



## Aspects relating to environmental geology in connection with historical mining and metallurgy sites in Styria 1997 - 1999

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### 1. Summary

The selective tests of some historical mining and metallurgical sites, which were presented by the "Geologische Bundesanstalt" (Geological Federal Agency) in 1994, partly showed very heavy concentrations of heavy metal in the area of the former lead-zinc mines of the Palaeozoic age in Graz. Due to the high number of historical mining and metallurgical sites, it was necessary to preselect the sites that have to be classified as being suspicious areas due to the damage caused by them on the basis of the geological, hydrogeological and use related basic data. According to a priority plan within the Province, the investigations were limited to the lead-zinc mining districts in the Graz and its environs.



### 2. Starting Position

By incorporating aspects relating to mining history, mining geology, geography and hydrogeology, the following mining districts are described extensively:  
Arzwaldgraben, Rabenstein, Guggenbach Nord, Guggenbach Süd, Großstübing, Deutsch-feistritz- Friedrichbau, Deutschfeistritz, Schrems-Talgraben, Rechberg, Peggau - Hinterberg - Taschen, Stiwoll



### 3. Goal

The studied sites are to be delimited in several steps until only the sites where real hazards must be expected in terms of the content and surroundings are subjected to a comprehensive examination using chemical laboratory techniques. For the sites that are classified as being suspicious areas due to the damage caused by them, a basic data record was made according to the Regulation of the Federal Ministry of Environment, Youth and Family. The sites are also assessed to find out whether there would be considerable risks for people and the environment at the existing use, whether such risks would be possible in case of modifications or whether hazards need not be assumed because the values are below the limiting and reference values.



### 4. Procedure

The investigation of the individual sites was done in the following steps:

- Basic study in terms of mining history and geology (what is important is the technical development at

winning, processing and smelting, which have a considerable effect on the composition of the landfills and their content of pollutants),

- Mapping of landfills and other mining traces in the terrain,
- Acquisition of the geological, hydrogeological, ecological ambient parameters and of the parameters relating to the geography of settlements,
- Acquisition of endangered goods to be protected,
- Determining possible load paths,
- Documentation and digitalisation,
- Specification of the sites to be subjected to further studies.

Ecologically relevant effects of former mining and metallurgy:

- Mountain movements due to mining
- Changes in the local water household by the creation of water conductivity
- Stockpiling dead rock and material containing ore in the immediate mining area and the resulting load of the ground and the vegetation by heavy metals
- Contamination or interference of natural ground with losses from ore processing: though these impacts on the ground mostly cover much a lower area, there may also be considerable concentrations of pollutants
- Distribution of loaded landfill material in the course of later use, (e. g. as bulk material)
- Dispersion courts and flows in brook and inundation sediments due to the erosion of landfill material,
- Impairment of ground and surface water caused by loaded pit water and landfill eluates,
- Sedimentation or discharge of residues from smelting processes, which used to lead to acute damage, e. g. in draining ditches,
- Flue gas emissions and heavy metals put on the landfill in the vicinity of the smelting sites. Though this kind of load may cover large areas, the concentrations of pollutants in the ground mostly are relatively low.
- Former acute damage, e. g. in forests.

The biological availability of heavy metals is, above all, controlled by the pH value, the content of organic substances, the cation exchanging capacity, the structure of the ground, the calcium carbonate equivalent as well as their interaction. As for the solubility and complexing capacity of heavy metals in relation to the pH value, it becomes obvious that all considered elements will, except for copper, have an extraction maximum at pH values <4. Organic substances reduce the solubility and availability of the mentioned heavy metals in the acid area.

The acquisition of an exchanging coefficient defined by the concentration of the metal in the overground share of the plants in relation to the overall concentration in the ground gives a rough survey of of the relative biological availability. Table 1 shows the standardised exchanging coefficients for some heavy metals, which have been determined by KLOKE.

Element	Exch. Coefficient
Cd	1-10
Cr	0.01 - 0.1
Cu	0.01 - 0.1
Pb	0.01 - 0.1
Zn	1 - 10

Table 1: Exchanging coefficients between ground and plants for some heavy metals (KLOKE in ALLOWAY & AYRES 1996)

The technique used for processing is decisive for the heavy metal content of the landfill. Smelting (further treatment of the ores or concentrates) leads to a concentration of undesired by-products in the waste products. Besides diffuse immissions due to the sedimentation of airborne dust in the vicinity of metallurgical industry, landfills for production waste are sources of contamination that cover small areas but often cause heavy impacts.

Mining District	Hydrogeological Conditions	Assessment and Ecological Relevance of the Landfills
Arzwaldgraben	Water accumulator	No further need for investigations, do not use sediments as bulk and building material!
	Rock series with prevalent	No further need for investigations, slopes are to be

Rabenstein	overground drainage, which are not karstic and less permeable	partly stabilised, do not use landfill material as bulk and building material!
Guggenbach Nord / Topenauer, / Rieger	Water accumulator (various kinds of slate)	No further need for investigations, slopes are to be partly stabilised, do not use landfill material as bulk and building material!
Guggenbach Süd / Pulvermühlbaue, / Unteres Revier, / Oberes Revier	Water accumulator (rocks that are badly permeable)	The springs are almost exclusively dependent on the formation of slope debris Site "Oberer Ludwigstollen" classified as being highly loaded. If it is further used as a pasture, detailed samples will have to be taken. The study of heavy metal load of the water of the spring in the discharge area of the Landfill 163/1004c-08H is very recommendable in view of the supply of the Market Town Übelbach with drinking water. The spring on the foot of the "Franziskastollen" ("Stollen" - working level) should be investigated for heavy metals if it is used as drinking water. Generally do not use landfill material as bulk and building material!
Großstübing / Silberberg, / Horkbaue, / Bergwerk	<p>Four homogeneous areas:</p> <ol style="list-style-type: none"> <li>1. Intensively fractured rocks with a high permeability, exclusively subterranean drainage and deep mountain water body: frequent spring discharge</li> <li>2. Intensively fractured rocks with a high permeability, dominantly subterranean drainage and low mountain water body</li> <li>3. Slightly permeable rocks with drainage near the surface</li> <li>4. Alluvial unconsolidated material of the "Stübingbachtal" ("Tal" - valley): low thickness of the aquifer storage, temporary drying of the brook, qualitatively and quantitatively not very important for water management. An exception is formed by the section below the "Brandnerbach" ("Bach" - brook); here there is the shaft well for the supply of the Commune of Großstübing with drinking water</li> </ol>	<p>No further need for investigations. If material is shifted because of high water, the ground on the alluvial cones below the Landfills 163/1005b-02H and 163/1005a-10H should be subjected to further sampling and analyses in view of an increased content of heavy metals.</p> <p>The water of the shaft well of the Commune of Stübing should be investigated for a possible heavy metal load in the discharge area.</p> <p>Generally do not use landfill material as bulk and building material!</p> <p>The landfill of the pyrite mine in Großstübing, which partly is already used as building land, is suitable for further house building if some conditions are observed.</p>

Deutschfeistritz / Friedrichsbau	<p>In the area of buildings and landfills, very badly permeable rocks are prevalent.</p> <p>The quaternary valley filling of the "Übelbach" ("Bach" - brook) consists of sands and pebbles with a considerable share of coarse clay. The existing groundwater body is used for drinking water purposes even though it is not very productive. There also is a pit well for supplying the Market Town of Deutschfeistritz with drinking water.</p>	<p>The mining site Friedrichsbau on the left side of the "Übelbach" ("Bach" - brook) is an abandoned polluted area that is extremely loaded with heavy metals. Investigations have shown a considerable entry of heavy metals in plants. Slag material has been eroded and carried by the "Übelbach" ("Bach" - brook). This means that sediment loads rich in heavy metals may have been transported over longer distances and deposited again. Therefore, the left bank of the "Übelbach" ("Bach" - brook) should be stabilised in the area of the landfill.</p> <p>Gravitational water flowing from the area of the landfill may penetrate into the low groundwater relatively quickly. Both the slag landfill and the highly contaminated bottom layer are factors that may endanger groundwater.</p>
Deutschfeistritz / Elisabethbau, / Martinibau	<p>In principle the rocks may be classified as being water accumulators. In the area of tectonic interferences and layer limits, however, there may be a certain degree of water conductivity.</p> <p>The main role in terms of subterranean drainage is played by the slope debris covers, which are partly quite thick. A part of the supply of the Commune of Schrems with water is taken from the area of the "Dreieinigkeitsbau" ("Bau" - mine) at the outlet of the "Haselbachgraben" ("Graben - ditch). The caught water discharges are, on the one hand, situated directly at the dumped mouth and, on the other hand, on the foot of the landfill.</p>	<p>The landfills of the former "Josefibau" ("Bau" - mine) mostly are situated within the Commune of Schrems. The landfill area on the right border is used for agricultural purposes. It may be assumed that the gravitational water flowing from the landfill area penetrate into the low groundwater rapidly quickly and may therefore endanger groundwater. For the spring catchments at the lower "Dreieinigkeitsstollen" ("Stollen" - working level), it is recommended to analyse the water for heavy metal loads. The slopes of the landfills in the catchment area of the "Hartscheidtbach" or "Haselbach" ("Bach" - brook) should be stabilised. Generally do not use landfill material as bulk and building material!</p>
Rechberg	The rocks may be classified as being water accumulators.	Due to the prevalent use for forestry, further investigations are not really necessary.
Hinterberg /Draxlerkogel, Taschen / Mitteregg	The rocks may be classified as being water accumulators.	Due to the prevalent use for forestry, further investigations are not really necessary. Generally do not use landfill material as bulk and building material!

Table 2: Description of the lead-zinc mining districts in Graz and its environs



## 5. Result / Benefits

Most landfills were installed in rock that is very badly permeable. Therefore, groundwater is only endangered in few cases. The goods to be protected that are affected most are those of the ground. Most landfills are situated in areas that are used for forestry. Areas used for agriculture are also affected. Measures recommended are not only the sampling and analysis of the landfill material and the vegetation for heavy metal load on areas used for agriculture but also the study of sources of drinking water that are influenced by landfills. Landfill slopes in the catchment area of brooks should be stabilised in order to avoid further material loads. The use of landfill material as bulk and building material, which has been practised up to now, should be stopped in order to avoid an extensive and uncontrolled spreading of contaminated material. By way of summary the benefit of this project is the creation of a basic data record of suspicious areas for the sites Deutschfeistritz/Friedrichsbau and Schrems-Josefibau

