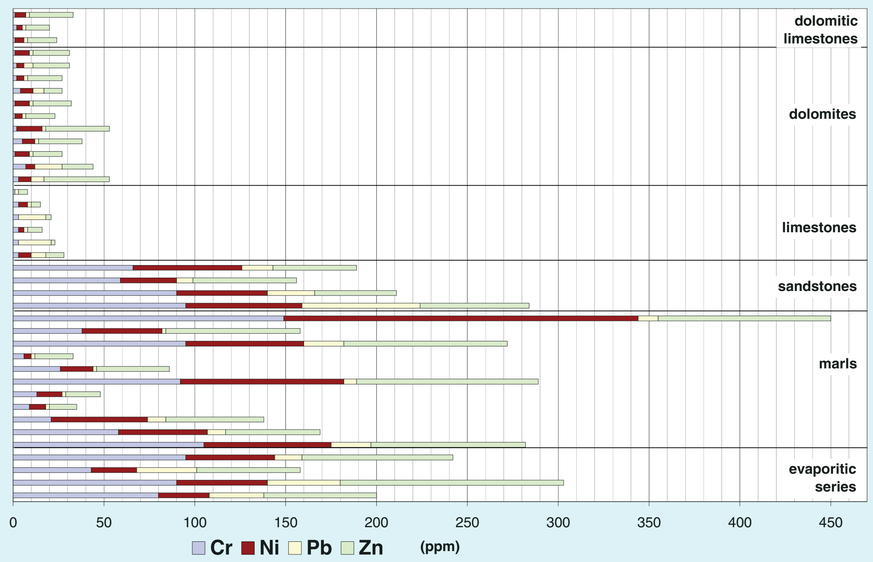
▲ **evaporites** ▲ **limestones & dolomitic limestones**

Stratigraphic position of sample / Lithology of sample

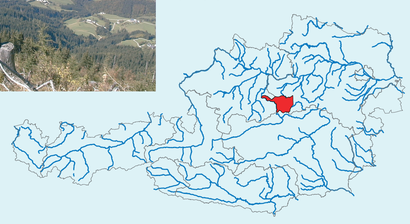
Stratigraphic position of sample	Lithology of sample
Losenstein- / Schrambach-Formations (Neokom)	marl
Plattenkalk (Norium - Rhätium)	dolomitic limestone
Hauptdolomit (Norium)	dolomite
Opponitz-Formation (Upper Karnium)	limestone
Lunz-Formation (Lower Karnium)	sandstone & marl
Partnach-Formation (Ladinium - Karnium)	marl
Haselgebirge (Permian)	evaporites



Trace element content of selected whole rock samples



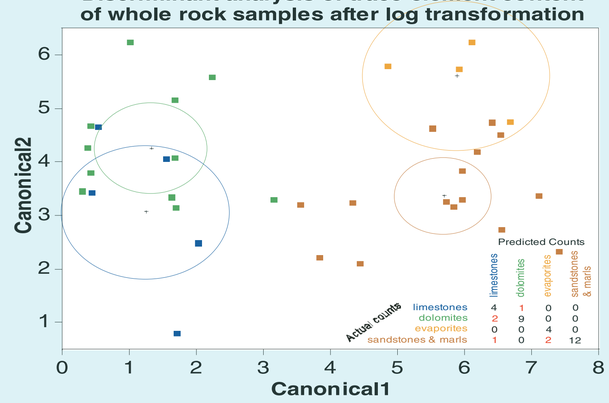
Typical landscape in study area



Location of study area in Austria

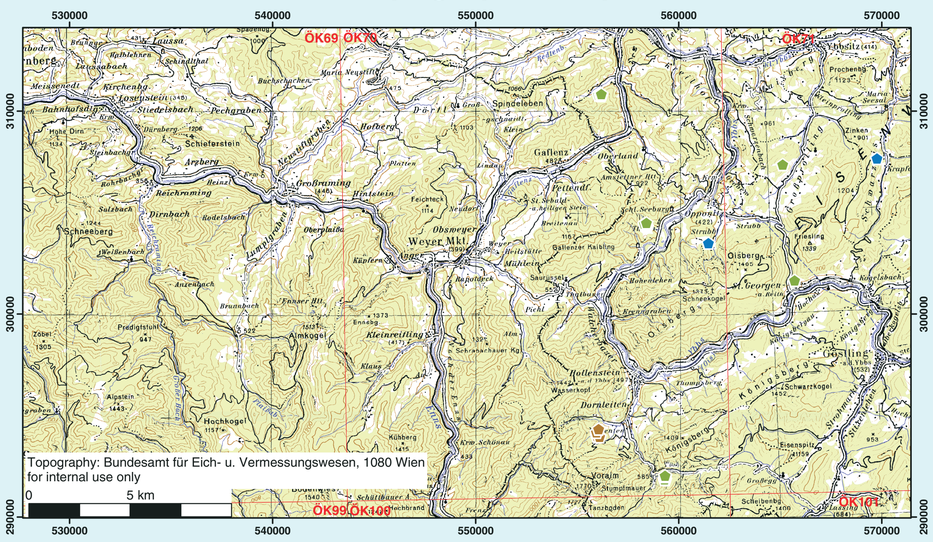
The study area, located in the Northern Calcareous Alps, is dominated by folded Triassic limestones and dolomites with interbedded sandstones and marls. Evaporitic series show minor occurrences. Jurassic limestones and marls, followed by Cretaceous sandstones and marls are the top members of the stratigraphic succession. Gravels and moraines represent the remnants of the quaternary glaciation period.

Discriminant analysis of trace element content of whole rock samples after log transformation



Sediments with terrigeneous influence show much higher heavy metal contents (200 - 400 ppm in total) than dolomites (40 - 60 ppm in total) and limestone samples (20 ppm in total). Discriminant analysis based on trace element content shows only minor miss-classification of rock samples.
However, our data sets might not meet the criteria for discriminant analysis (multi-variate normality, equal variances) and these effects have to be considered.

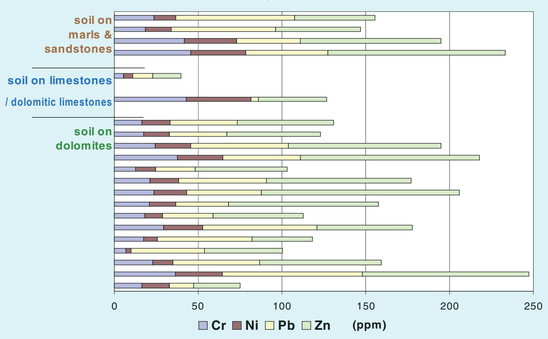
Topographic Map



● **soils on dolomites** ● **soils on limestones & dolomitic limestones**

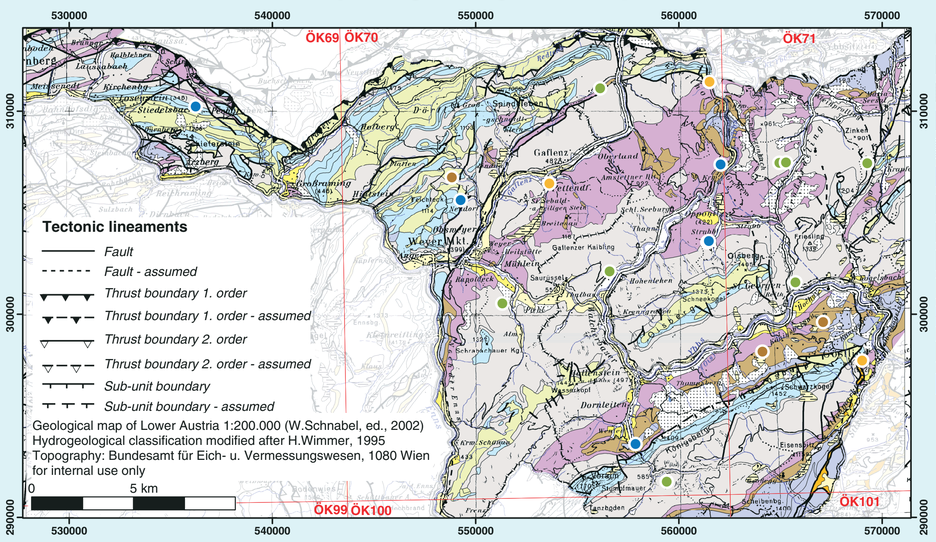
● **soils on marls and sandstones**

Trace element content of selected soil samples (aqua regia extract)



The sums of chromium, nickel, lead and zinc contents in soil samples (total amount as analysed by aqua regia extract) are similar to those of sandstone, marl and evaporitic rock samples, reaching maxima of up to 250 ppm. In contrast, soils overlying carbonates exhibit much higher trace element levels than their source rocks, possibly due to intercalations of marl within dolomite beds. No correlation becomes apparent at first sight between the chemical make-up of soils and their underlying lithology.

Hydrogeological Map



Hydrogeological Classification

- *Holocene valley fill*
- *Talus, alluvial fans, mass movements*
- *Würm - Niederterrasse (gravel)*
- *Würm - Moraine*
- *Riss and pre-riss coarse sediments*
- *Marls and sandstones (Neokom)*
- *Limestones (Malm - Rhät)*
- *Hauptdolomit, transition beds (Nor)*
- *Opponitz Formation (limestones, marls, gypsum)*
- *Lunz Formation (sandstones, marls, coal)*
- *Reifling Formation; Muschelkalk; Gutenstein limestone*
- *Werfen Formation (sandstones, evaporites)*

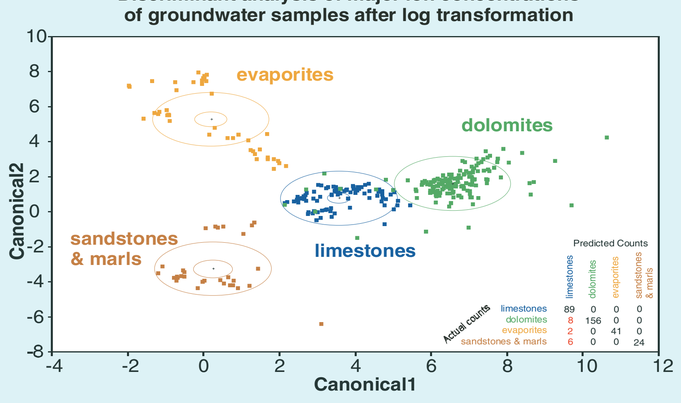
● **springs with sandstones & marls dominating the catchment areas**

● **springs with dolomitic catchment areas**

● **springs with evaporites dominating the catchment areas**

● **springs with limestone catchment areas**

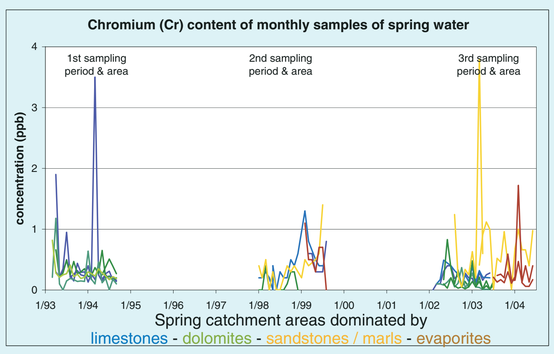
Discriminant analysis of major ion concentrations of groundwater samples after log transformation



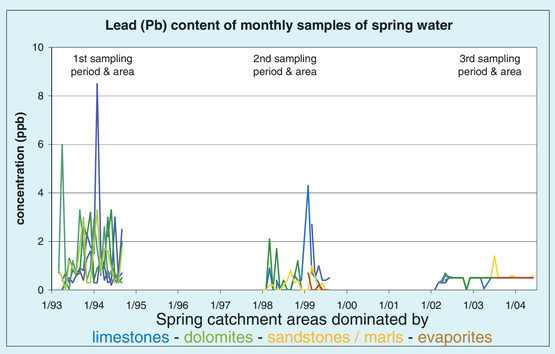
As expected, discriminant analysis of major ion concentrations reveals that the hydrochemical signature of most samples corresponds to the lithological make-up of the catchment area.

However, some samples do not fall into the "correct" category indicating that groundwater traveled through lithological units other than the one present at the discharge area.

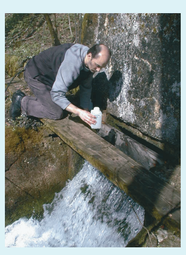
Chromium (Cr) content of monthly samples of spring water

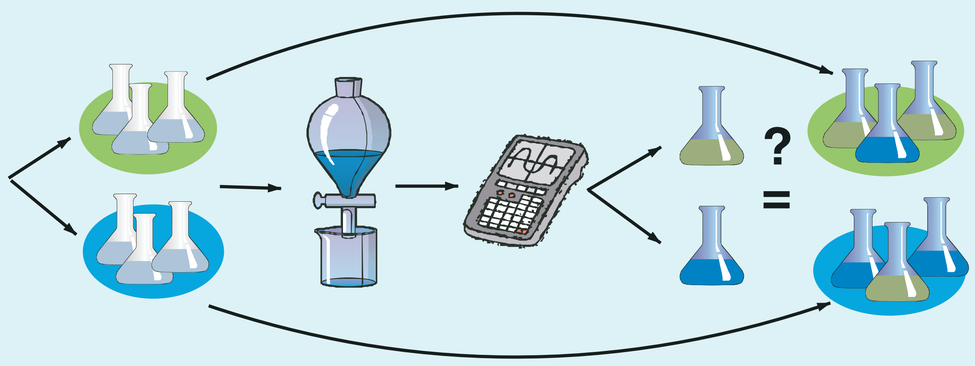


Lead (Pb) content of monthly samples of spring water



Discriminant analysis of trace element concentrations of groundwater samples does not show any clear distinction between the water types described above. However, time series reveal high temporal variations of individual elements and a decreasing trend of lead concentrations over the last ten years.





sampling | **grouping according to lithology of catchment area** | **hydro-chemical analysis** | **discriminant analysis** | **grouping according to hydrochemical water type** | **correspondance to lithological classes ?**

This study was funded by the governments of Lower and Upper Austria and by the Ministry of Education, Science and Culture.

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