EUROSOIL 2008 - EXCURSION 1CH/A-pre-congress
"ALPINE SOILS AND LONGTERM ECOSYSTEM RESEARCH"
(SWISS PART)

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1 GENERAL INTRODUCTION

The excursion starts at the Swiss Federal Institute for Forest, Snow, and Landscape Research in Birmensdorf (Research Institute of the ETH-board Zurich) where the concept of the Swiss longterm ecosystem research will be presented. This will be followed by a trip to the top of the Uetliberg with hopefully a nice view over the midlands to the alps and the city of Zurich.

The second day we will travel by bus to Davos and visit the geological rock-slide of the Totalp where the soil formation on serpentinic rock will be shown. The afternoon of the second day is dedicated to the visit of the Swiss Federal Institute for Snow and Avalanche Research Davos.

The third day a permanent plot of the longterm ecosystem research in Celerina (Engadin) will be presented, followed by a sightseeing of the Morteratsch-glacier and a stop at the visiting center of the national park in Zernez.

The second part of the excursion will be tackled by the Austrian collegues. Figure 1 shows the itinerary of the Swiss part of the excursion.

Fig. 1: General map of Switzerland with the itinerary of the excursion: Birmensdorf and Uetliberg –accomodation in Zurich – Davos-Wolfgang – Davos-SLF – accomodation in Davos – Celerina – Pontresina – Zernez – Schuls – accomodation in Schuls – transfer to Austria.

1.1 The Alps

(according to a text by Prof. Dr. Thomas Mosimann (1986), Geographisches Institut der Universität Hannover, slightly modified and shortened)

The Alps constitute a unique, clearly defined, and excitingly diversified region of Europe. One of the great mountain ranges of the earth, they are the most densely settled and, in terms of engineering, industry, and tourism, the most extensively exploited of all. The Alps stretch from the French Mediterranean coast in the west to Vienna in the east, and from the Plain of the Po in the south to the Rhone Valley, the Swiss Mittelland, and the Bavarian foot-hills in the north. In comparison to other mountain ranges they cover only a small area, some 240'000 km^2, or 2.5 % of the continent. They extend for roughly 1200 km and attain their maximum width of 240 km between Bavaria and the „Trientiner" Alps, although at many points they are only 150 km or less in width. The highest peaks occur in the west, the highest being Mont Blanc at 4810 m. The range of peaks stretching between Mont Blanc and Monte Rosa, in the Valais, may be regarded as the roof of the Alps. Eastwards the peaks sink to around 3800 m in the Austrian Alps (Grossglockner 3798 m). Nevertheless, the mountains rise very steeply from the foothills, especially in the south: the northern edge of the Plain of the Po, at 200 m, and Monte Rosa, at 4634 m, are only 50 km apart as the crow flies.

The Alps can be roughly divided into three sections: the western Alps, the Central Alps, and the eastern Alps. The western Alps lie between the Mediterranean coast and the Swiss Rhone Valley. The Central Alps comprise the whole of the Gotthard massif and include the most concentrated area of upwelling springs in Europe. The eastern Alps extend from the „Rhätische" Alps to Vienna and are the largest section in terms of area. Politically, the Alps are shared by 6 countries, the greates portions lying in France, Italy, Switzerland, and Austria. Since most of their national territory lies within the Alps, Switzerland and Austria can be regarded as truly Alpine states.

Tectonically, the Alps are a young mountain range. They form part of the immense fold system that includes the Atlas Mountains in North Africa, and the mountains in southeastern Spain, the Pyrenees, The Apennines, the Dinaric Alps, the Carpathians, the Caucasus, the Pontine Mountains, and the Taurus Mountains in Europe. The main phase of folding and mantle formation occurred during the Oligocene/Miocene, although the tectonic movement is still continuing today, and the land is evidently still rising. From the tectonic viewpoint, the Alps must be divided into two main units, east and west (Fig. 2). The eastern region is mainly characterised by the large mantle areas, and can be roughly divided into the calcareous Alps in the north and the gneiss area in the centre and the south. The western part can be sub-divided into three regions: the northern section, consisting of various sedimentation series with limestone predominating; the central area, comprising autochthonous massifs exposed by erosion and characterised by granite; and the southern and south-eastern part, where gneiss and schist predominate. The southern Alps form yet a third, minor unit, mainly of sedimentary rock, but also with gneiss series and in particular young intrusions (granite).

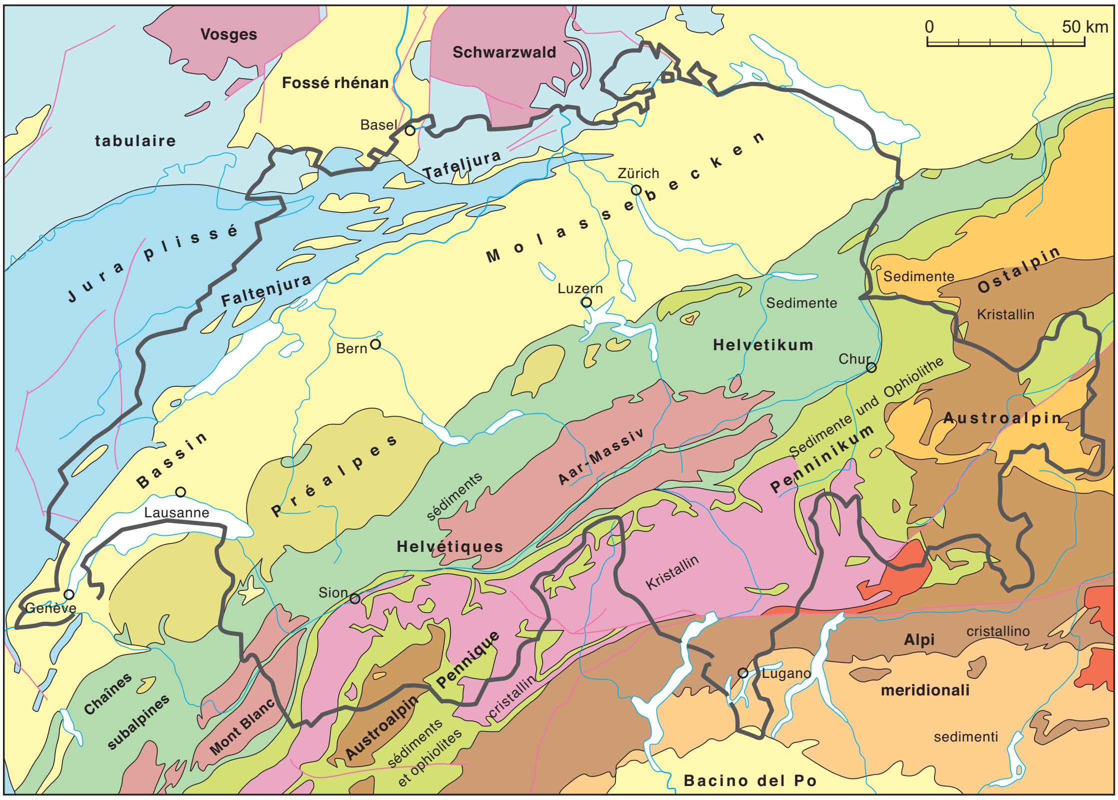

Fig. 2: Tectonic map of Switzerland.

Because of their situation within the continent of Europe, the Alps are exposed to a variety of climates. Maritime, continental, and mediterranean climates converge here. From east to west the Alps straddle the transition zone between the submediterranean and subcontinental climates and consequently experience differences in temperature patterns. These differences become particularly apparent if temperatures (sea level temperature) at the foot of the Alps are compared with those in the central valleys. The mean temperature in the inner valleys is 1 – 3°C higher than in non-Alpine regions of the same altitude and elevation. A special climatic feature, especially in the north-south valleys and their surroundings, is the föhn. The greatest differences between the various climatic regions, however, are those in precipitation. Precipitation due to barrage situations ultimately results in heavy precipitation on the outer and inner margins of the Alps and islands with little precipitation and many hours of sunshine in the centre. In Switzerland, the heaviest precipitation (up to 320 cm / year and more) falls on the northern margins and the main ridges, while the heaviest in the Alps as a whole (400 cm / year or more) occurs in the Julian Alps, north of the Adriatic. The most intensive precipitation occurs in the southern Alps and the bordering foothills. The high level of precipitation combined with the present permanent snow line naturally results in much glacial activity: the tongues of the largest glaciers extend until recently as low as 1800 m. Nowadays, with the climat change and the global warming, most glaciers retreat. As the foothills rise to the central peaks, the climate becomes increasingly continental, and the altitudinal zonation rises correspondingly. The present climatic snowline, for instance, rises from 2500 m at the northermost margin of the Alps to 3100 m in the heart of the western Alps and 2800 m in the east. Timberline lies around 1800 m in the north but climbs to 2300 m in the centre, although it must be borne in mind that in most cases the actual timberline has been depressed by human activity and does not necessarily correspond to the potential timberline.

The present pattern of natural formations, and thus also of land use, was basically laid down during the Pleistocene, when the glaciers repeatedly advanced towards to the edge of the mountains and even out into the foothills, thereby shaping the present relief and in particular gouging out the large U-shaped valleys. The most important of these run along major tectonic fault lines. The numerous lakes typically found along the edges of the Alps are basically also a result of this glacial activity, even though many of the depressions were present beforehand. As regards the formation and distribution of soil types, the most important results of the glaciation are, of course, the ground moraines and gravel areas which are so widely distributed through-out the foothills and the heart of the Alps. Since the last Ice Age occurred only 12'000 – 15'000 years ago, the soils of the Alps are, with very few exceptions, young ones.

As Switzerland has all sorts of geological substrates, the soil profiles shown during the excursion represent only a small part of all the possible soil types (BLASER et al. 2005). The first two profiles are at Wolfgang pass near Davos. One profile developed on pure Serpentinite, the other on a mixture of acid crystalline rock and Serpentinite. Figure 3 shows a section of the Swiss map with the geographical location of the two soil profiles.

The „Landschaft Davos“ (official denomination of the political community) is a resort in the north-east of the canton grison. It is situated in a transition area between the humid northern and the dry central alps of grison. With a surface area of 253 km^2 it is the second largest community of Switzerland. The main valley (Landwassertal) runs from NNE to SSW and the Landwasser is a tributary of the Hinterrhein. From SE three smaller valleys meet the Landwassertal: the Flüela-, Dischma- and Sertigtal. The NW-exposed side with the range of the areas of Parsenn and Strela and the mountain tops Weissfluh, Schiahorn and Chüpfenflue shield the Landwassertal to NNW.

Davos-Dorf and Davos-Platz (around 11'000 inhabitants) are situated in the upper part of the main valley and are the largest urban areas in the Landschaft Davos. In the other parts of the main valley and in the side-valleys there are smaller, mainly agricultural settlements (Laret, Wolfgang, Frauenkirch, Glaris, Spina, Monstein and Clavadel) and farmyards.

The Wolfgang is situated on the border between the Austroalpine nappes in the east and the penninic nappes in the west. The in-situ serpentinite on the western side of the Wolfgang pass belongs to the Arosa Zone, a jurassic-upper cretaceous-complex with ophiolites. The eastern side of the Wolfgang pass with the soils of the excursion is dominated by rock-slide material of the younger pleistocene and by stream debris of the holocene.

During glaciation the valleys of the Landschaft Davos were the origin of an indigenous glacier which went up to 2600 m. a. s. Therefore, only the highest mountain tops were free of ice. The glacier moved on the one hand to south-west where it met the Albula-glacier, on the other hand to the north to the Silvretta-Landquart-glacier. In late pleistocene the Davos-glacier disintegrated into various glacier tongues which built its own moraines.

Originally, the valley of the Landwasser drained in the area of Davos to the north-east. The watershed was at that time between Albula and Landwasser in the surroundings of Glaris. In the late pleistocene there was a big landslide (rock-slide of Totalp, see below) which resulted in a new watershed in the proximity of Wolfgang. As a consequence of this rock-slide the great lake of Davos was built with a length of 13 to 14 km. In the course of time the alluvial cones of the tributaries divided the lake in various basins. The discharge in the south was barred by moraines which were in a relatively short time countersunk. As a result the great lake of Davos partly leaked and reduced to the dimensions of the actual lake of Davos. As a consequence of the great lake of Davos, various deltas were filled which contributed to the morphology of the high valley.

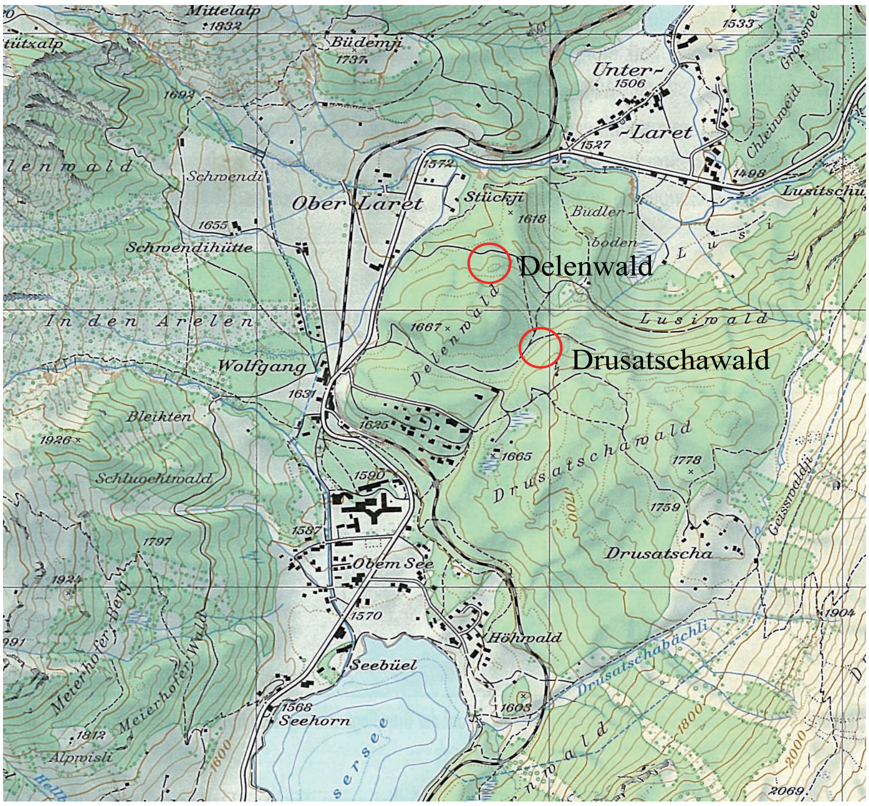

Fig. 3: Geographical location of the soil profiles Delenwald and Drusatschawald

1.2 Long-term forest Ecosystem Research

The mission of the long-term forest ecosystem research (LWF) is to improve our understanding of how natural and anthropogenic stresses affect forests in the long term, and which risks for humans are involved. Consequently, it is needed to gain a more profound knowledge of the cause-effect relationships in the forest ecosystem and the underlying processes. The aims of LWF are:

- ★ to assess external anthropogenic and natural stresses (e.g., atmospheric deposition, climate)
- ★ to assess changes of relevant forest ecosystem components
- ★ to evaluate the influence of external stresses on forest ecosystems
- ★ to develop indicators of forest health
- ★ to analyse the risks under different stress scenarios

Using a network of selected study sites, the long-term response of forest ecosystem components and processes are monitored to the most relevant stress factors. The particular emphasis is on atmospheric deposition, the biogeochemical cycle, the climate, the soil, the ground vegetation and the trees.

The mission is in agreement with the aims of the "International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests" (ICP-Forests) and the "International Co-operative Programme on Integrated Monitoring of Air Pollution Effects" (ICP-IM).

The LWF is part of the International Long-Term Ecological Research Network ILTER.

In Switzerland, there are 17 LWF-plots representing broad spectra of different site characteristics (bedrock, climate, topography, vegetation, …). The LWF-plots were installed in the years 1994 to 1997. Their size is varying between 0.2 and 2 ha, whereas most of the plots have a size of 2 ha.

Figure 4 shows the situation of the LWF plots in Celerina with the two subplots a and b, each with a size of 2 ha. The monitoring is done in subplot a, subplot b rests as a reserve in case of natural calamities (storm, insects).

Fig. 4: Situation of the two subplots of the LWF site Celerina.

2 METHODS

2.1 Soil physical analyses

Particle size distribution, Pipette-Method, after GEE & OR (2002);

Bulk Density, excavation method, after GROSSMAN & REINSCH (2002);

Particle Density, after FLINT & FLINT (2002a);

Total Porosity, after FLINT & FLINT (2002b);

Saturated water conductivity, determination on the basis of tabulated conductivities, input parameters are texture and bulk density, after AK SK (1996);

Available water capacity, determination on the basis of tabulated capacities, input parameters are texture, bulk density of the fine earth, humuscontent and stone content, after AK SK (1996).

2.2 Soil chemical analyses

The exchangeable cations were extracted with 1 M NH_4Cl (soil:solution ratio: 1:10, extraction time: 1 h), after LUSTER & BLASER (2006). The exchanged elements were measured by inductively coupled plasma atomic emission spectrometry (ICP-AES; Optima 3000, Perkin Elmer Corp.).

The pH-value was measured in 0.01M $CaCl_2$, after THOMAS (1996).

Total organic C- and total N-content were determined by catalytic combustion (automatic CN analyzer Carlo Erba Instruments NA 1500).

Pyrophosphate-extractable Fe; after BASCOMB (1968); measured by atomic absorption spectrophotometry (AAS; Philips PU 9200).

Oxalate-extractable Al and Fe; after SCHWERTMANN (1964), McKEAGUE & DAY (1966), and JACKSON et al. (1986); measured by atomic absorption spectrophotometry (AAS; Philips PU 9200).

Dithionite-extractable Fe; after MEHRA & JACKSON (1960), and HOLMGREN (1967); measured by atomic absorption spectrophotometry (AAS; Philips PU 9200).

HNO_3-extractable element contents approximating an effective total element content; after AITANG & HÄNI (1983); measured by atomic absorption spectrophotometry (AAS; Philips PU 9200).

3 EXCURSION POINTS

3.1 Excursion point 1: Uetliberg, close to Zurich, overview of the landscape

Site characterisation

Location: top of the Uetliberg; altitude: 870.8 m.a.s.l.

Swiss coordinates: 679600 / 244800

The mountain range of Albis belongs to the upper freshwater molasse and consists mainly of marl, sandstones and molasse-conglomerates. On the highest elevations, mainly at the Uetliberg, there are layers of high-lying, often consolidated plateau gravels (conglomerates) which were deposited by glaciers during the earlier glaciations (glaciers of Linth and Reuss during Günz and Mindel).

Climate: Zurich has a transitional climate, but is mainly influenced by warm and moist winds which come from the Atlantic Ocean. For this reason, the climate is milder than the typical climate at a latitude of 47 degree.

Temperature in ° C

Meteoro-logical station	Altitude m.a.s.l.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Ave-rage
Zurich	556	-0.5	0.9	4.2	7.8	12.1	15.2	17.6	16.7	13.8	9.3	3.9	0.6	8.5

Precipitation in mm

Meteoro-logical station	Altitude m.a.s.l.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Average
Zurich	556	67	70	69	87	103	124	117	133	92	69	82	73	1086

Relief: hilltop

Landuse/vegetation: forest

Fig. 5: View from Uetliberg to the Alps with the lake of Zurich in the front.

3.2 Excursion point 2: Soil profiles at Wolfgang pass in Davos, canton Grison: skeletic Cambisol (serpentinitic) and podzol

Site characterisation

Location

The little hill east of Wolfgang at an altitude between 1500 and 1780 m.a.s.l. is the deposition of the rock-slide which happened 14'000 years BP in the late pleistocene. Since that time this hill was never glaciated and the soil development could proceed unhinderedly (GASSER, 1990).

Geologists assume various theories about the course of the rock-slide. In general, one assumes a two phase event. Soil investigations (JUCHLER & STICHER, 1985) confirm the theory of two successive rock-slides containing two different rock types. The *Drusatscha*- and *Lusiwald* with a mixture of acid crystalline rock and Serpentinite can be assigned to the first rock-slide of Drusatscha; the *Delenwald* and *Budlerboden* with pure Serpentinite are a result of the rock-slide of Wolfgang. The northern part of the hill of „*Drusatscha*“ detached at a later date and filled as a little land-slide the valley of Stützbach forming the flat area of „*Unter-Laret*“ and „*Grossweid*“ with the „*Stützwald*“ as a front. The „*Lusiwald*“ with its steeper slope and the concave form remained after the last land-slide (JUCHLER, 1988; JUCHLER & STICHER, 1985).

The soil profiles are at two different sites:
Drusatschawald, altitude: 1660 m.a.s.l., swiss coordinates: 785000 / 189880
Delenwald, altitude: 1615 m.a.s.l., swiss coordinates: 784750 / 190200

Climate

The climatic conditions in the Landschaft Davos can be described as temperate central alpine to continental. Generally, the sum of precipitations is rather low, there is a low cloudiness and al long sunshine duration with little wind in the valley. However, within the whole area there are quite big differences. The upper valley of Landwasser belongs together with the Prättigau to the climatic zone of the northern alps with a lot of precipitations. The lower valley of Landwasser is already temperate continental with a rather dry inneralpine mountain climate. On the average the precipitations in the Landschaft Davos are 1007 mm per year, so below the average of 1250 mm for whole Switzerland. If the wind comes from south, there is a foehn-effect which supports the character of low precipitations. If the wind comes from north, Davos is better protected by the Wolfgang pass than for example the Prättigau where the winds from north can enter unhamperedly. Even though Davos is located 350 m higher than Klosters, there are clearly less precipitation in Davos. Around 40% of the precipitation is snow. As a general rule, snow cover lasts from beginning of november to end of mai (IMBECK & OTT 1987). The growing season lasts 3 to 4 months (mai/june until september). The mean temperature in january is around –7°C and in july approximately +12°C. The mean minimum in january is –21°C and the mean maximum in july is +24°C. The number of frost days is quoted with 192 per year, those of ice days with 60.

Temperature in ° C

Meteoro-logical station	Altitude m.a.s.l.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Ave-rage
Davos	1590	-5.3	-4.7	-2.2	1.3	5.9	9.0	11.3	10.8	8.3	4.7	-1.0	-4.4	2.8

Precipitation in mm

Meteoro-logical station	Altitude m.a.s.l.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Average
Davos	1590	74	64	65	60	99	130	143	146	98	63	72	70	1082

Relief — Delenwald: at a slope with an inclination of 5%
Drusatschawald: at a slope with an inclination of 60%

Landuse/vegetation — forest (at both sites)

Soil profile description:

Delenwald (skeletic Cambisol, serpentinitic)

Of (5 – 3 cm):	pH strongly acid, pieces of organic sturctures, origin well recognizable, strongly rooted horizon, very loose density, with a straight boundary switching over to:
Oh (3 – 0 cm):	pH strongly acid, fine and unstructured organic material, origin not recognizable any more, strongly rooted horizon, very loose density, with a straight boundary switching over to:
Ah (0 – 5 cm):	loamy silt, 5% coarse fraction (skeleton), 10YR/3/3 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, very loose density, with an undulated boundary switching over to:
Bv1 (5 – 15 cm):	loamy silt, 5% coarse fraction (skeleton), 10YR/4/4 (moist), pH moderately acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, very loose density, with a smeared boundary switching over to:
Bv2 (15 – 20 cm):	loamy silt, 13% coarse fraction (skeleton), 10YR/4/4 (moist), pH moderately acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, loose density, with an undulated boundary switching over to:
BC1 (20 – 50 cm):	loam, 44% coarse fraction (skeleton), 10YR/4/6 (moist), pH slightly acid, no carbonate content, fine friable sub-polyhedral structure, moderately rooted horizon, no hydromorphic features, moderate density, with a smeared boundary switching over to:
BC2 (50 – 70 cm):	loamy sand, 33% coarse fraction (skeleton), 2.5Y/4/2 (moist), pH slightly acid, no carbonate content, fragmented structure, slightly rooted horizon, no hydromorphic features, moderate density, with an undulated boundary switching over to:
Cv (> 70 cm):	sand, 48% coarse fraction (skeleton), colour not determined, pH slightly acid, no carbonate content, fragmented structure, slightly rooted horizon, no hydromorphic features, moderate density.

Analytical results:

Soil physical parameters (Delenwald):

Table 1: Soil physical parameters of the soil profile of Delenwald; n.d. = not determined

Horizon	Depth [cm]	Stone content [$\%_v$]	Soil Texture [$\%_g$]			Density [g cm^{-3}]			Saturated water conductivity [cm d^{-1}]	Available water capacity [l m^{-2}]
			Sand (2000-630 µm)	Silt (630-2 µm)	Clay (< 2 µm)	real	Soil	Porosity [%]		
Of	5-3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7.4
Oh	3-0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	11.1
Ah	0-5	5	21	55	24	2.25	0.3	0.87	100	17.6
Bv1	5-15	5	22	56	23	2.34	0.6	0.74	100	35.2
Bv2	15-20	13	19	54	27	2.70	0.8	0.70	100	10.2
BC1	20-50	44	41	32	27	2.64	1.4	0.47	9	30.2
BC2	50-70	33	81	11	8	2.65	1.4	0.47	126	26.1
Cv	> 70	48	85	11	4	2.65	1.4	0.47	155	30.4

Soil chemical parameters (Delenwald):

Table 2: Exchangeable cations and pH-value in the fine earth fraction of the soil profile of Delenwald; < d.l. = below the detection limit

Horizon	Depth [cm]	pH	Exchangeable cations [$mmol_c$ kg^{-1}]								CEC [$mmol_c$ kg^{-1}]	BS [%]
			Na	K	Ca	Mg	H	Mn	Al	Fe		
Of	5-3	4.0	1.94	12.2	106.8	125.2	184	4.85	4.20	1.82	441	55
Oh	3-0	4.4	2.04	8.0	61.1	135.9	169	7.80	5.58	2.19	392	52
Ah	0-5	4.4	1.19	1.6	26.7	121.8	154	7.13	1.52	0.23	314	48
Bv1	5-15	5.3	1.00	1.3	9.9	92.8	87	0.34	<d.l.	0.06	192	54
Bv2	15-20	5.6	0.98	0.5	7.3	75.8	58	0.24	<d.l.	<d.l.	143	59
BC1	20-50	5.8	0.96	0.3	4.6	58.7	32	0.13	<d.l.	<d.l.	97	66
BC2	50-70	5.9	0.95	0.1	4.2	51.0	32	0.11	<d.l.	<d.l.	88	63
Cv	> 70	6.1	0.94	<d.l.	3.7	43.3	7	0.08	<d.l.	<d.l.	55	85

Table 3: C-, N-, and extractable Fe- and Al-contents in the fine earth fraction of the soil profile of Delenwald. The inorganic carbon content is in all horizons below the detection limit of 0.3 g/kg; < d.l. = below the detection limit; n.d. = not determined

Hori-zon	Depth [cm]	C- and N-contents [g kg^{-1}]			C_org N_tot^{-1}	Extractable Fe and Al [g kg^{-1}]				
		N_tot	C_tot	C_org		Fe_d	Fe_o	Fe_o/Fe_d	Fe_p	Al_o
Of	5-3	18.3	398.8	398.8	22	n.d.	n.d.	n.d.	n.d.	n.d.
Oh	3-0	15.6	330.8	330.8	21	n.d.	n.d.	n.d.	n.d.	n.d.
Ah	0-5	12.6	368.2	368.2	29	49.8	14.4	0.29	3.63	2.08
Bv1	5-15	4.1	102.4	102.4	25	27.1	12.3	0.45	3.35	2.74
Bv2	15-20	1.4	29.8	29.8	21	36.7	9.5	0.26	1.90	2.10
BC1	20-50	0.5	12.3	12.3	24	13.4	3.5	0.26	0.95	1.46
BC2	50-70	< d.l.	3.9	3.9	-	11.0	3.0	0.27	0.47	1.15
Cv	> 70	< d.l.	2.1	2.1	-	9.4	2.8	0.30	0.28	0.84

Soil profile description:

Drusatschawald (podzol)

Of (12 – 3 cm): pH extremely acid, pieces of organic sturctures, origin well recognizable, strongly rooted horizon, very loose density, with a straight boundary switching over to:

Oh (3 – 0 cm): pH extremely acid, fine and unstructured organic material, origin not recognizable any more, strongly rooted horizon, very loose density, with a straight boundary switching over to:

Ah (0 – 1 cm): loam, 1% coarse fraction (skeleton), 7.5YR/2/3 (moist), pH extremely acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, very loose density, with an undulated boundary switching over to:

E (1 – 3 cm): loam, 13% coarse fraction (skeleton), 7.5Y/5/3 (moist), pH extremely acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, very loose density, with an undulated boundary switching over to:

Bh (3 – 5 cm): loam, 13% coarse fraction (skeleton), 7.5YR/4/6 (moist), pH extremely acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, very loose density, with an undulated boundary switching over to:

Bs (5 – 20 cm): sandy loam, 9% coarse fraction (skeleton), 7.5YR/4/1 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, moderately rooted horizon, no hydromorphic features, very loose density, with a smeared boundary switching over to:

BC (20 – 40 cm): loamy sand, 38% coarse fraction (skeleton), 7.5YR/6/2 (moist), pH moderately acid, no carbonate content, fragmented structure, slightly rooted horizon, no hydromorphic features, dense compactness of packing of the fine earth, with a smeared boundary switching over to:

Cv (> 40 cm): loamy sand, 53% coarse fraction (skeleton), colour not determined, pH moderately acid, no carbonate content, fragmented structure, slightly rooted horizon, no hydromorphic features, dense compactness of packing of the fine earth.

Analytical results:

Soil physical parameters (Drusatschawald):

Table 4: Soil physical parameters of the soil profile of Drusatschawald; n.d. = not determined

Horizon	Depth [cm]	Stone content [$\%_v$]	Soil Texture [$\%_g$]			Density [g cm^{-3}]			Saturated water conductivity [cm d^{-1}]	Available water capacity [l m^{-2}]
			Sand (2000-630 µm)	Silt (630-2 µm)	Clay (< 2 µm)	real	Soil	Porosity [%]		
Of	12-3	n.d.	n.d.	n.d.	n.d.	1.44	0.1	0.93	n.d.	33.3
Oh	3-0	n.d.	n.d.	n.d.	n.d.	1.44	0.1	0.93	n.d.	11.1
Ah	0-1	1	34	41	26	2.44	0.7	0.71	100	3.7
E	1-3	13	34	41	26	2.44	0.7	0.71	100	4.1
Bh	3-5	13	32	41	27	2.44	0.7	0.71	100	6.4
Bs	5-20	9	40	45	15	2.61	0.7	0.73	100	41.0
BC	20-40	38	66	28	6	2.73	1.5	0.45	51	28.5
Cv	>40	53	77	18	5	2.75	1.7	0.38	43	14.1

Soil chemical parameters (Drusatschawald):

Table 5: Exchangeable cations and pH-value in the fine earth fraction of the soil profile of Drusatschawald; < d.l. = below the detection limit

Hori-zon	Depth [cm]	pH	Exchangeable cations [$mmol_c$ kg^{-1}]								CEC [$mmol_c$ kg^{-1}]	BS [%]
			Na	K	Ca	Mg	H	Mn	Al	Fe		
Of	12-3	3.3	2.2	16.4	38.4	147	24.7	0.8	9.7	2.2	242	85
Oh	3-0	3.4	2.0	9.2	28.3	198	21.9	0.2	15.2	4.5	279	85
Ah	0-1	3.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
E	1-3	3.2	1.5	0.9	6.5	68	7.4	0.6	82.6	9.0	176	44
Bh	3-5	3.7	1.9	1.2	7.5	37	14.9	0.1	128.4	7.5	198	24
Bs	5-20	4.2	1.7	0.5	7.5	74	3.5	0.4	41.7	1.7	131	64
BC	20-40	5.2	1.6	< d.l.	7.0	69	1.2	0.2	0.3	0.1	79	98
Cv	> 40	5.4	1.5	1.5	5.4	83	0.9	0.1	0.2	< d.l.	93	99

Table 6: C-, N-, and extractable Fe- and Al-contents in the fine earth fraction of the soil profile of Drusatschawald. The inorganic carbon content is in all horizons below the detection limit of 0.3 g/kg; n.d. = not determined

Hori-zon	Depth [cm]	C- and N-contents [g kg^{-1}]			C_org N_tot^{-1}	Extractable Fe and Al [g kg^{-1}]				
		N_tot	C_tot	C_org		Fe_d	Fe_o	Fe_o/Fe_d	Fe_p	Al_o
Of	12-3	1.56	44.0	44.0	28	n.d.	n.d.	n.d.	n.d.	n.d.
Oh	3-0	1.56	44.0	44.0	28	n.d.	n.d.	n.d.	n.d.	n.d.
Ah	0-1	n.d.	n.d.	n.d.	n.d.	35.3	18.5	0.53	22.6	3.2
E	1-3	0.31	6.4	6.4	20	2.9	1.1	0.36	1.8	2.9
Bh	3-5	0.62	12.0	12.0	19	32.2	24.6	0.76	30.0	4.7
Bs	5-20	0.22	4.8	4.8	22	39.8	22.4	0.56	28.9	3.2
BC	20-40	0.06	1.4	1.4	23	13.9	6.7	0.48	7.1	0.8
Cv	> 40	0.04	0.7	0.7	18	8.2	3.4	0.41	3.6	0.7

3.3 Excursion point 3: Soil profile at Celerina, plot of the longterm ecosystem research, canton Grison: podzol

Site characterisation

Location The lower hillsides in the Engadin are covered by shallow moraines. That is also true for the site of the longterm ecosystem research plot in Celerina. The moraine stems from the last glacial maximum (18’000 years BP) and the following phases of glaciation (15’000 to 10’000 years BP). It builds the substratum of the soil formation. Lithologically, the moraine is free from carbonates.

The site is at an altitude of 1850 m.a.s.l.; swiss coordinates: 788085 / 151918

Climate The Engadin area belongs to the continental inner-alpine climate zone. The lower Engadin around Schuls is one of the dryest regions in the canton Grison, whereas the upper Engadin is open to the south and gets more precipitations compared to the lower Engadin if clouds coming from south and are retained by high mountains. In relation to the altitude of 1850 m.a.s.l. the annual average precipitations of 1397 mm are rather low which is typical for a continental climate.

Temperature in ° C

Origin of the data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Ave-rage
interpolated	-6.7	-6.0	-3.3	0.2	4.9	8.3	10.7	10.3	7.7	3.5	-2.2	-5.6	1.8

Precipitation in mm

Origin of the data	Ja n	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Average
interpolated	84	75	100	125	150	133	130	142	125	120	130	83	1397

Relief middle of a slope with an inclination of 34%

Landuse/vegetation mixed forest with larch and Swiss stone pine

Soil profile description (podzol):

AE (0 – 4 cm): silt, 1% coarse fraction (skeleton), 10YR/5/2 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, very loose density, with a straight boundary switching over to:

E1 (4 – 15 cm): silt, 2% coarse fraction (skeleton), 10YR/6/3 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, moderate density, with an undulated boundary switching over to:

Bs1 (15 – 27 cm): silt, 8% coarse fraction (skeleton), 10YR/5/4 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, moderate density, with an undulated boundary switching over to:

E2 (27 – 35 cm): silt, 6% coarse fraction (skeleton), 2.5Y/6/3 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, moderate density, with an undulated boundary switching over to:

Bs2 (35 – 45 cm): silt, 6% coarse fraction (skeleton), 10YR/5/6 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, strongly rooted horizon, no hydromorphic features, moderate density, with a smeared boundary switching over to:

B (45 – 60 cm): loamy sand, 9% coarse fraction (skeleton), 2.5Y/5/4 (moist), pH strongly acid, no carbonate content, fine friable sub-polyhedral structure, moderately rooted horizon, no hydromorphic features, moderate density, with a smeared boundary switching over to:

BC (> 60 cm): loamy sand, 38% coarse fraction (skeleton), colour not determined, pH strongly acid, no carbonate content, fragmented structure, slightly rooted horizon, no hydromorphic features, dense compactness of packing of the fine earth

Analytical results:

Soil physical parameters :

Table 7: Soil physical parameters of the soil profile of Celerina; n.d. = not determined

Hori-zon	Depth [cm]	Stone content [$\%_v$]	Soil Texture [$\%_g$]			Bulk Density [g cm^{-3}]		Saturated water conductivity [cm d^{-1}]	Available water capacity [l m^{-2}]
			Sand (2000-630 µm)	Silt (630-2 µm)	Clay (< 2 µm)	Soil	Fine earth		
AE	0-4	1	44	47	9	0.84	0.83	100	12
E1	4-15	2	36	52	12	1.20	1.17	49	29
Bs1	15-27	8	47	45	8	1.27	1.16	47	30
E2	27-35	6	46	48	6	1.26	1.18	39	20
Bs2	35-45	6	50	43	7	n.d.	n.d.	39	25
B	45-60	9	49	44	6	1.16	1.11	39	37
BC	60-120	38	46	50	4	1.66	1.50	34	91

Soil chemical parameters:

Table 8: Exchangeable cations and pH-value in the fine earth fraction of the soil profile of Celerina

Hori-zon	Depth [cm]	pH	Exchangeable cations [$mmol_c$ kg^{-1}]								CEC [$mmol_c$ kg^{-1}]	BS [%]
			Na	K	Ca	Mg	H	Mn	Al	Fe		
AE	0-4	4.0	0.34	3.0	46.7	12.8	9.6	5.10	32.6	0.45	111	57
E1	4-15	4.0	0.30	1.1	18.9	5.5	9.2	1.92	57.8	0.34	95	27
Bs1	15-27	4.2	0.32	1.2	10.1	2.8	3.6	0.16	25.2	0.41	44	33
E2	27-35	4.2	0.29	0.6	11.2	3.2	4.5	0.15	33.9	0.33	54	28
Bs2	35-45	4.3	0.33	1.7	10.9	2.9	3.2	0.13	23.4	0.43	43	37
B	45-60	4.4	0.25	1.7	9.5	2.5	1.0	0.06	18.4	0.36	34	41
BC	60-120	4.5	0.19	1.2	5.0	1.2	0.8	0.04	8.0	0.17	17	46

Table 9: C-, N-, and extractable Fe- and Al-contents in the fine earth fraction of the soil profile of Celerina. The inorganic carbon content is in all horizons below the detection limit of 0.3 g/kg

Hori-zon	Depth [cm]	C- and N-contents [g kg^{-1}]			C_org N_tot^{-1}	Extractable Fe and Al [g kg^{-1}]				
		N_tot	C_tot	C_org		Fe_d	Fe_o	Fe_o/Fe_d	Fe_p	Al_o
AE	0-4	2.5	51.8	51.8	20	4.5	2.9	0.64	2.2	1.2
E1	4-15	0.7	13.9	13.9	19	5.6	4.2	0.74	2.9	1.8
Bs1	15-27	0.3	6.7	6.7	20	6.8	4.9	0.71	4.3	2.0
E2	27-35	0.3	4.3	4.3	17	3.7	2.8	0.75	1.9	1.3
Bs2	35-45	0.4	9.0	9.0	21	14.0	10.6	0.76	7.3	3.3
B	45-60	0.3	7.1	7.1	21	9.3	8.3	0.89	6.5	3.3
BC	60-120	0.1	2.4	2.4	19	3.7	2.1	0.58	2.1	1.5

Table 10: HNO_3-extractable element contents (approximated total contents) in the soil profile of Celerina

Hori-zon	Depth [cm]	HNO_3-extractable element contents [mg kg^{-1}]							
		P	Ca	Mg	K	Na	Fe	Al	Mn
AE	0-4	316	2078	1554	892	80	7818	6739	783
E1	4-15	174	1505	1712	829	74	9843	8069	671
Bs1	15-27	446	1761	2529	1181	75	13574	9933	192
E2	27-35	166	1493	1181	837	83	6936	6056	143
Bs2	35-45	811	1830	2645	1344	76	20899	12229	197
B	45-60	708	1980	3056	1610	76	18389	12370	181
BC	60-120	775	2343	2760	1503	62	10437	8763	211

3.4 Excursion point 4: View to the Morteratsch glacier

Figure 6 shows the view to the Morteratsch-glacier one has looking direction south from the street Pontresina-Passo del Bernina (792300/148100, swiss coordinates).

Fig. 6: View to the Morteratsch-glacier

3.5 Further excursion points:

Information on the other excursion points (WSL Birmensdorf; SLF Davos; visiting center of the national park in Zernez) will be hand out on the excursion.

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"SOILS AND SITES IN THE FORMER GLACIAL AND PERIGLACIAL AUSTRIAN REGIONS" (AUSTRIAN PART)

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1
SUBJECT AND PROGRAMM OF THE FIELD-TRIP 1CH/A – Austrian Part

During the Austrian part of this excursion 1CH/A the intention is to show the influence of climate, topography, and altitude above sea level on soil genesis on different substrates in and around the Eastern Austrian Alps.
This excursion starts in the relatively dry and warm inner alpine valley of the Inn river (Haiming: profile 1CH/A – 1)) and moves through the northern part of the Alps (Maishofen: profile 1CH/A – 2) climbing up southward to the top of the mountain ridge, in the environment of the Großglockner (profiles 1CH/A - 3, 4 and 5). After this profiles the excursion attains in the Limestone Alps and has the next stop on a re-cultivated area (Hintersteineralm, profile 1CH/A - 6). This excursion will be finished after a visit of the Geological Study Trail Furth, near Göttweig, and the profile 1CH/A - 7, a loess-carrier in a brick pit near Pottenbrunn on the Vienna West Railway Station.

Programme from the 21th to the 24th August 2008 in Austria:

Thursday, 21th August	Departure 8.00 from Scuol/Schuls to Haiming (profile 1CH/A - 1), Lunch and profile 1CH/A - 2 in Maishofen, Departure to the Glocknerhaus via Großglockner-Hochalpenstraße, Overnight stay in Glocknerhaus.
Friday, 22th August	Departure 8.00: Gamsgrube (profile 1CH/A - 3), and Senfteben (profile 1CH/A – 4), Pasterzen glacier, Overnight stay in the Glocknerhaus.
Saturday, 23th August	Departure 8.00 from Glocknerhaus, Fallbichl (profile 1CH/A - 5), Open air stone collection near Fuscher-Lacke, Edelweißspitze, Salzach and Enns valley, Overnight stay in Irdning.
Sunday, 24th August	Departure 8.00 to Pyrhnpass: Hintersteinerlam (profile 1CH/A – 6), Melk, Danube valley (Wachau), Lunch, Furth: Geological Study Trail,

Pottenbrunn (profile 1CH/A - 7),
Vienna West Railway Station (Wiener Westbahnhof).

2
INTRODUCTION TO AUSTRIA – A GENERAL GEOGRAPHIC SURVEY

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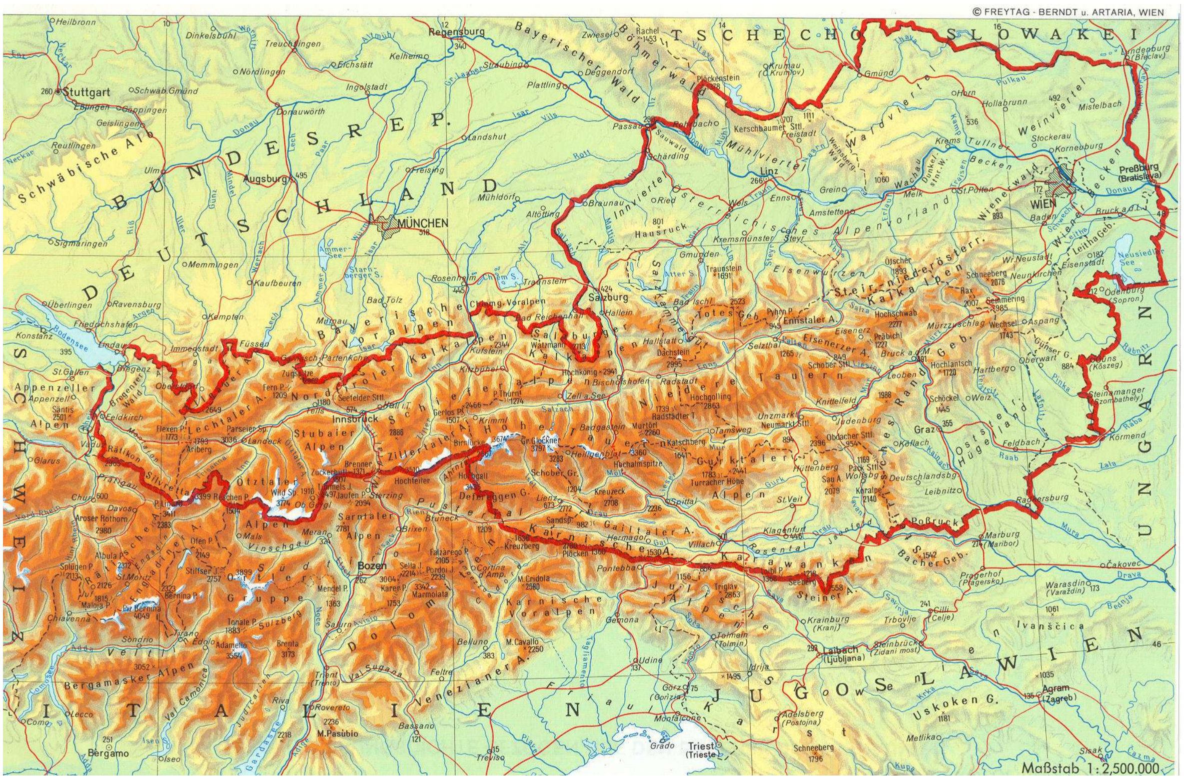
The historical development of the Republic of Austria, which now covers an area of 83.871 km^2, is very eventful.
The earliest traces of human activities on Austrian territory, dating as far as 180,000 BC, have been found in caves, such as Gudenus Cave near Hartenstein in the Krems valley, Lower Austria, and Drachenhöhle – Dragon's Cave – near Mixnitz in Styria. A great number of finds in the loess region – such as the famous Venus of Willendorf (Lower Austria), which was probably created around 30,000 BC – are further witnesses of settlements in the period between about 100,000 and 10,000 BC. Then, in the Neolithic (New Stone age, about 5,000 to 1,800 BC), the early gatherers and hunters settled down in regions of favourable climate, such as the Weinviertel, a wine-growing region in Lower Austria. They built simple huts and practised agriculture and animal husbandry. Mining, notably copper mining, by the Illyrians between 1,700 and 700 BC and the Early Iron Age from 800 to 400 BC, were centred at Hallstatt in Upper Austria, as well as salt mining. This, and trade, created the basis for cultural expansion and for the foundation of the first state on Austrian territory by the Celts, the Kingdom of Noricum, in the 2nd century BC. Between 15 BC and 476 AC, three Roman aministrative districts, the provinces of Raetia, Noricum and Pannonia, occupied what is today's Austria. The first bishoprics came during the 4th century and existed until the Huns, Goths, Langobards and Rugii settled, from the 5th century onwards during the Peoples' Migration.
The end of the 7th century saw the area from the Alpine foothills down to the Vienna Woods as well as the Enns valley settled by Bavarians, whereas today's Carinthia and the territories further west were occupied by the Slavs – as witnessed by many place names.
After the fall of the Carolingian Mark (the state founded by Charlemagne, 768-814), Otto I the Great (929-973) founded a new state. A deed dated November 996 testifies to the fact that Otto's grandson, Otto III, gave a landed property at Neuhofen an der Ybbs to the Diocese of Freising in today's Bavaria. This document mentions the property as being situated in Ostarrichi, the Old German name of Austria, for an area between Amstetten-Krems-St. Pölten in Lower Austria.
Under the Babenbergs (976-1246), an East Frankish noble family, this region continuously developed into a state and country of the name of Austria. Succeeding the Babenbergs, the dynasty of Habsburg, then shaped the history not only of Austria but of Europe from 1273 to 1918, for 645 years. Under Charles V, in the 16th century, Austria had developed into an empire that extended not only from Spain to the Balkans but also overseas. While at that time, as a saying went, the sun did not set in Austria, the country is now more or less what remained of the Danube Monarchy under the terms of peace treaties of St. Germain-en-Laye in 1919 and Trianon in 1920. The next important landmarks in Austria's history were

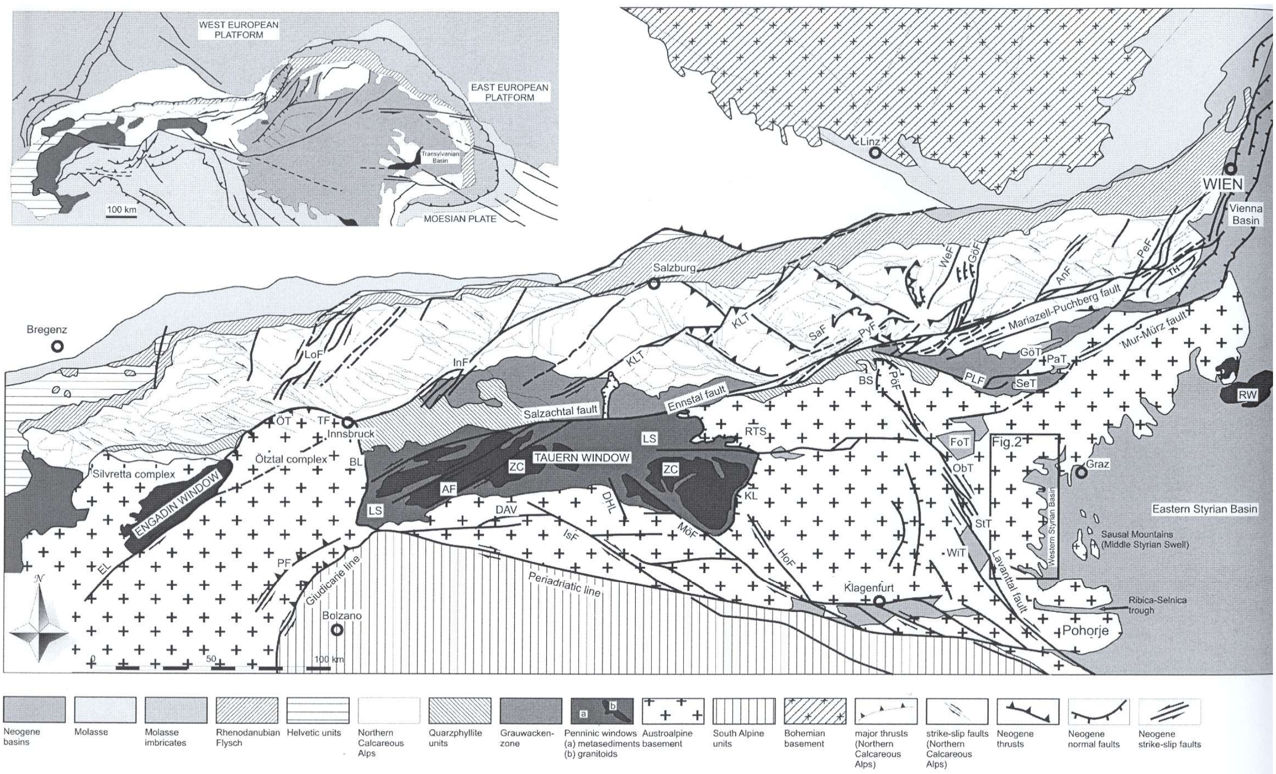
the invasion by the German troops on 11th March 1938, the Anschluss to the Deutsche Reich, the beginning of the Second World War on 1th September 1939, the liberation of Vienna in April 1945 by the Red Army, the foundation of the Second Republic on 13th April 1945, the Austrian Treaty after World War II on 15th May 1955, Austria's accession to the European Community in 1st January 1995, as well as the introduction of the Euro currency on 1st January 2002.

So eventful the history of this land is, so diverse is also the geological formation, the climate conditions, the physical-geographical configuration, the soil cover, and the small rooming of the landscape as well.

Austria is a mountainous country (see Map 2.1 and 2.2), which is assumed to about 10% of the area of the Variscan Massif (Moldanubian and Moravian Zone) – now a middle mountain landscape, with moderate to strong relief , at an altitude of 400 to 900 m, maximally 1,387 m asl. It consists of granite in the west, partly in contrast to it in the east of gneiss Bohemian Massif and – of several disregarded exceptions like Sauwald, Kürnberger Wald, Neustadtler Platte, Dunkelsteiner Wald – the Danube in the south and the Manhartsberg in the east make its boundary (see Map 2.1).



Map 2.1: Physical map of Austria.



Map 2.2: Geological map of Austria.

Figure captions

Figure 1: Tectonic map of the Eastern Alps displaying major and minor Paleogene to Neogene fault systems (after Linzer et al., 2002).
AF=Ahrtal fault; AnF=Annaberg fault; BL=Brenner line; DHL: Döllach-Heiligenblut line; EL=Engadine line; GöF=Göstling fault; HoF=Hochstuhl fault; InF=Inntal fault; IsF=Iseltal fault; KL=Katschberg line; KLT=Königssee –Lammertal –Traunsee fault; LoF=Loisach fault; LS=Lower Schieferhülle; MöF=Mölltal fault; ÖT: Ötztal thrust; PF=Peijo fault; PeF=Pernitz fault; PLF (encircled)=Palten – Liesing fault; PöF=Pöls fault; PyF=Pyhrn fault; RTS=Radstadt thrust system; RW=Rechnitz window; SaF=Salzsteig fault; TH (encircled)=Talhof fault segment of the Salzach-Ennstal-Mariazell-Puchberg fault system; TF=Telfs fault; WeF=Weyer fault; WGF=Windischgarsten fault; Z=Zell pull-apart structure; ZC=Zentralgneiss core.
GöT=Göriach Basin; PaT=Parschlug Basin; SeT=Seegraben Basin; FoT=Fohnsdorf Basin; ObT=Obdach Basin; WiT Wiesenau Basin; StT=St. Stefan Basin
KrT=Krappfeld Gosau Basin; KaT=Kainach Gosau Basin.

Dominant are the Easter-Alps, which occupy about 64% of the areas, and which can be divided as the Flysch zone (about 5%), the northern Limestone Alps and the Graywacke zone (about 22%), the Central Alps (about 33%) and finally, the Southern Alps (about 4%).

The forelands (about 22%) in the north and in the south-east, and partly the inner alpine, partly the alpine periphery basins (Vienna Basin, Klagenfurter Becken, Lungauer Becken and Tullner Feld with in total about 4%), as well, surround this alpine body.

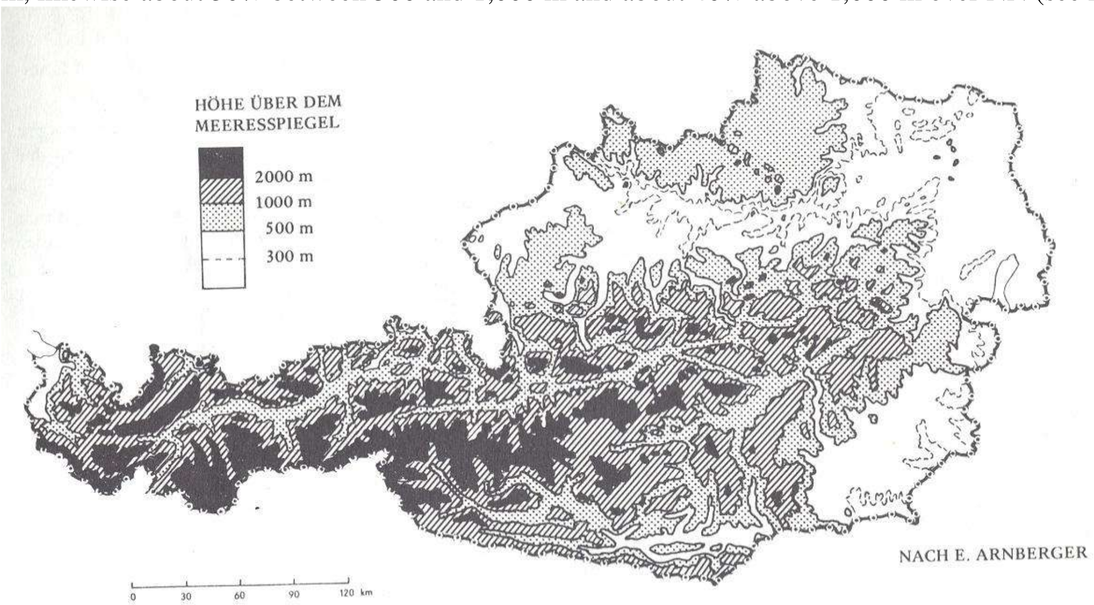
The Easter Alps, which are lower and wider in contrast to the West - Alps, consist – also again in contrast to the West - Alps – not of autochthonous massifs, rather let recognise a very complicated folding and mantle character.

The Central Alps are separated from the Flysch Alps and the Limestone Alps, as well as the Graywacke zone by the northern longitudinal valley furrow (Klostertal, Arlberg, Inntal, Gerlospass, Salzachtal, Ennstal, Schoberpass, Murtal, Semmering, Schwarzatal) on the one side, and on the other side from the Drau river by the longitudinal valley furrow (Pustertal, Drautal, Klagenfurter Becken, Mißlingtal). The Central Alps have very abrupt forms and elevations up to 3,798 m asl (Großglockner) particularly in the western and the central part due to the resistant gneiss, granite and mica schist – in order to name only the most important ones.

The softer, lower and mostly greened forms ("Grasberge") characterize the Graywacke zone, are very important due to mines (Magnesium, Copper ore, Iron ore). They are adjacent to the northern Limestone high Alps and the foothills with plateau-character in the east and the range type in the west at an altitude up to 3,038 m (Passeierspitze).

In the South of the periadriatic juncture, there are the partly widely fissured South Alps, which are formed partly of limestones and dolomites, partly of mica schists, and - analogous to the northern Limestone Alps show also plateau-character.

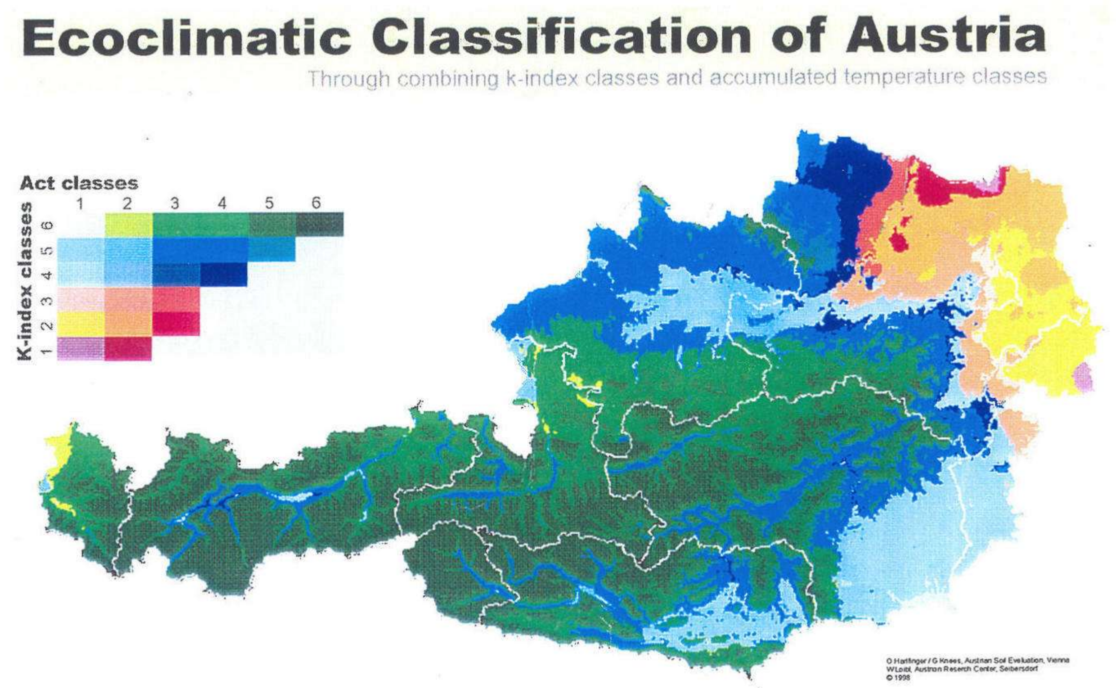
Thus, in Austria, the alpine body has a length of about 525 km and a width of 265 km on the East and of only 32 km at the narrowest place in the West. The closed alpine main crest extends almost over 200 km with altitudes above 2,000 m without the lower transitions of Radstädter Tauernpass and Katschbergpass up to Brenner. So, it is nothing to be surprised, that only about 39% of land lies under an altitude of 500 m, likewise about 30% between 500 and 1,000 m and about 40% above 1,000 m over NN (see Map 2.3).



Map 2.3: Altitude above sea-level.

The highest point of Austria is the summit of the Großglockner (3,798 m asl), the highest permanent settlement is the Rofenhöfe in the Tyrolian Ötztal (2,014 m), the highest road connection over the Alps (during the summer season) is the Hochtor (2,504 m), the lowest settlements are Illmitz and Wallern in the Seewinkel (Burgenland) with 117 m, the lowest area is the Neusiedler See: 115 m, and a depression about 11 km in the East of the Neusiedler See with only 114 m asl.

Concerning the macroclimatic conditions, only that should be mentioned here, that Austria lies in the transitional zone of the strong oceanic influence in the west and the continental influence in the east, manifested by the increasing temperature-contrast in the summer and winter, and at the same time by the decrease of the mean annual precipitation toward the east (see Map 2.4). These climatic zones are more or less modifies due the altitude and the relief, so that they can be subdivided into atlantic, continental (pannonic) and alpine typed climate areas.



If we combine the classes of accumulated temperature with the classes of climatic water balance we get an "Ecoclimatic Map of Austria". The map distinguishes 22 climate types and shows the important agroclimatic differences in Austria.
High accumulated temperatures in connection with weak semi-arid and semi-arid conditions only occur in the northeast of Austria and characterize the whole Pannonic climatic area. The climatic water balance is in this area during the vegetation time on the average negative.
At accumulation temperatures over 3050 °C in connection with weak humid conditions we have the best situation for high plant production. These conditions exist in a large area from the Linz region to the northeastern and southeastern foothills of the Alps to the south of Burgenland and Styrian Flat (Illyricum). In a small area we find these conditions also in the Carinthian Basin and in the middle and upper Inn valley. Accumulated temperatures of over 3050 °C in connection with moderate and very humid conditions occur in the Rhein valley and in a small area in Flachgau in Salzburg county. This type represents the best conditions for meadows.

Design: Gerd Knees

Map 2.4: Ecoclimatic Classification of Austria.

The atlantic (oceanic) coined climate areas are characterized by the lower annual amplitude of temperature, moderately warm summer, absence of a drought with an annual sum of precipitation, mostly above 1,000 mm. By the impact of rain-carrying N and NW winds, there are frequently abundant ascent-rains on the alpine north-side, which lead to an annual precipitation of 2,000 mm or more in the Bregenzer Wald and in the Salzkammergut. The continentally (pannonic) climate areas present, with a large amplitude, an annual sum of precipitation of only about 600 mm with a minimum of 450 mm, where a draught during the summer and rigidity in the winter with bare frost are further symptoms. The Weinviertel (Carpartian foreland), the eastern part of the northern alpine foreland, the Vienna and Tullner Basin and the North Burgenland are considered to be in the pannonic climate province.
For the Waldviertel (north-west part of Lower Austria) is the pannonic highlandtype characteristic. The illyric-type climate province with a high thermic continentality as submediterranean symptoms is characterised by a second maximum of precipitation in the late autumn, with absence of dryness. This climate province covers the south-eastern alpine foreland, the south part of Styria, the south part of the Lavanttal and the Klagenfurter Becken.

Within the alpine climate province, a strong dependence on the altitude on one side and great differences between the peripheries and the inner zones on the other can be found. The area is generally characterized by short cool summers, rash weather changes, long, snowrich winters, development of foehn in the S-N-directed valley (Wipptal, Zillertal, partly Salzachtal, Gasteinertal) and the winter inversions (Lungau, Klagenfurter Becken, Mürztal, Middle Ennstal). Further, the inner alpine dry valleys are to be mentioned (Upper Inntal, Kaunertal, Pitztal, Ötztal, Lower Wipptal, Upper Mölltal, Upper Iseltal, an others), where the precipitations are about 800 mm, often only 650 mm (e.g. Upper Inntal). The position in the lee is to be taken as the cause. Especially, in the northern Limestone Alps and also in the South Alps, the ascent-rains cause the extreme sums of annual precipitation, e.g. 2,700 mm in the Karnischen Alps.

Regarding the altitude-limits of the natural vegetation, distinct differences can be drawn between the western (more moist and cold), and the eastern parts (warmer and dryer), further between the Central Alps (Sivretta, Samnaun, Ötztaler and Zillertaler Alpen, Hohe and Niedere Tauern, Gurktaler and Seetaler Alpen, Steirisches Randgebirge) positions and the foothills in the north (North foothills, north lime and slate Alps) and in the South (Karawanken and Karnische Alpen, Gailtaler Alpen). We found likewise on the soil cover a hypsometric change of the plants associations due the fall in temperature of about 6°C per 100 m, a shortening of the vegetation period. Due to these facts we distinguish in Austria seven main vegetation zone: the collin zone until 250 – 400 m in the foothills in the north and in the south (500 m in the Central Alps), the submontan zone until 350 -500 (700) m, the montan zone until 1,500 – 2,000 m, this is also the limit oft the unified forest, the subalpin zone until 1,800 – 2,100 (2,300) m, the upper tree line and krummholz (dwarf trees), the alpine zone until 2,500 – 2,800 m, the limit for unified vegetation, the subnival zone until 2,800 – 3,100 m and the nival zone, the zone with perpetual snow and/or glaciers above this limit.

The Austrian territory is drained up to 96% to the Danube, up to 3% to the Rhine and up to 1% to the Moldau; the longest river is the Danube: The Austrian share is 350 km, followed by the Mur with 348 km, the Inn with 280 km, the Salzach with 225 km, and the Enns with 254 km.
The very different water distribution of the water-bearing from Danube and Inn demonstrates Figure 2.1.

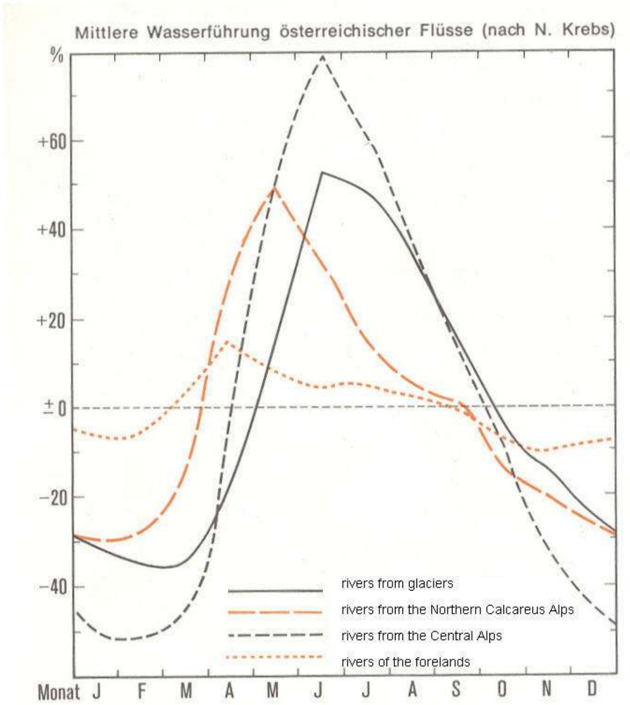


Figure 2.1: Middle amount of water of some Austrian rivers (after N. Krebs).

These rivers Danube and Inn can be taken as example for the considerable differences in the extent of the seasonal fluctuations of the volume of water carried by the Austrian rivers. Whereas there is a difference of 500% between the month of minimum and that of maximum discharge with the Inn near Kufstein there is one of only just over 100% with the Danube in Vienna. Moreover it is characteristic for the Inn that 55% of the total discharge is shared by June; July and August, and only 7.5% by December, January and February.
Moreover, Austria has about 5.200 natural lakes, such as Lake Constance (international water between Austria, Switzerland and Germany) with a total area of 538.5 km^2 , and up to a maximum of depth 396 m, the Neusiedler See (135 km^2 Austrian share, about 2 m deep), the Attersee (45.9 km^2, max. 469 m deep), the Traunsee (24.5 km^2, max. 423 m deep), the Wörther See (19.3 km^2, max. 440 m deep), the Mondsee (14.2 km^2, max. 481 m deep), the Millstätter See (13.3 km^2, max. 588 m deep), the Wolfgangsee (13.5 km^2, max. 538 m deep), the Ossiacher See (10.6 km^2, max. 502 m deep), and the Hallstätter See (8.4 km^2, max. 508 m deep).

Concerning the soil cover from Austria, the first statement for their composition and distribution is the hypsometric change: The increasing of precipitation and the decreasing of the temperature (in the west moister and colder, in the east more warm and dryer) with increasing see level. Besides it, the chemical composition of the parent material (substrate) is the second determining factor. Due to these factors and the influences of other factors, e.g. vegetation, animal activity, human influences and time, we have a very large variability of soil types in Austria. According to the Austrian Soil Classification 2000 and the WRB 2006 I try to give an overview on the soil distribution in Austria. In the pannonic climate region, the north-eastern part of Austria we find on loess dominant Calcic Chernozems, Leptic Regosols and Haplic

Regosols, accompanied with Haplic Phaeozems, and in the higher positions Haplic Cambisols. In the Seewinkel – on the eastern site of the Neusiedler See, we find some sites with Calcic Solonchaks and Haplic Solonetz, but normally a mixture between these two soils types. In the foreland in the north and in the south-east too we find dominant Gleyic and Haplic Luvisols, Haplic Cambisols in the northern foreland, in the south-eastern foreland Stagnic Cambisols and Luvic Stagnosols. The Bohemain Massif is featured by the dominance of Leptic and Haplic Cambisols, Haplic Umbrisols, and Haplic Podzols. Besides these types we find a number of Ombric and Leptic Histosols. In the Flysch zone we find many kinds of Stagnosols and Histosols, occasional Haplic and Gleyic Podzols. In the Limestone and Dolomite Alps in the North and in the South many kinds of Rendzic, Cambic, and Lithic Leptosols occurs, occasional interrupted by palaeosols, like Ferralic Cambisols. In the Central Alps Haplic Cambisols, Umbric Leptosols and Leptic Umbrisols dominate, very occasional Haplic Podzols and Ombric Histosols. Big valleys and basins are covered by colluvial sols (on the borders), many kinds of Calcic, Gleyic and Stagnic Fluvisols on the rivers, and Histic and Haplic Gleysols, and Histosols on stagnant sites. Besides these soils we find many sites with a heavy and long-term human influence, and the results are Terric, Hortic, and Regic Anthrosols.

From the total surface of 83,871 km^2 (=100%), 43.3% of them are forest, 30.9% agrarian areas (54% of them arable land), 10.3 % alpine pastures, 2.2% gardens, 1.7% lakes, rivers and channels, 0.7% construction areas, 0.6% vineyards, and 10.3% other.
The number and areas of agricultural and forestry holdings by socio-economic characteristics are 2005: 189,300 holdings with an average areas of 40.0 ha, 74,463 of them (37%) full-time farmers with an average areas of 40.3 ha, and an average agrarian areas of 18.8 ha, 106,616 (59%) part-time farmers with an average areas of 15.8 ha, and 8,222 (4%) legal entities with an average areas of 350.6 ha. In Austria, we have a very high number of organic farmers: 19,056 holdings with an average area of 31.5 ha,
331,528 tractors, 12,087 combine harvester, and 3,070 beet harvester were 2005 in use. The cereals and meat supply balance in 2003 were 97% respectively 110%, the yields lies 2005 per ha 50.3 dt wheat, 103.1 dt corn maize, 708.6 dt sugar beet, and 49.5 hl wine. The irrigated areas were about 4,000 ha. The share of the agriculture from the gross domestic product is only about 2%.
Agriculture and forestry had a radical structural change after the World War II and the membership on the EU (1995). Our country was obliged to change the agrarian policy. Now we focused on two objectives: a high productivity with the best quality as well as rural country and soil conservation. Every farmer is obliged to find the best way to maintain the agricultural fertility, to survive against the international competition, and - especially in the alpine areas - to conserve cultural landscapes (e.g. the ÖPUL-programme).
The enormous decrease of about 1 million persons in the population in agriculture and forestry from 1951 to 1983 could be not only enhanced by the mechanisation and rationalisation, rather, in spite of a continuous decrease of lands for agriculture and forestry – now about 10 to 15 hectare per day (!) –the share of the domestic production at food products could be reached by the increase in productivity in all sectors of agriculture and forestry.

The total number of residential population is 8.265,925 (1.1.2006), from it are (annual average) 3.184,117 employees. The share of the agrarian sector was 26,337 persons (0.8%), trade and industry 867,036 persons (27.3%), and service 2.176,996 persons (68.4%).
Austria has an administrative organisation in form of nine federal states and Table 2.1 shows the areas and population of these federal states and there capitals.

Table 2.1: Federal states, population, population density and federal state capitals of Austria

Federal state *capital*	Area (km^2)	Population	Population density (person per km^2)
Burgenland	3,965.46	279,317	70
Eisenstadt		*12,183*	
Kärnten	9,535.83	560,300	59
Klagenfurt		*92,160*	
Niederösterreich	19,177,68	1.581,422	82
Sankt Pölten		*51,073*	
Oberösterreich	1,982.26	1.402,050	117
Linz an der Donau		*188.362*	
Salzburg	7,154.23	528,351	74
Salzburg		*148,4783*	
Steiermark	16,392.41	1.202,087	73
Graz		*244,604*	
Tirol	12,1647.71	697.435	55
Innsbruck		*116.851*	
Vorarlberg	2.601.48	363,526	140
Bregenz		*124,733*	
Wien	414.65	1,651,437	3.983
Wien	414.65	*1.651,437*	*3.983*
Österreich/Austria	83,871.71	8.265,925	99

Statistik Austria (2006)

From the Austrian population 7.768,421 persons confess to the Roman Catholic and Uniate Curch, 376,150 to the Protestant Church AB and HB, 338.980 to the Islamic, 179.472 to the Orthodox, and 8.140 to the Israelite denominations. 1.123,925 persons are without denomination or don't made accounts.
Concerning the regional structure of Austrian industries, it must be mentioned that about 21% of the gross national product as produced by the industry, 27% by trade and other services. And, as usual, the industrial centre lies in the traditional parts of the country.
Here, the area including Vienna and the Vienna Basin is to be mentioned. It has a very widely scattered trade and lacks large enterprises – the reason is the city of Vienna and its surrounding areas.
A second centre is the upper Styrian industrial area in the zone of the Mur and Mürz rivers with steel works and other metal industries; and somewhat also from it is the area around the provincial capital Graz, further Leoben and Weiz, with metal work, a very modern car-cluster and electrical industries. The third industrial area can be found in the triangle of the cities Linz-Wels-Steyr in Upper Austria. Here, steel, metal, chemical, paper and cellulose industries are dominant. Further, worth mentioning are the industry sites in the south of the city Salzburg, in Lower Inntal, and in Vorarlberger Rhein-valley, where Dornbirn is the centre of textile and garment industry.

The Austrian tourist trade, to which a great importance for the trade balance is attached – about 16% of the gross domestic product is coming by the tourism (2005): 119.241,539 stay over-nights (about 10 mio.

in private houses), of its 31.500,907 Austrian peoples and 87.740,632 foreigners. The Austrian tourism is characterized by a further increase of over-night accommodations in the winter seasons and by the high number of private, relatively cheap quarters (about 1/3 of all).

Austria has an excellent traffic-communications and transportations: The Austrian Federal Railway System carried 2005 on his lines (length of 5,690 km, 3,560 km electrified) 191.600,000 passengers and 81.898,000 tons. On the roads were 2005 transported 288,163.000 tons, by ships 9.336,000 tons – with an increase after the opening of the Main – Danube – Canal as a very important water way in Central Europe -, and by air 195.000 tons.

The very dense network of highways, motorways, federal roads and provincial roads is used by a stock of 5.646,882 motor vehicles (2005), of that 4.156,743 private cars and station cars, and 338,888 heavy good vehicles, and 9,301 busses.

A number of well constructed airports are the service of the civil aviation system. Vienna-Airport Schwechat, which has two runways (the construction of an additional runway is under discussion) has got about 78% (15.803,435 persons) from total amount of commercial air transport at Austrian airports of 20.255,549 persons. Other airports are in the provincial capitals: Salzburg (1.657,053 passengers), Graz (860,764 passengers), Innsbruck (724,760 passengers), Linz (689,168 passengers), and Klagenfurt (520,369 passengers).

So, Austria of today present herself as a modern industrialized state with a – in accordance with the balance-sheet – self-support in agricultural sector and as a country, which can look back on a very eventful history.

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3
CONTRIBUTION TO THE GEOLOGY OF THE CENTRAL ALPS

Günter FRASL

The excursion route crosses the deepest tectonic unit of the whole structure of Eastern Alps, the "Tauern Window" during the journey through Großglockner - Hochalpenstraße.
The contents of the series of the "Tauern Window" corresponds to the Penninic facies area of the Swiss Alps.
Major division of age:
I. The central gneiss (premesozoic Granitoids) and their accompanying prepermian portion of the schist cover ("Habachformation" and "Old Crystalline") are now often parallelized with the middle Penninicum of the Swiss Alps. By some authors, these parts are also parallelized with the Helvetikum. These deep parts will be encountered while travelling towards Heiligenblut.
II. On the other profile at the Großglockner - Hochalpenstraße, we shall cross the Perm-mesozoic and tectonic higher parts of the "Schieferhülle" (schist cover), which show nappe structures and regional metamorphism of alpidic age. This younger schist cover consists of the following series or formations:
1) The permian-undertriadic "Wustkogel-formation" correspond somewhat to the “alpine Verruccano” (quarzites, arcose-gneisses, phengite-schists); these are, however, not open directly on the road.
2) The middle Triassic is characterized by lime and dolomite marbles as well as by cellular dolomites grauwacke. This succession ("Seidlwinkltrias") will be encountered in between Hochtor and Edelweißspitze.
3) The shallow Upper Triassic is equivalent to the Swiss Quartenschiefer of the Keuper facies: this can be best recognized by the lightcoloured mica-schist with chlorite mottles, similarly by quartzites (partly, with chloritoid and cyanite: Edelweißspitze), and also by gypsum. Its subordinate black phyllite grades into the more than 1 km thick.
4) Bündner Schiefer formation (mainly Jurassic to Lower Cretaceous calc-schist and dark phyllites) and their accompanying ophiolites (green-schist and serpentinites).
The original facies division of the Mesozoic Era from north to south is assumed to be as follows:
A) The "Brennkogel Facies": Stratigraphic successions and a mainly phyllitic-quartzitic development of Bündner Schiefer with frequent dolomite breccias. It fits best to the middle Penninic Facies area (comparable to the "Brianconnais").
B) The "Glockner Facies": It corresponds first to the Jurassic to Lower Cretaceous ocean floor in the Piemontais zone in the Western Alps (South Penninic), consisting of km-thick lime-micacous-schists, as well as of substancial ophiolite masses in particular prasinites and serpentinites (corresponding to the

"Upper Schieferhülle unit" according to CORNELIUS & CLAR, 1939): The Großglockner itself and some others of the summits in the surrounding (see the Edelweißspitze: Panoramic - View).
C) The "Fusch Facies" is similar to the phyllite rieh Brennkogel Facies. It comprises again the Stratigraphic succession and might correspond to the southern border of the Penninic Ocean.
On the alpidic Metamorphism:
a) An early alpidic high-pressure metamorphism, originated by a quick subduction, is still recognizable especially in the eclogitic prasinites.
b) The whole schist cover was subjected to a younger alpidic regional metamorphism, a low-pressure metamorphism (low grade, green schist facies, epizone). This metamorphism has been relatively stronger (the first staurolites in Mölltal) at the axial culmination and southwards from it, while it decreases distinctly towards the northern margin of the Tauern-window (down to a local stilpnomelane formation).
The Updoming of the Tauern-window has been caused by a neogene rise of the Tauern arch: one easily can see the regional south dripping foliation planes on the southern side of the Glocknerstraße, the axial culmination at the Crestline and the increasingly north dipping planes on the northern side.

4
ECOCLIMATIC ASPECTS OF INN-VALLEY UP TO THE HOHE TAUIERN

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The excursion route will lead to climatically quite varying areas and will give a certain view into the wide diversity of the alpine climatic zones.

It covers the driest inner alpine valley landscape on to the wet locations in the direct influence of northern water-stagnant zones. Moreover, the high alpine conditions will be shown by the example of the Hohe Tauern and the contrasts between alpine north-side and alpine south-side will be pointed out. Beside the mesoscale climatic influences, several places underlie microclimatic-effects, which result from the topographical position. These are mentioned in the climate description of each profile according to the System of Austrian Soil Survey. The following description of climate may explain more the essential (tensions) features and differences of heat and water balance of the excursion area.

Inntal:

The climate of the Inn-valley is determined to a great extent by the down-wind effect. The barriers against the rain-bearing wind in this area are caused not only by the height of the surrounding mountain ranges, but are also due to the greatest N-S extent (240 km) of Alps in the Tyrol region (FLIRI, 1975). The most distinct development of the downwind effect occurs in Upper Inn-valley and the adjacent lateral valleys. Hence, we find here the driest part of North Tyrol with a long-range sum of annual precipitation between 600 mm and 800 mm. In comparison to the fringe the attenuation of the precipitation activity includes primarily the precipitation density and the frequency of extremely abundant cases. Secondly, the quantity of precipitation, and at least, the frequency of precipitation is reduced (FLIRI, 1962). Opposite to alpine periphery in the north-west, the precipitation amounts to only about 35 % in Upper Inn-valley in winter and in spring, in summer about the half, and 42 % in autumn. In the course of year, due to the scarcity of precipitation, an allochthonous climate is developed in Upper Inn-valley in the winter, which shows distinct merits in connection with temperature-relations and radiation-influences (LAUSCHER, yeat unknwn). These conditions are confirmed by the small cooling quantity in the winter (Fig. 4.1), where, obviously, the monthly mean wind velocity of 0.2 - 0.4 m/s in Haiming can not be taken as representative for the valley. Of course, 2 values of 800 W/m2, as calculated for Imst, show these special conditions, which are often found also in the protected high valleys of the Alps (MÖRIKOFER, year unknown).

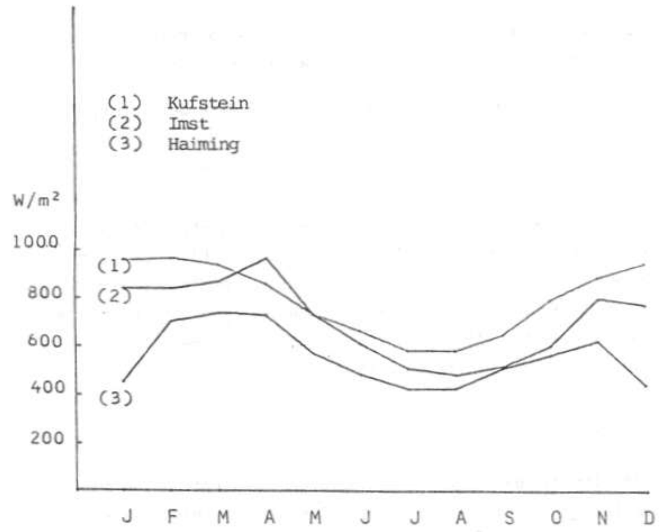

Figure 4.1: Cooling off/year.

In the late spring and, above all, in the summer Tyrol entirely comes under the influence of the west-storm strengthen by the monsoon, from which the maximum precipitation in summer is well understood. A secondary minimum precipitation is marked in October. This is traced from the frequent occurrence of anticyclone weather Situation (Indian Summer). Differences, conditioned to relief, also occur within the dry region.

This results into that, that the openings towards the North (e.g. Fernpaß) shift the stagnancy-effect in diminished form, locally, into the inner alpine region. From that Situation, it is clear, why Imst and Pitz-valley show higher precipitation as Haiming with 713 mm (period 1921 - 70), which is on the downwind side of Tschirgant. Beside the average precipitation sum, the variability of the monthly precipitation quantity also presents an important dimension for the water balance. With the calculation on the %-basis, it is in a simple way possible to present a certain insight (see Tab. 4.1).

Table 4.1: Percent of monthly precipitation, recorded in the period of 1951 – 1980.

Altitude	Location	Precipitation	10 %	30 %	50 %	90 %
880 m	Ried im Oberinntal	630 mm	12	27	44	107
785 m	Imst	727 mm	15	34	56	117
578 m	Innsbruck- Flughafen	949 mm	25	48	71	144
590 m	Kössen	1620 mm	42	87	126	240
754 m	Zell am See	1079 mm	23	48	83	166
1025 m	Döllach	826 mm	17	36	60	135
675 m	Obervellach	893 mm	20	40	63	150
150 m	Obersiebenbrunn	533 mm	12	24	34	93

In this connection, it is remarkable that the 10%-value at the driest place in Upper Inn-valley (Ried) amounts to 12 mm, just like in the dry zone of East Austria (Obersiebenbrunn) with about 100 mm less precipitation. This means, that the months with the least precipitation in Upper Inn-valley are similar to those of the typical dry zone in East Austria. However, with the higher precipitation-classes it starts to show differences between the two compared zones and this should be taken as a characteristic of precipitation distribution. The effect of stagnancy at northern alpine periphery, for example at Kössen, can be shown clearly; because, with already 10%-value an amount of 42 mm is reached, which can be expected at Ried only with about 50%-value.

The effect of stagnancy in Lower Inn-valley is, however, not so extreme in general yet the decrease of amount of precipitation, in comparison to the total stagnancy in the north, accounts only 19 - 27%. The sum of annual precipitation of about 1200 mm in Lower Inn-valley leads to a prolonged snow-covering period, which is about 100 days, whereas, in Upper Inn-valley in spite of a greater altitude, this lasts only about 80 - 90 days. In the higher positions in the northern stagnancy zone, the duration of snow cover period increases not only with the increase of precipitation activity (1500 -2000 mm in 600 - 1200 m asl), but also due to the fact that the quantity of winter precipitation rises to 20%. Hence, here, at 1000 m above asl, already 140 - 150 snow cover days per year as perennial mean, can be encountered. This value is found in West Austria only in Bregenzer Wald. The difference portion of upwind and downwind effects within Inn-valley in Tyrol determines not only the precipitation regime, but also characterises the temperature relationships up to a certain extent. Therefore, we find an evidently favourable thermal condition both for the annual temperature and the 14 o'clock temperature during the Vegetation period (April - August) in Upper Inn-valley in contrast to Lower Inn-valley. The difference in 14 o'clock temperature is particularly clear presented in an altitude-diagram (see Fig. 4.2).

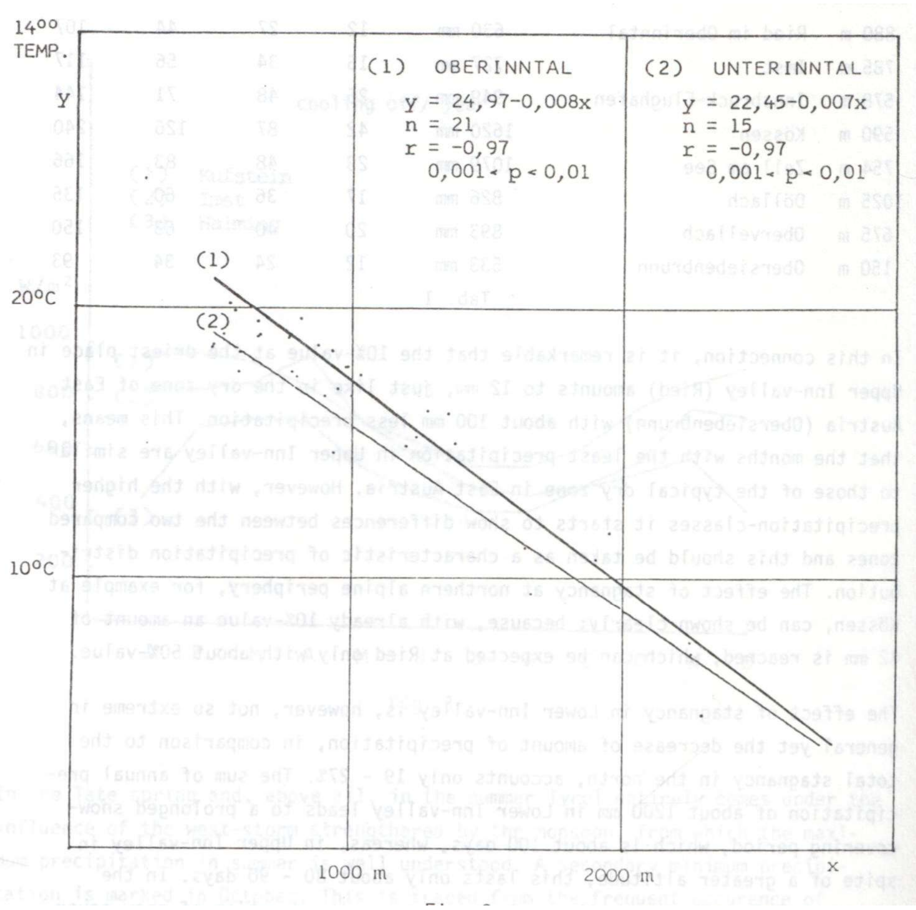

Figure 4.2: Difference in 14 o'clock temperature Upper Inn valley and Lower Inn-valley.

It appears from this, that the same temperature level in Upper Inn-valley is about 150 m higher than in Lower Inn-valley. Indeed, the differences blend with the increase of altitude. The dependence of temperature on altitude can be exactly determined by a linear regression, like the high correlation coefficient or significant level affirms. In this connection, it is interesting, that about the calculation of certainly measure (Bestimmtheitsmaße) ($B = r^2$) 94% of the explainable can be reduced to the influence of the altitude. On the other hand, for the amount of precipitation, the variance, which is explainable by the altitude lies between 20-25%. This means, that the amount of precipitation is determined less by the altitude, rather than by other factors, such as the topography.

Hohe Tauern:

The Tauern as part of the Eastern Alps represent in a pronounced way as weather and climatic borderline. While the north lies in the transitional zone of the Atlantic continental climatic regime, the Mediterranean influences, intervene from the south. The interaction of different weather-influences is eventually still dependent on the altitude, so that a reduced excessive slope-climate up to a typical high mountain-climate is found beside the continentally coined valley climate (STELZER, 1981).

The contrast between the alpine north side and the alpine south side can be proved by almost all meteorological parameters. The degree of cloudiness on the alpine north periphery amounts to 65%, while, on the southern side, it is 50% (HARLFINGER, 1985, SCHÜEPP & SCHIRMER, 1973). The differences are not the same in all the seasons rather they occur specially in summer, when, in the South, the Mediterranean high pressure belt becomes more effective. Consequently, the southern side has a longer sunshine duration in the summer (LEISTNER, 1984) than the northern side. The amount of about 10% higher global radiation in the south of Hohe Tauern is to a large extent due to the summer half-year. This is shown in the comparison (see Fig. 4.3) between Hofgastein (860 m) and Obervellach (780 m) (BRUCK et al., 1985).

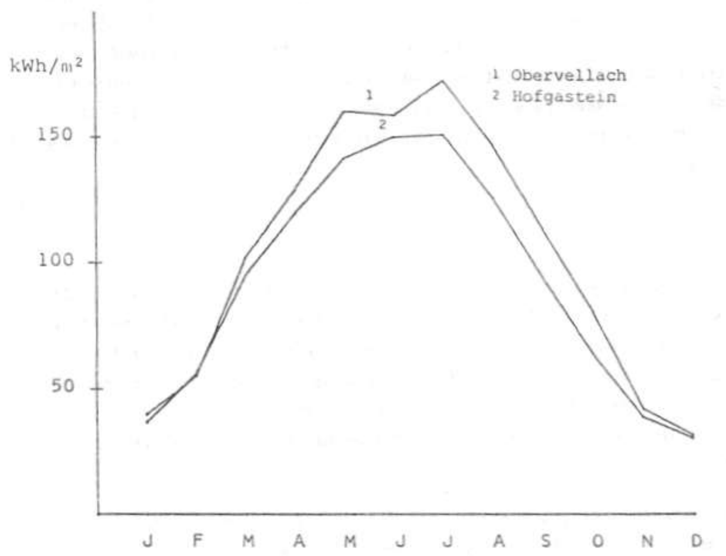

Figure 4.3: Sum of global radiation in Obervellach and Hofgastein

The portion of the sky radiation moves at this altitude by 40% in the summer and by 50 - 60% in the winter (REITER et al., 1982). This can by considerably larger because of the local horizon-shielding. In the long run, the sky radiation increases, because the cloudiness factor increases through the human-genetic air mixing. The increased energy supply on the alpine south side results expectedly in a higher temperature level. So, the isotherms of 5° and 10° range lie in the south of the alpine main crest about 150 m above that of the alpine northern side (DOBESCH, 1983). One finds a similar result, if the annual temperature, the temperature of the Vegetation period or the duration of the Vegetation period are taken as comparative values (JEANNERET & VAUTIER, 1977). The favourable conditions of the southern side can be more evidently proved by calculating the sum of the temperature during the vegetation period

(FLIRI, 1960). From Tab. 4.2, it is evident that the difference in the thermal relationships between the northern and the southern sides on the middle altitude can amount even to an altitudinal difference of more than 200 m.

Table 4.2: Differences of the temperature summation of north and south positions.

Altitude (m)	Temperature summation		
	exposition North	exposition South	Austrian average
800	2330	2680	2478
1000	2070	2410	2220
1200	1800	2120	1962
1400	1530	1830	1704
1600	1270	1540	1446
1800	1000	1270	1188
2000	730	980	930
2200	450	700	672
2400	200	410	414
2600	0	140	156

It is also typical for the locations of the southern slopes to have a greater air dryness in contrast to those of the northern slopes. The difference amounts annually in an average about 1.5 Hpa at 1000 m and more 1 Hpa at 1500 m altitude. In the winter, the differences, however, are much less (DOBESCH, 1983). The apprehension of the precipitation relationships in the high mountains brings not only technical problems for measurement, but also suffers from the small amount of measuring stations. Hence, the record of precipitations of the high mountains should be assessed with caution. The records of the high stations with 1600 - 1700 mm per year are undoubtedly too low (WILFINGER, 1981, LAUSCHER & ROLLER, 1956). On the other side, the seasonal differences become obscured with the increase of the altitude. Consistently, besides the summer maximum, a winter maximum, or in the south a late autumn maximum appears. It is also sure, that the sum of precipitation increases with the altitude. However, this increase on the northern and southern sides is not regular. While, in the north-stagnancy of the Hohe Tauern, a certain linear dependence on the altitude can be proved, the southern slope in the deeper position is actually drier and increases spasmodically on the high locations. The higher variability of precipitation is also characteristic for the Mediterranean influence on the southern side of the Alps. According to Tab. l, the 10%-value of Obervellach corresponds well to the quantity of annual precipitation in comparison to other places mentioned. Of course, for 90%-value, it is evident, that abundant precipitation is often possible here.

The lasting of the snow-cover is very firmly ascertained by the microclimatic conditions and hence, is subject to local changes. Mesoclimatically on the northern side of Hohe Tauern, about 130 days of snow-cover at 1000 m and 230 days of snow-cover at 2000 m can be taken into account. On the southern side, we get 100 days of snow-cover up to 1000 m, about 130 days at 1300 m and around 220 days at 2000 m. The depth of snow increases at the same time, not only with the altitude, but also shifts its maximum value too late in the spring. While in the lowland, the snow-depth is highest in February, the maximum at 1800 m is in April and at 2500 m not before May (STEINHAUSER, year unknown).

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5
SOIL FORMATION IN THE MOUNTAINS WITH SPECIAL CONSIDERATION OF THE CLIMATIC AND TOPOGRAPHIC CONDITIONS (LOCATIONS IN RAIN STAGNANCY AND RAIN SHADOW, AS WELL AS HIGH ZONAL SUCCESSION)

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The genesis and dynamics of soils in the high mountain areas are also controlled by the same factors as in the valley and basin areas. However, these show a different valence in the said high alpine areas. So, the climate dominates and, here in particular, the participating parameters of the normally higher amount of annual precipitation, and the lower mean of annual temperature and in consequence, the completely changed evaporation-rations. However, the factors relief and human influence in addition to the factors rock and Vegetation add a special part to these. Here it is attempted to give a closer view to the special stress of the above mentioned factors in the alpine zone, especially in the high mountains and the sub alpine range.

The attempt becomes difficult and complicated by the fact that the disturbed profiles with a high share of allochthonous and heterochthonous materials in the sloping areas are quite normal, while the undisturbed profiles are quite an exception. Hence, the study of these processes must result into a combination of partial findings from a great number of observed positions.

Concerning the factor climate, a dependence of position should also be added along with the above mentioned increase of precipitation with the altitude. Altitude, inclination and declination have a special effect on soil development - here should be mentioned only the inclination-rain on the north-facing slopes and rain shadow on the south facing slopes. So, a mean annual precipitation of 1,079 mm (period 1951 – 1980) is recorded at Zell am See, situated at 754 m asl. in the north of the alpine main crest, while this is 826 mm at Döllach, situated at 1,024 m (about 270 m higher), in the south of the alpine main crest (HARLFINGER, in this booklet).

As a further example, the varying radiation value should also be cited. A level surface (49°N latitude) receives 151,000 ly (=cal/cm2)/ year, at the soul Position (35°), however, 183,000 ly, i.e. about 22% more. With a slope of 30°, these differences were more pronounced: The north exposition receives only 87,000 ly, but the south exposition receives 182,000 ly, i.e. about 10% more (KLUG & LANG, 1983).

The higher sum of precipitation, already mentioned, causes, mainly on the convex positions and positions with longer frost, the development of the alpine Pseudogley, in which the causes of the colour development - whether this is due to the substrate colour, wet bleaching of podzolization - still demand discussion and the naming of horizon and the profiles; and makes the taxonomy order difficult.

In connection to the temperature, it should be mentioned, that the isotherm of 5°C and 10°C still at about 150 m in the south of alpine main crest is higher than that of the northern side. The analogous differences of about 200 m in relation to the sum of temperature and snow-cover are to be ascertained (HARLFINGER, in this booklet).

The low temperatures are also to be considered as the cause of retarded humus decomposition in the surface soil, and, in consequence, the presumption of the development of 'alpine humus' as defined by W. Graf is to be rejected (ZÖTTL, 1965).

Further, the factor relief is of special importance, because, between this and the natural or human exerted mass movements, a dose relationship of alteration exists in the climate, near to the soil, the Vegetation cover as well as the soil depth and the soil maturity. So, an unstable state of equilibrium might exist in the soil depth, depending on the slope, texture and quantity and intensity of precipitation. This situation if often affected by the local factors, such as, upwind or downwind position, altitude and duration of snow-cover, presence of absence of soil frost as well as weathering of parent material, so that it requires only a small impulse to initiate a development of “Plaiken”, that is so frequently determinable today.

This idea should directly lead to the third factor, i.e. the factor human influence. This should be discussed more in detail. By human activity, the low and middle alpine pastures were created as a result of clearing and rooting of the woods in the high middle ages. Thereafter, these were maintained in this new equilibrium through more or less intensive cultivations. Later on, by some changes in agriculture, such as nursing of the alpine pasture and/or grazing by heavy livestock, can run this process totally into different direction. SCHNETZINGER (1972) has already pointed out about the pseudogleyzation of surface soil by cattle-steps at Zell am See (770 m asl). This phenomenon is also ascertained in intensively pastured high mountains and subalpine pasture areas, especially on cohesive parent materials. Further, if overcrowded with heavy livestock, beside the development of "Viehgangeln" (pasture-paths), threading-down of their edges and often the initiation of "Plaiken" occur (RIEDL, 1983). These can also originate through excessive nursing of the alpine pasture e.g. absence of mowing. The excessively long grass, avoided by the cattle, freezes together with old snow and is dragged off with sod during the downslide, thus initiating the development of "Plaiken".

For the sake of completeness, still, the factors rocks and Vegetation might course by described.

Along with the fundamental significance of rock chemistry (calcareous, non calcareous, mixed forms) as well as of structure (loose, firm), the striking influence of flue dust has often an effect. On the basis of measurement, a record of 1,138 kg/ha/year was obtained below the Edelweiß-spitze. This fact is, in no way, an individual case in the Alps (NESTROY, 1984).

Concerning the Vegetation on soils of the alpine area, this should be borne in mind, that, beginning with a pioneer Vegetation not covering the area, which can occur as forms of spots, stripes or garlands, one can come across all stages (or phases) up to an area-covering, satisfactory Vegetation, as far as the highest claim of quality and quantity is concerned. In this connection, special attention should be given to protect the labile Vegetation from heavy cattle on the detritus fan and rock fan, so that no strong biological obstruction can take place.

On Table 5.1 you find a list of the most important plants in the environment of the Franz-Josefs-Höhe und Glocknerhaus.

Table 5.1: Vegetation around the Franz-Josefs-Höhe und Glocknerhaus.

Scientific name	German name
Alchemilla vulgaris agg.	Gemeiner Frauenmantel
Helianthеum alpestre	Alpen-Sonnenröschen
Anthyllis vulneraria ssp. alpestre	Alpen-Wundklee
Geum montanum	Berg-Nelkwurz
Ranunculus montanus	Berg-Hahnenfuß
Ameria alpina	Alpen-Grasnelke
Arnica montana	Arnika
Ajuga pyramidalis	Pyramiden-Günsel
Gentiana acaulis	Stengelloser Enzian
Gentiana punctata	Punktierter Enzian
Gentiana lutea	Gelber Enzian
Salix waldsteiniana	Bäumchen-Weide
Salix helvetica	Schweizer Weide
Adenostyles alliariae	Grau-Alpendost
Pseucedanum ostruthium	Meisterwurz
Geranium sylvaticum	Wald-Storchschnabel
Salix retusa	Stumpfblatt-Weide
Salix reticulata	Netz-Weide
Salix serpillifolia	Quendel-Weide
Salix herbacea	Krautweide
Larix decidua	Lärche
Pinus cembra	Zirbe
Arabis alpina ssp. alpina	Alpen-Gänsekresse
Linaria alpina	Alpen-Leinkraut
Cerastium uniflorum	Einblüten-Hornkrau
Oxyria digyna	Säuerling
Dryas octopetala	Silberwurz
Gypsophila repens	Kriechendes Gipskraut
Thamnolia vermicularis	Würmchenflechte
Cetraria islandica	Isländisches Moos
Xanthoria elegans	Zierliche Gelbflechte
Rhizocarpon geographicum	Landkartenflechte
Arabis soyeri	Glanz-Gänsekresse
Primula farinosa	Mehlprimel
Saxifraga stellaris ssp.robusta	Stern-Steinbrech
Pinguicula alpina	Alpen-Fettkrau
Carex bicolor	Zweifarben-Segge
Carex capillaris	Haarstiel-Segge
Carex frigida	Eis-Segge
Jincus triglumis	Dreiblüten-Simse
Tofieldia pusilla	Kleine Simsenlilie
Carex atrofusca	Schwarzrote Segge
Saxifraga aizoides	Bach-Steinbrech
Saxifraga oppositifolia	Gegenblatt-Steinbrech
Saxifraga biflora	Zweiblüten-Steinbrech
Linaria alpina ssp. alpina	Gewöhliches Alpen-

	Leinkraut
Anthyllis vulneraria ssp. alpestris	Alpen-Wundklee
Poa minor	Klein-Rispe
Gypsophila repens	Kriechendes Gipskraut
Artemisia mutellina	Echte Edelraute
Chamydomonas nivalis	Schneealgen

This brief description of effect of soil forming factors in the mountainous areas may serve as an informative contribution to the soil configuration and can be just to sum up to the following points:
1. Soils in the Alpine regions exhibit greater vulnerability and are slow to scar over in relation to the soils at lower regions. This is particularly true of grazing (cattle treading, overgrazing), mechanical injury (skiing, mountain biking) as well as path shortcuts.
2. A high percentage of silt as is present in many soils tends to favour erosion. Such locations are in particular need of mechanical stabilisation as by means of a continuous vegetation cover.
3. As the snowless period is short – 9 months on average at an altitude of 600 m, 8 months at 1,000 m, 6 months at 1,500 m, 5 months at 1,900 m and only 2 ½ months at 2,400 m - the soil is very slow to regenerate and develop. Nevertheless, the soil is often found to be surprising deep.
4. Alpine soils tend to be extremely shallow so as to offer little water storage capacity. This is also the reason why many plants at such locations are equipped with transpiration protection devices enabling them to survive climatic droughts.
5. Alpine soils on slopes tend to be in an unstable equilibrium. Hence, soil depth, great or small, should not be used as a criterion of soil maturity. Neither is the formation of smooth slopes (“Glatthänge”) equivalent to a stable soil cover of uniform depth.
6. Alpine soils are surprisingly rich humus, not only in their top horizon but often in underlying horizons, a fact discovered and described as “Alpine humus” as early as 1907 by Count Leiningen.. This is probalby not due to plant physiology but to a slightly increased humus production together with somewhat inhibited decomposition of organic matter.
7. Alpine soils have a good „long-term memory“. This often allows tracing of long location geneses in a soil profile and its sequence of horizons.
8. High podzolization is rare, as might be expected, and can be identified only at extreme locations.
9. Since we are normaly faced with soil complexes rather than soil types, informations on the regional landscape and regional soil-development trends is of prímary ímportance.
10. The disturbed soil profile is the rule, the undisturbed soil profile is the exception!

6
Special Informations about Cities and Landscapes

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6.1 Historical rockfalls in Tyrol

The rockfall of Köfels
This rockfall occurs during the Mesolithic period (about 8,700 y BC) and was with about 2 to 3 km^3 the biggest rockfall in the Alps.
The Tschirgant rockfall occurs about before 3,000 years (Late Bronze Age). During this event a rock areas of about 9 km^2 glided in the Inn-valley.

6.2 Landscape area Upper Inntal

We travel through the Upper Inntal from Landeck to Innsbruck, consequently Inn-valley itself and the bordering mountains ranges. In the North, they have predominant limestone of the Northern Limestone Alps (Middle and Upper Triassic Age, as well as Jura Age), forming the southern edge of it (Lechtaler Alps; Tschirgant and Mieminger mountains). In the South, on the contrary, there is predominant granite and tonalite gneiss of the Ötztaler Mass.
The agricultural lands in the main valley lies at about 630 m altitude asl, and reach 1,800 m altitude into the alpine pasture. The inner alpine warm region, which reaches in the West of Telfs, is typified with a mean sum of annual precipitation of more than 730 mm (in the valleys) with a mean annual temperature of 8°C. The suitable conditions for production force the grassland farming, but specially on the terraces allow the existence of some arable areas with the production of cereals, silo-maize, and orchards.
Innbruck is the provincial capital of Tyrol, situated at 574 m asl on a level alluvial cone of the river Sill. The development of this city with 116,851 inhabitants (2005) into a unique inner alpine area is conditioned, primarily, by the position at the pass-foot at the interface of Brennerline into the furrow of the northern longitudinal valley.
In 1677, Innsbruck got a University; transport business and public service were further pillars of the urban-economy. The development of the Brennerstraße, the railroads (towards Brenner, Kufstein, Arlberg and Mittenwald), as well as the motorways intensified the transport suitability. Several cableways (Haferlekar, Patscherkofel, Absamer Lizum) make the surrounding mountains accessible, so that even the tourism particularly through the winter sport rose on a top position in Austria.
Out of the sights of the old city, only the gothic oriel „Goldenes Dachl", the Imperial Palace, the court church with the grave of Maximilian and the Laubengassen should be mentioned.

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6.3 Landscape area Mitterpinzgau

This area is the catchment area of Saalach and extends from Zell am See in the South up to Steinpass; in the centre is the Saalfeldner Basin at 530 to 600 m asl. This area lies within Graywacke zone: graywacke schist is the dominat rock.
Climatically, this area is characterized with climatic level „c“ and „d“ after the Austrian Soil Evaluation with a mean annual sum of precipitation between 1.000 and 2.000 mm and a mean annual temperature below 7°C.
In consequence of the position of the basin and alpine pasture and reaching up to 2.000 m asl and covering about ¼ area of the cultivated lands, the grassland is dominant, besides, about 30% farms with a large amount of forests.

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6.4. The Hohe Tauern National Park

This park with some 1.800 km^2 is the largest natural reserve in Central Europe, and covers the last generally untouched parts of the Eastern Alps in Carinthia, Salzburg and Tyrol. The national park has been zoned: Core zones (untouched alpine region), conservation zone (protection of alpine farming landscape) and strictly protected area (ban on any intervention).
Within the wide core zones, special legal protection is extended to the rock formations, morphological formations e.g. Bratschen, glaciers, mountain pastures and meadows, alpine forests and lakes, torrents and water falls as well as to the varied fauna and flora.
In this protection is also included the man’s activities in the alpine region, which go back long before Jesus Christ – for example dairy farming above the tree line was only possible in harmony with the laws of nature.

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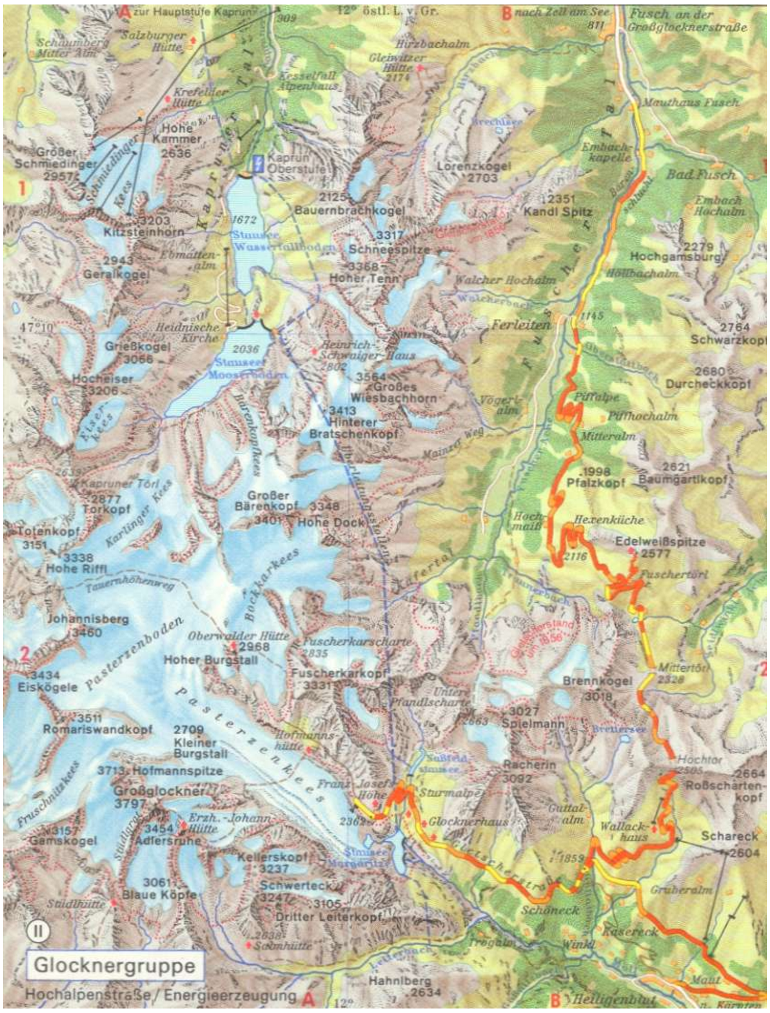
6.5 The Großglockner - Hochalpenstraße (compare Map 6.5.1)



Map 6.5.1: The Glockner-group (ex: Dierke Weltatlas, 1974).

This road presents an engineering accomplishment of Hofrat Dipl.-Ing. F. WALLACK, who has constructed in order to cross the alpine main crest between the then existing crossing Brenner in the West and Radstädter Tauern in the East with a distance of 156 km.

The forerunner of this road was already a Roman way, later the old Glocknerstaße, which was built in 1990 to 1908 an overcome an altitude difference of 1,700 m between Heiligenblut and Glocknerhaus as a single track road with a maximum gradient of 10%.

The first blast to the Großglockner-Hochalpenstraße was made on the 30th August 1930. On an average, 3,200 people, who were engaged at different construction locations between 1,500 and 2,500 m could finish the work on the 3rd August 1935, within 6 summer construction periods (i.e. about 26 months). About 460,000 m^3 material was removed, 410,000 m^3 rocks was blown, 67 bridges with span between 2 and 32 m were built, as well as 2 tunnels (Hochtor with 312 m at 2,506 m asl, at the same time the highest of the road, and Mittertörl with 117 m length) were constructed. The highest point is the Edelweißspitze with 2,571 m asl and the Kaiser-Franz-Josefs-Höhe - named after a visit from emperor Franz Joseph and empress Elisabeth [Sis(s)i] in the year 1856 - on the end of the glacier-road in a position of 2,369 m asl.

With a length of 47.8 km (Bruck-Heiligenblut), with 36 bends and the glacier-road from Guttal (8.7 km), the road has a maximum gradient of 11%. The construction costs amounted to 25.8 mio. AS, which corresponds the amount of about 50 mio. Euro - at present.
Since the opening of this road in the year 1935 were 50 mio. visitors are recorded. In the year 2005 passed 192,230 private cars 6,235 busses and 67,826 motorcycles, in the year 2006 184,301 private cars, 6,198 busses and 71,178 motorcycles, finally in the year 2007 187,587 private cars 5,726 busses and 73,998 motorcycles.

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6.6 The Pasterze and the development of the glaciers after Würm

The last maximum of this glacier – the name means pasture – was about 1850 and extend until to the Hofmannshütte. Since this time the glacier was eight times smaller then today and the area was pasture and woodland. This is proved by the melt out from larch and stone pine trunks in the years 1989 and 1990. The age of these is 10,300 up 3,600 years, in the time of early and medium Late glacial.
The Pasterze shows a thickness of ice of 120 and a length of 4 km by a volume of 1.77 km^3 ice. The melting water could supply 100,000 persons (200 l/caput need) during 200 years.
Since 1963 exists a funicular from the Franz-Josefs-Höhe and ends on the glacier surface in the year 1963.
In the present time the water is damed by the Möll-concret dam (93 m high) and Margaritzen-concret dam (40 m high).
The last maximum of the Würm glaciation was about 23,000 years BP. Since about 19,000 BP began the quick deglaciation, and from 13,000 years BP began the development of vegetation and soils in the valleys and basins.
Table 6.6.1 and the Figures 6.6.2 and 6.6.3 illustrate this situation.

Table 6.6.1: Length, surface and volume of the Pasterze glacier in the years 1852, 1924, 1969, 1985 and 2002.

Year	1852	1924	1969	1985	2002
Lenght (km)	11.0	10.3	9.5	9.0	8.4
Surface (km^2)	26.5	22.6	19.8	18.9	18.5
Volume (km^3)	3.5	2.9	2.2	2.0,	1.8

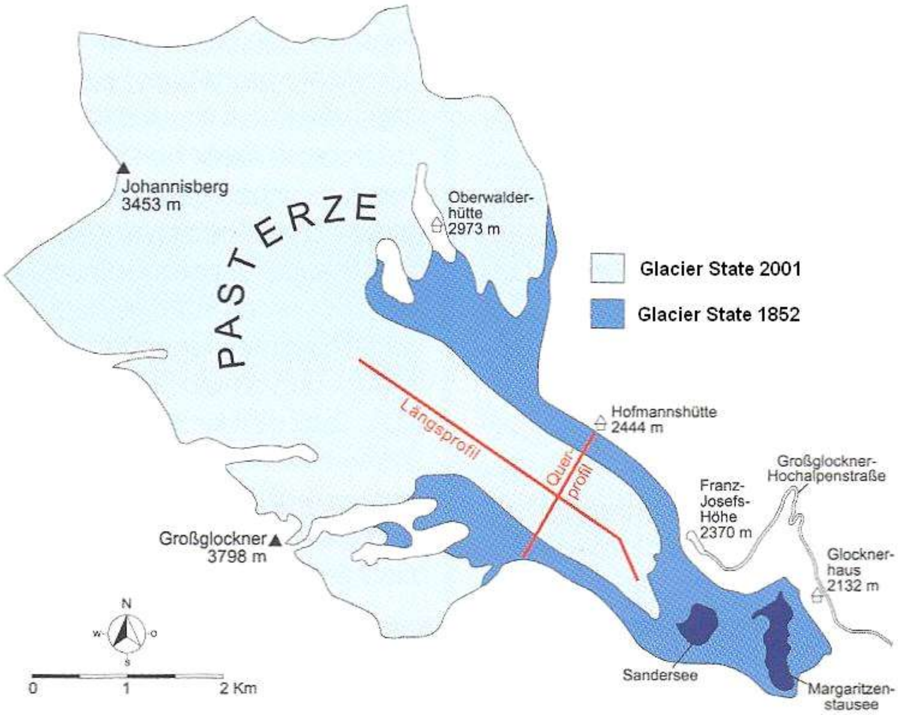

Figure 6.6.1: The Pasterze and its environment.

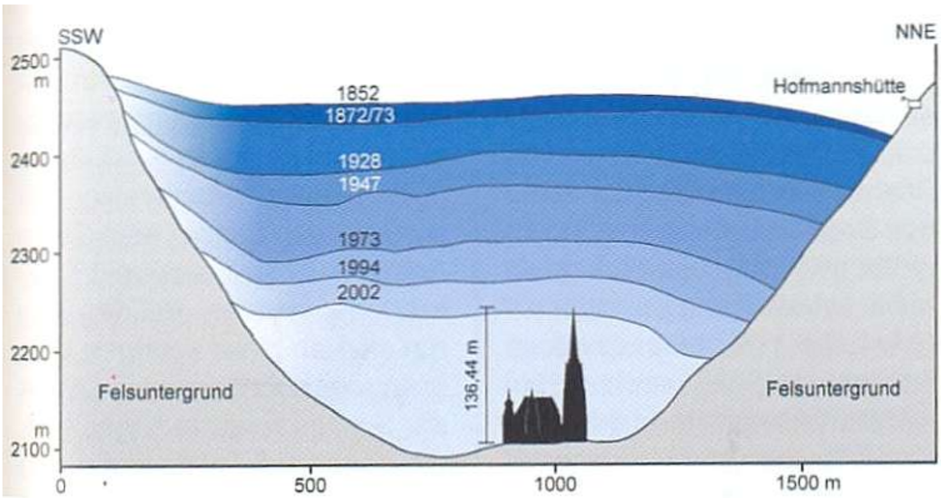

Figure 6.6.2: The profile of Pasterze in the area of the Hofmannshütte.

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6.7 The Glocknerhaus

This refuge was built in the year 1876 on the final point of the first Glockner-road. The position is 2,132 m asl, and we can see the characteristic stepslike gable. The owner is the Section Klagenfurt of the Austrian Alpine Association. The general restoration took place in the years 2001/2002.

6.8 Edelweißspitze: Panorama - View

General orientation: The location itself is formed of light grey, partly cyanite-bearing Keuper schists, which locally contain gypsum lentils and overly yellowish Triassic dolomite (partly with ochreous Rauhwackes). We are on the flat-lying axial high of the Tauern Arch and can clearly recognise this arch looking westward over the Fusch-valley in the wide anticline of the "Upper schist cover" (Wiesbachhorn, 3,400 m). One can also see the anticlinal structure in SE - direction, where at the horizon even the care of the Sonnblick central gneiss emerges (Hocharn, 3254 m).

View towards N:

The flat-lying schist cover in the adjoining Triassic marbles, is increasingly dipping against N towards the Salzach-valley. The Zell Lake, visible just N of the longitudinal Salzach valley, is situated already in the Greywacke-Zone N of the Tauernfenster, hence in a Lower Palaeozoic Area of the Upper Austro Alpine Unit. To the same unit also belong the Northern calcareous Alps, which raise at the background (from W to E: Leoganger Steinberge, Steinernes Meer, then towards NE the Dachsteinplateau).

Towards SW to S:

The Großglockner summit, emerging at the background towards SW is the highest point of Austria and belongs to Upper Schist Cover, just like the other summits, -running on its both sides from W to S. More towards S, at the nearby Brennkogel (with an ancient gold mine), there is a big serpentinite body in the Bündnerschiefer of Brennkogelfacies to be seen, which can be traced close up to the Hochtor. In the S there emerge the Triassic marble just at the Hochtor tunnel under the Bündnerschiefer series of Margrötzenkopf as a result of a transverse folding with N-S axes. These flat lying marbles cover extended areas between here and the Hochtor.

Against East at the other side of the Seidlwinkel valley their light-yellowish dolomitic continuation shows a big N-dipping recumbent fold with a reduced and inverted limb around a greenish-white core of quartzite and fine grain gneiss (Wustkogel formation of Permoskyth). Above and below this Permotriassic nappe-core of the Seidlwinkl Nappe, a thick Bündnerschiefer sequence with grey phyllites and quartzites is recognizable. In the background the impressive green pyramid of Ritterkopf represents again a mass of ophiolites belonging to the Glockner facies ("Upper Schist Cover").

LITERATURE

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6.9 The northern Alpine-foreland

In Austria exist two forelands: one in the North, one in the Southern-East. In the centre of the following interpretations is the Austrian part of the northern Alpine foreland.
The border in the South of this areas is the Molasse-zone, the are clay-marls, sands, gravels and conglomerates, in the North is the Bohemia Massif, further in the East the Carpathian foreland and the northern part of the Vienna Basin.
In the lithological point of view are neogen sediments the underlying bed. This is overlies from quaternary sediments (gravels and sands). The morphological superimposing took place during the last Ice time by the Inn-, Salzach- and Traun-glaciers. We can see in the landscape the tracers of the moraines, outwash plains and pleistocene terraces (Günz, Mindel, Riss and Würm) and the recent valleys.
The soil cover, coming from Schlier or loamy loess above gravel or neogen sediments, partly direct above gravel demonstrates a chrono-catena: The upper part (the Older Cover Gravel) is covered by Stagnosols and stagnic subtypes of Cambisols and Luvisols, the Younger Cover Gravels and High terraces by Cambisols and Luvisols. There are the highest productive sites of this foreland. Relatively young soils (e.g. Haplic Cambisols and Rendzic Leptosols) cover the Lower terraces; the have a medium or low fertility.
In the valley we find partly gleyic soils, partly Fluvisols with or without Calcium Carbonate.
In every case, the northern foreland is in the agricultural point of view one of the most important area of Austria.

7
DESCRIPTION OF SITES AND SOILS

7.1 Soil analytical Methods

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The excursion profiles were analyzed by physical, chemical and mineralogical methods in different research laboratories.
In the following the methods are described in the sequence of the listing of analytical results in the tables in this chapter.

<u>1. Physical methods</u>
Profiles 1CH/A-1 to 5:
Particle size distribution (texture) was determined by a combined method, using sieves and pipette after dispersion with Na-pyrophospate and H_2O_2- pretreatement for humus destruction.

Profiles 1CH/A- 6 and 7 after the ÖNORM L 1061-2.
Hydraulic conductivity (k_f) of the water saturated soil was determined according to DIN 19683 at undisturbed soil samples, taken in vertical position from natural soil, with a constant pressure head and hydraulic gradient of 1. - The results represent geometric mean values of 5 parallels.

Bulk density (ρd) was determined according to DIN 19683 from undisturbed soil samples by drying at 105°C.

Porosity (n) was calculated according to DIN 19683 using bulk density (ρd) (see above) and particle density (£s) values, determined by pycnometric methods

$$n= (1 - \rho d/ \rho s) * 100$$

Matrix potential (Ψm) (pF = log Ψ m) was determined according to DIN 19683 at undisturbed soil samples in 5 parallels, using a pressure plate apparatus.

2. Chemical methods

Profiles 1CH/A-1 to 5:
pH (H_20, $CaCl_2$) was determined electrometrically in soil suspensions with H_20 and 0,01 M $CaCl_2$ at a soil: solution ratio 1:2,5.
Fe in Na-dithionite-citrate and Fe and Mn in NH-Oxalate (Fe/Mn) extracts was analyzed using the methods described by Schlichting and Blume, 1966, slightly modified.
The elements were determined quantitatively by plasma absorption spectroscopy (DCP).
Phosphorous (Pa) was analyzed, using the Egner-Riehm method with 0,02 M Ca-lactate and 0,02 M HCl at pH 3,7 for acid soils (pH <6) and the Schüller method with 0,05 M Ca-lactate, 0,05 M Ca-acetate and 0,3 M acetic acid at pH 4,1 for soils with pH>6.
Humus content (org. %) was determined by dry combustion in a Woesthoff apparatus with conductivimetric measurement of CO_2 using the factor 1,72 for the conversion into humus values and by a modified Walkley and Black method, compare Schlichting and Blume, 1966.
Total Nitrogen (N_t) analysis was done by the Kjeldahl method, using salicylic acid to bind $N0_2$ and titration of N after distillation.
Carbonate content was analyzed volumetrically with a Scheibler calcimeter, measuring $C0_2$ development after soil treatment with diluted HCl .
Cation exchange capacity (CEC), exchangeable cations and base saturation (V %) were determined by a modified Mehlich procedure, using 0,2 M $BaCl_2$ and 0,036 M triethanolamine at pH 7,5 as exchange solution. Exchangeable cations and Ba were analyzed by atomic absorption spectroscopy. Base Saturation was calculated from CEC and the sum of exchangeable cations.

Profiles 1CH/A-6 and 7:
pH in $CaCl_2$ after ÖNORM L 1083,
Carbonate content (Scheibler) after ÖNORM L 1084,
Humus (Walkley) after ÖNORM L 1080 (trocken), für Prof. 6: nass 1081,
CEC and exchangeable Ca, Mg, K, Na, Fe, Mn, Al after ÖNORM L 1086-1,
P and K (CAL-Extract) after ÖNORM L 1087.
Profile 1CH/A-6: Humus after ÖNORM L 1081 (wet combustion), profile 1CH/A-7 after ÖNORM L 1080 (dry combustion).

3. Mineralogical methods

Profiles 1CH/A-1 to 5:

Clay mineral distribution was analyzed by X-ray diffraction after Separation and treatment of the clay fraction (< 2 µm) with K, Mg, glycerine and dimethylsufoxide (DMSO), using Cu K α radiation. Quantitative clay distribution was estimated by measurement of peak surfaces using correction factors.

Profile 1CH/A-6:

Qualitative and semiquantitative determination of the mineralogical components were made by x-ray diffraction analysis with a Phillips PW 1800 (cobalt tube) in the angle range of 3° to 85° 2Θ. Part of each sample was milled to grain size appropriate for x-ray analyses and pressed to a sample holder. Semiquantitative calculations were carried out by comparing characteristic x-ray reflection intensities with calibration diffractograms.

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7.2 Profiles 1CH/A – 1 to 7 and the Geological Study Trail

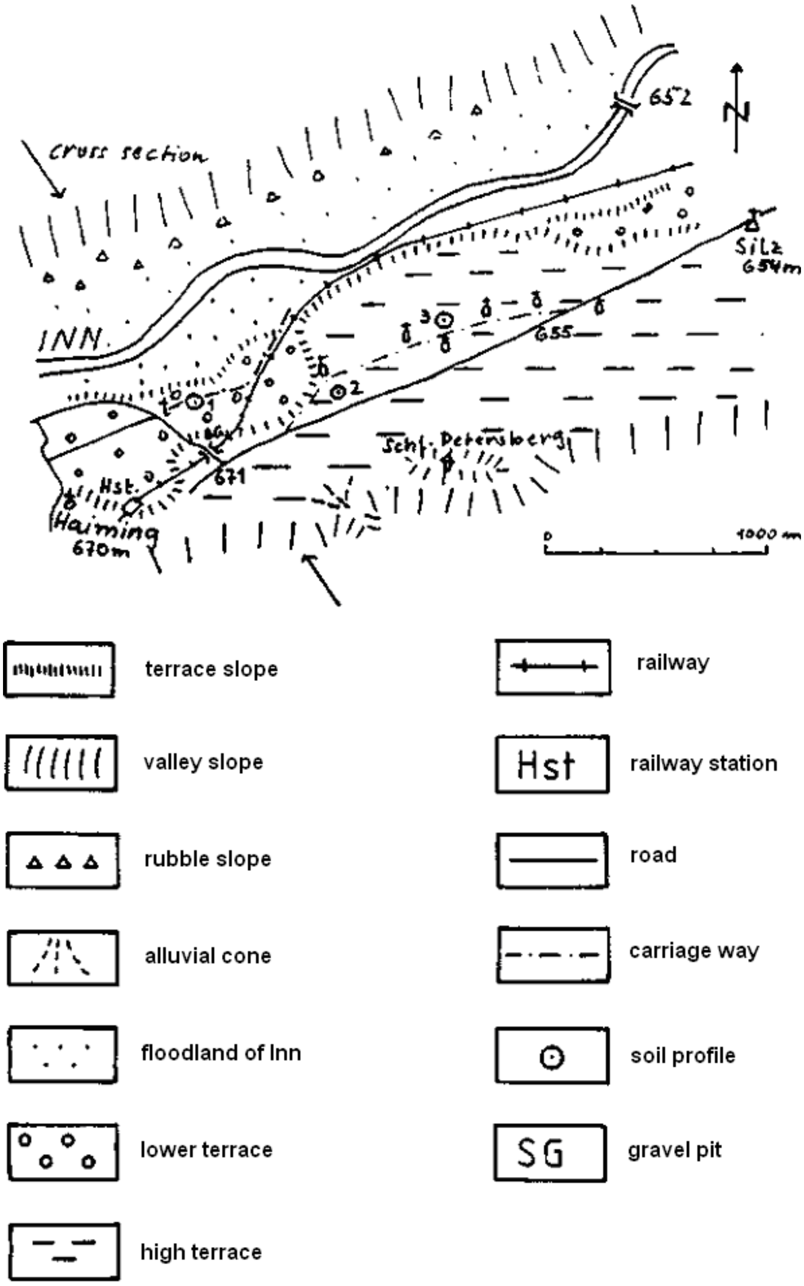
Soil profile Haiming (1CH/A – 1), Tyrol: Calcaric Chernozem (Siltic)

Site characterisation:

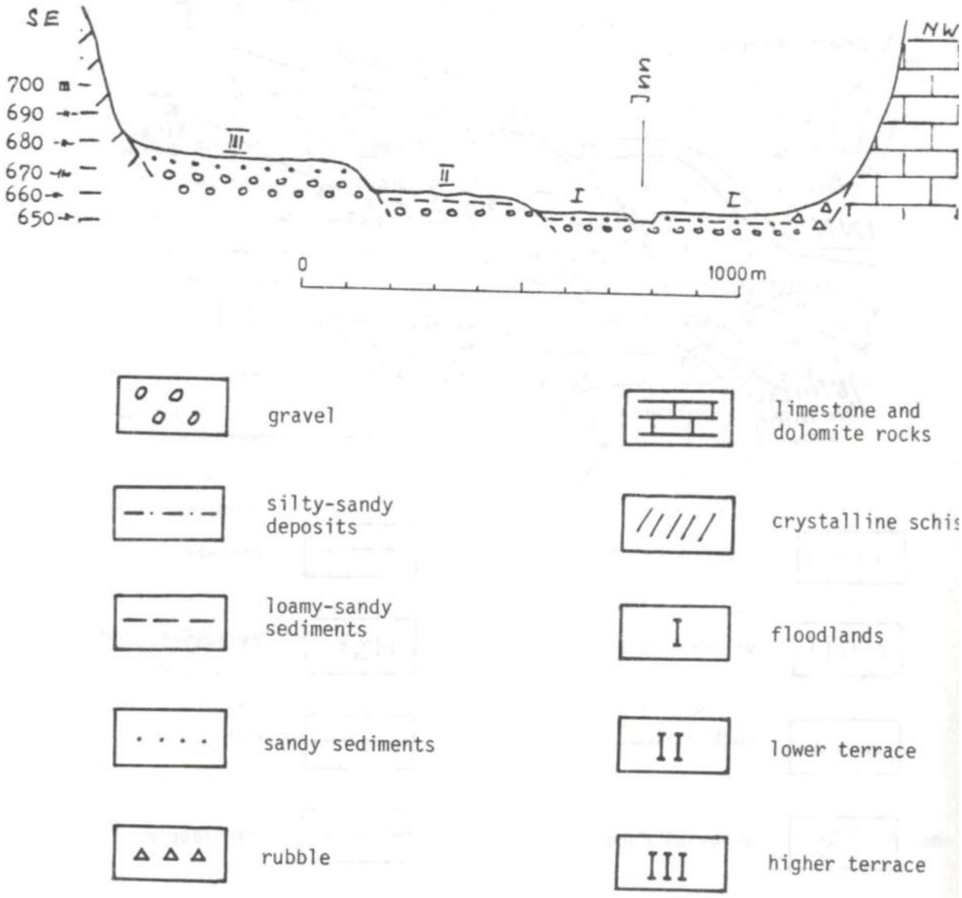
On map A.1.1 it can be seen that the Inn-valley is divided into three parts, the recent floodplain of the Inn (young Holocene), the lower terrace of Haiming (late glacial to early Holocene period) and the higher terrace of Haiming-Silz (late glacial period "Gschnitz -Stadium").

The local glacier of the Ötz-valley advanced during the Gschnitz stage into the Inn-valley. It reached the northern edge of the valley and blocked the Inn. Afterwards a big washout, consisting of the

gravels which have their origin in the Ötztaler Alpen, was built in front of the glacier. It was topped with a thin (50 to more than 100 cm) layer of lime-free coarse sand.
When the ice, blocking the Inn-valley melted the Inn eroded parts of the washout and built up his calcareous Sediments. A lower terrace was formed, divided from the higher terrace by a steep slope of about five meters high. This new terrace is composed of calcic and crystalline gravel. The undulating surface of the gravel deposit is covered with a layer of fine loamy sand (30 to 100 cm). The depth of soil on this terrace varies more than on the higher terrace.
During the younger Holocene the Inn eroded again and made the recent flood land, 1-1 1/2 meters below the lower terrace. This floodplain consists of a layer of silty-sandy deposits which cover the gravel below one meter or more.
Today the Inn is completely regulated and therefore there is no flooding. With reason the intensive agriculture the slope from the lower terrace to the floodplain has been leveled off.
The geomorphological and geological situations are shown in a cross-section through the Inn valley, with 6.25 fold increased height, see map A.1.2.



Map A.1.1 : Geomorphological situation of the Inn-valley near Haiming.



Map A.1.2 : Cross-section through the "Inn" valley near Haiming, increased height: 6.25 fold.

<u>Location</u>: 660 m asl, low terrace of the Inn.

<u>Climate</u>: warm temperate climate with weak humid conditions.

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
7°C	19°C	225	600-700 mm

<u>Relief</u>: very gentle alluvial terrace.

<u>Landuse</u>: arable land, cereal cropping.

<u>Soil profile description</u>:

Ap (0-20 cm) Sandy loam, moist: very dark brown to very dark gray (10 YR 2/2 - 3/1), crumbly to subangular blocky structure; very friable, sticky and plastic, many worm holes, abundant roots, abrupt smooth boundary

A1 (20-35 cm) Loam with very low gravel content, moist: very dark gray (10 YR 2/2 - 3/1), angular-blocky structure, very friable, very plastic and sticky, many worm-holes, abundant roots, gradual boundary

AC (35-45 cm) Loam, moist: dark gray to dark grayish brown (10 YR 4/1 - 4/2), subangular blocky, very friable; plastic and sticky, many worm-holes, few roots, gradual boundary

ACk (45-60 cm) Loam with spots of humus, moist: grayish brown to brown (10 YR 5/2 - 5/3), subangular prismatic structure, very friable, plastic, non sticky, carbonate concretions and efflorescences in worm-holes, few roots, many worm-holes, gradual boundary

C1 (60-80 cm) Sandy loam, moist: light brownish gray to very pale brown (10 YR 6/2 - 7/3), subangular prismatic, very friable, plastic, non sticky, some carbonate concretions, few worm-holes, few roots, gradual boundary

C2 (80-95 cm) Sandy loam, moist: gray to light gray (10 YR 6/1 - 2/5 Y 7/1), subangular blocky, very friable, non plastic, non sticky, few roots, clear boundary

C3 (95-100+ cm) Bank of fine and coarse gravel of the Inn-river.

Table A.1.1 : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-20	20-35	35-45	45-60	60-80	80-95
Particle size distribution (%) S/Si/C (textural class)	64/28/8 (SL)	42/50/8 (L)	44/44/12 (L)	44/46/10 (L)	50/44/6 (SL)	69/29/2 (SL)
Dry bulk density (g/cm^3)	1.24	1.51	1.52	n.d.	n.d.	n.d.
Total porosity (%) water content (%) at pF 0.6 pF 1.8 pF 2.5 pF 4.2	53 52 42 35 11	44 44 37 31 12	44 42 36 21 9	n.d.	n.d.	n.d.
Saturated water conductivity (cm/d)	55	25	24	n.d.	n.d.	n.d.
pH ($CaCl_2$)	7,4	7.5	7.7	7.7	7.7	7.7
$CaCO_3$ (%)	11	11	13	16	13	21
Organic matter (%)	5.7	3.9	1.9	1.2	0.7	0.7
Ntot (mg/g)	2.4	1.4	0.6	<0.1	<0.1	<0.1
C/N-ratio	13.7	16.3	18.7	n.b.	n.b.	n.b.
CEC_{eff} ($cmol_c.kg^{-1}$, $BaCl_2$) Ca ($cmol_c.kg^{-1}$, %) Mg ($cmol_c.kg^{-1}$, %) K $cmol_c.kg^{-1}$, %) Na ($cmol_c.kg^{-1}$, %) Base saturation (%)	22.8 19.4 (85) 1.9 (8) 1.4 (6) 0.1 (1) 100	18.3 15.6 (85) 1.6 (9) 1.0 (5) 0.1 (1) 100	13.7 11.8 (86) 1.1 (8) 0.7 (5) 0.1 (1) 100	9.8 8.7 (89) 0.8 (8) 0.2 (2) 0.1 (1) 100	6.8 6.1 (89) 0.6 (9) 0.1 (1) 0.1 (1) 100	3.4 2.9 (85) 0.4 (12) 0.1 (3) <0.1 100
Pedogenic Fe-Oxides (mg/g) Fe_d Fe_o Fe_o/Fe_d	 6.0 4.2 0.70	 5.2 4.5 0.87	 4.9 4.1 0.84	 6.5 3.6 0.55	 6.1 4.7 0.77	 3.8 2.8 0.74
Clay mineral distribution (%) Illite Chlorite Kaolinite	 66 25 9	 69 25 6	 69 25 6	 61 28 11	 62 30 8	 61 35 4

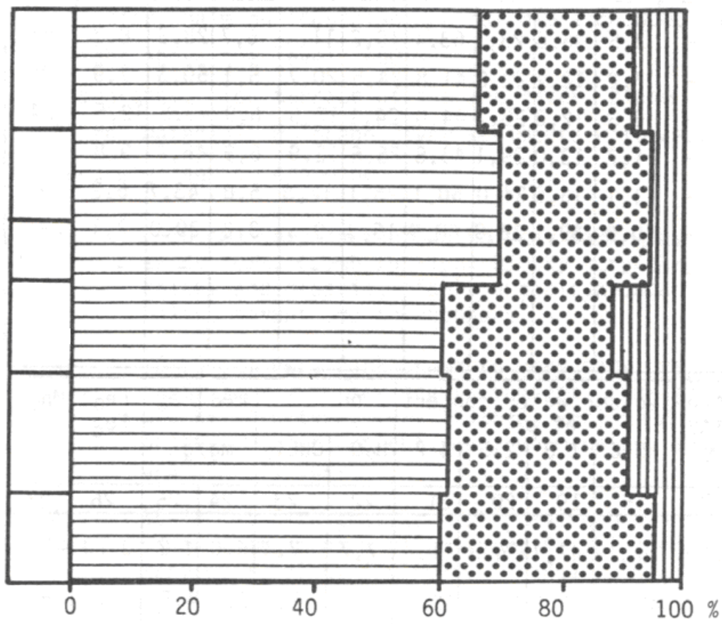


Figure A.1.1 : Clay mineral distribution profile 1CH/A-1.

Soil profile Maishofen (1CH/A – 2), Country of Salzburg: Epigleyic Cambisol

Site characterisation:

This profile is situated on a flat alluvial cone, see fig. A.2.1. This cone was built up by the river Saalach in the wide "Zeller See Furche", a glacial through valley.
The Sediments along the river and at the foot of the cone consist of sand, grit and gravel. Near the edges the coarse material is overlain by loamy-silty deposits and the influence of ground water increases.
Around the profile the thickness of the loamy-silty layer is one meter or more, the groundwater starts influencing the soil at a depth of about 65 cm. The Saalach is regulated, so the danger of floods in banned.

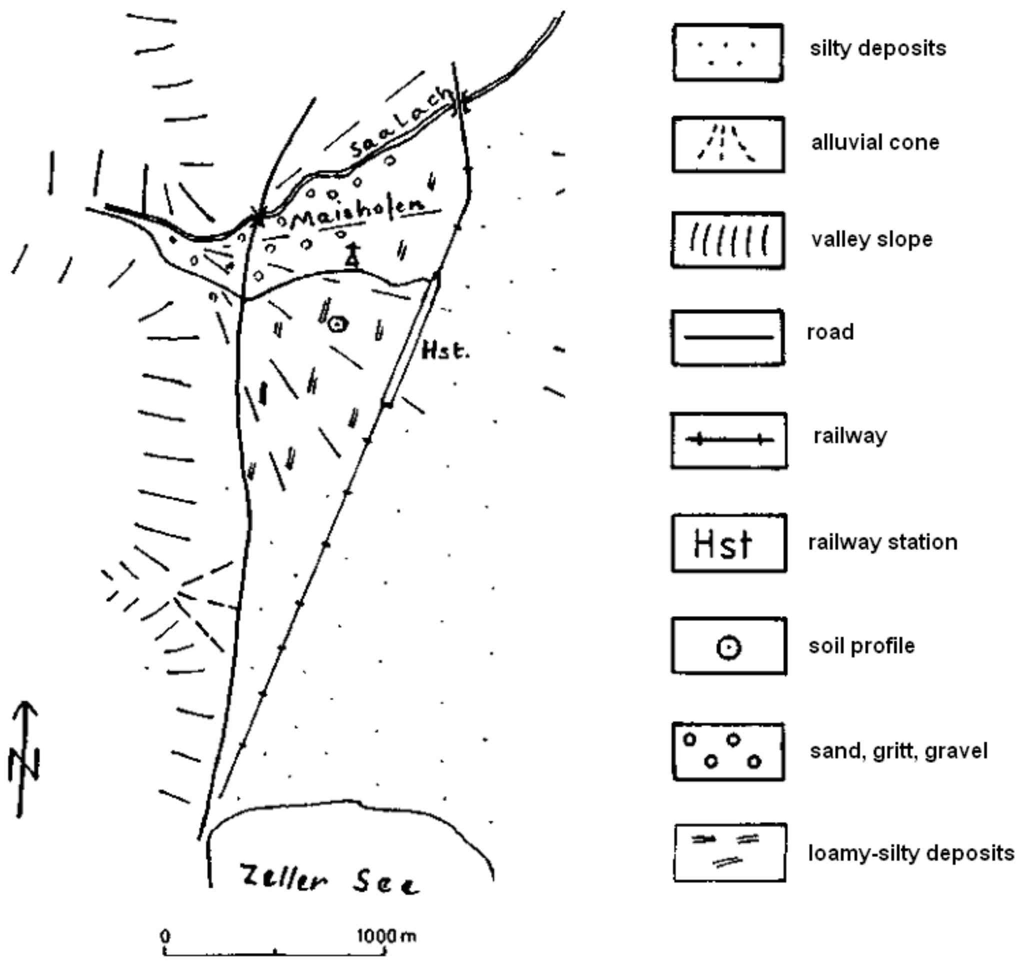


Figure A.2.1. : Geomorpholgical situation of the Zeller See Furche between the Zeller See and the Saalach river

Location: 772 m asl, terrace, 2° ENE.

Climate: warm temperate climate with moderate humid conditions.

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
6.5°C	18°C	215	1,000-1,200mm

Relief: very gentle alluvial cone, 2° ENE.
Landuse: pasture.

Soil profile description:

Ah (0-7 cm)	Sandy loam, moist: very dark grayish brown (10 YR 3/2), crumbly structure, very humic, very friable, non plastic, non sticky, some distinctive brownish stains, abundant roots, clear boundary
ABg (7-15 cm)	Sandy loam, moist: gray to grayish brown (10 YR 5/1 - 5/2), platy structures, very friable, plastic, weakly sticky, many weak brownish stains and holes and light grayish stains, many roots, gradual boundary
B (15-30 cm)	Sandy loam, moist: grayish brown to brown (10 YR 5/2 - 5/3), blocky angular structure, partly crumbly structure, very friable, plastic, non sticky, some brown and grayish stains, few roots, gradual boundary
BC (30-45 cm)	Loamy sand, moist: dark gray to dark grayish brown (10 YR 4/1 - 4/2), blocky angular to crumbly structure, very friable, non plastic, non sticky, few roots, clear boundary
C1 (45-60 cm)	Gravelly coarse sand
C2 (60-80 cm+)	Gravel.

Table A.2.1. : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-7	7-15	15-30	30-45	45-60	
Particle size distribution (%): S/Si/C (textural class)	57/33/10 (SL)	55/34/11 (SL)	53/38/9 (SL)	83/16/1 (LS)	92/8/0 (S)	
pH ($CaCl_2$)	5.0	4.9	5.0	5.0	5.1	
$CaCO_3$ (%)	0	0	0	0	0	
Organic matter (%)	4.0	1.9	1.6	0.5	0.2	
Ntot	2.8	n.d..	n.d.	n.d.	n.d..	
C/N-ratio	8.2	n.d.	n.d.	n.d.	n.d.	
CEC_{eff} ($cmol_c.kg^{-1}$, $BaCl_2$) Ca ($cmol_c.kg^{-1}$, %) Mg $cmol_c.kg^{-1}$, (%) K ($cmol_c.kg^{-1}$, %) Na ($cmol_c.kg^{-1}$, %) Base saturation (%)	16.0 5.9 (37) 1.9 (11) 0.4 (3) 0.1 (1) 52	11.8 3.9 (33) 1.2 (10) 0.1 (1) 0.2 (2) 46	6.5 2.2 (34) 0.6 (9) 0.1 8"9 0.2 (3) 48	7.0 2.4 (43) 0.5 (7) n.b. 0.1 (2) 43	n.b.	n.b.
Pedogenic Fe-Oxides (mg/g) Fe_d Fe_o Fe_o/Fe_d	 7.8 5.3 0.68	 8.3 6.1 0.73	 10.2 5.7 0.56	 6.7 2.6 0.39	 3.9 1,5 0.38	
Clay mineral distribution (%) Illite Chlorite	 39 61	 58 42	 48 52	 54 46	 55 45	

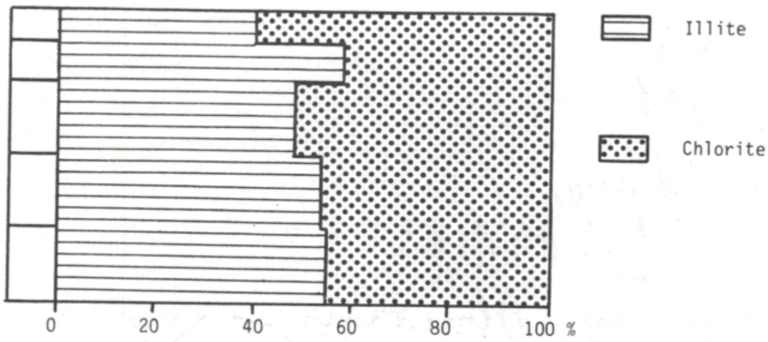


Figure A.2.2. : Clay mineral distribution profile 1CH/A-2.

Soil profile Gamsgrube (1CH/A – 3), Carinthia: Haplic Cambisol (Calcaric, Colluvic)

Site characterisation: slope system between Fucherkar Kopf and Pasterze.

Location; about 70 m above the Gamsgrubenweg.

Climate: cool temperate climate with strong humid conditions.

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
<1.5°C	<10°C	<165	1,500-2,000mm

Relief: 2,490 m asl, undulating slope: about 23° S.

Landuse: alpine meadow.

Soil profile description:

A (0-10 cm)	Sand with few coarse fragments (fine gravel), low content of organic matter, non plastic, non sticky, loose, high porosity, many roots, none biological activity, diffuse
Bg (10-45 cm)	Sand with few coarse fragments (fine and medium gravels), moist: dark brown (10 YR3/4), few mottles (organic matter), moderate massive, diffuse
B1 (45-100 cm)	Sand with few coarse fragments (gravels and stones), loose, non plastic, non sticky, few roots
B 2 (100-145 cm)	Sand, low content of organic matter, moist: brownish black-dark brown (10 YR 3/2-3/3), soft, few mottles (iron), few roots, diffuse
BC 1 (145-175 cm)	Sand and weathered mica, moist: dark brown (10 YR 3/3), massive, few roots, diffuse
BC 2 (175-190 cm)	Sand, moist: dark brown (10 YR 3/3), loose, few roots.

Table A.3.1. : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-10	10-45	45-100	100-145	145-175	175-190
Particle size distribution (%) S/Si/C (textural class)	92/7/1 (S)	90/9/1 (S)	88/11/1 (S)	82/16/2 (LS)	81/17/2 (LS)	81/16/3 (LS)
pH (KCl)	7.0	6.9	7.1	7.2	6.9	6.9
$CaCO_3$ (%)	60	39	24	0	n.d.	n.d.
Organic matter (%)	2.3	0	0	1,.5	0	0
CEC_{eff} ($cmol_c.kg^{-1}$, $BaCl_2$)	15	11	32	n.d.	n.d.	n.d.

Soil profile Senfteben (1CH/A – 4), Carinthia: Haplic Cambisol

Site characterisation:

The remains of a late glacial moraine rampart are asserted at ca. 1,900 -1,950 meters on the steep SE - slope of the "Wasserrad Kopf" (3,032 m). The moraine rampart consists of coarse pebble in sandy binder. At the bottom of the slope big blocks from the steep back slope can be found. The border of the rampart is affected by linear erosion and loosened to hillocks and channels, see fig. A.4.1.
Here the surface is strongly heterogeneous: the sandy initial material of t soil is a local, partly water-carried, weathering residuum of the carbonate-poor Bündner Schiefer, which are widely exposed here and which built the local bedrock too. The landslide blocks, which are lying all around and are often of one-meter length, originate from an up-hill, kilometre-sized serpentine body.

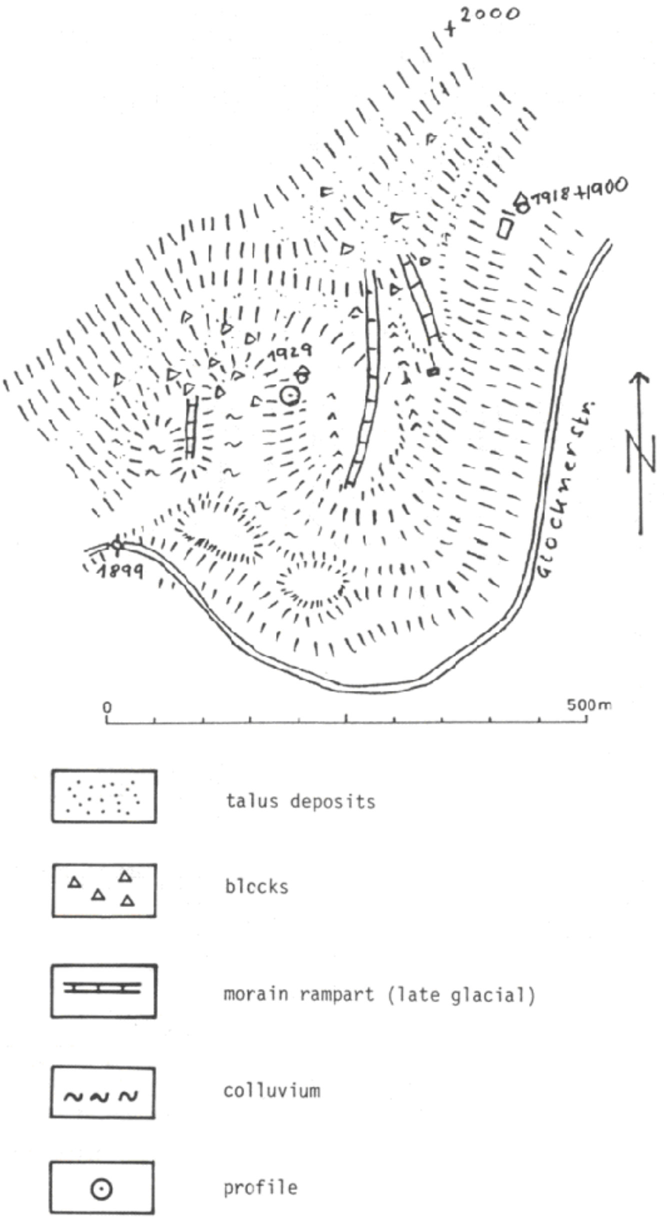


Figure A.4.1. : Geomorphological situation of the area around the site Senfteben.

<u>Location</u>: 1,930 m asl

<u>Climate</u>: cool temperate climate with strong humid conditions.

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
<1.5°C	10°C	<165	1,500-2,000mm

Relief: undulating slope: 20° SW.

Landuse: alpine pasture and meadow.

Soil profile description:

Ah (0-10 cm)	Sandy loam with some gravels, moist: very dark grayish brown (10 YR 3/2-4/2), crumbly structure, fine pores, very friable, plastic, non sticky, abundant roots, gradual boundary
AB (10-25 cm)	Sandy loam with some gravels, moist: dark brown to dark yellowish brown (10 YR 4/3 – 4/4), angular blocky structure, fine pores, very friable, non plastic, non sticky, some small light grayish stains, abundant roots, gradually boundary
B1 (25-35 cm)	Sandy loam with some gravels, moist: dark yellowish brown (10 YR 4/4), blocky structure, very friable, non plastic, non sticky, gradual boundary
B2 (35-50 cm)	Sandy loam with some gravels, moist: yellowish brown (10 YR 5/4), angular blocky structure, fine pores, friable, non plastic, non sticky, gradual boundary
C1 (50-85 cm)	Sandy loam, moist: brown (10 YR 5/3), clear boundary
C2 (85-100+ cm)	Sandy loam with ground moraine blocks, moist: grayish brown (2.5 Y 5/2).

Table A.4.1. : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-10	10-25	25-35	35-50	50-85	85-100+
Particle size distribution (%) S/Si/C (textural class)	56/30/14 (SL)	67/23/10 (SL)	66/22/12 (SL)	70/23/7 (SL)	73/20/7 (SL)	75/22/3 (SL)
Dry bulk density ($g/cm^{3)}$	1.00	n.d.	1.17	n.d.	n.d.-	n.d.
Total porosity (%):	61	n.d.	57	n.d.	n.d.	n.d.
water content (%) at						
pF 0.6	59		56			
pF 1.8	47		39			
pF 2.5	42		31			
pF 4.2	20		12			
Saturated water conductivity (cm/d)	310	n.d.	349	n.d.	n.d.	n.d.
pH ($CaCl_2$)	4.9	4.8	4.8	4.9	6.0	7.2
$CaCO_3$ (%)	0	0	0	0	0	53
Organic matter (%)	5.7	2.2	1.5	0.7	0.5	0.2
Ntot	3.1	2.0	1.0	0.6	0.4	0.2
C/N-ratio	10.6	6.5	9.0			
Corg	5.7	2.2	1.5	0.7	0.5	0.2
CEC_{eff} ($cmol_c.kg^{-1}$, $BaCl_2$)	18.9	9.7	7.0	4.8	4.2	n.d.
Ca ($cmol_c.kg^{-1}$, %)	8.2	2.3	1.4	1.2	2.3	
Mg ($cmol_c.kg^{-1}$, %)	2.3	0.6	0.3	0.3	0.4	
K ($cmol_c.kg^{-1}$, %)	0.1	0	0	0	0	
Na ($cmol_c.kg^{-1}$, %)	0.1	0.1	0.1	0.1	0.1	
Base saturation (%)	57	31	26	33	67	
Pedogenic Fe-Oxides (mg/g)						
Fe_d	23.0	29.9	26.3	22.2	19.5	11.2
Fe_o	8.9	11.6	10.5	10.2	5.1	1.3
Fe_o/Fe_d	0.39	0.39	0.40	0.46	0.26	0.12
Clay minerals (%):						
Illite	62	45	62	62	76	73
Chlorite	14	15	17	17	18	20
Kaolinte	7	17	8	8	3	0
Talc	17	23	13	13	3	7

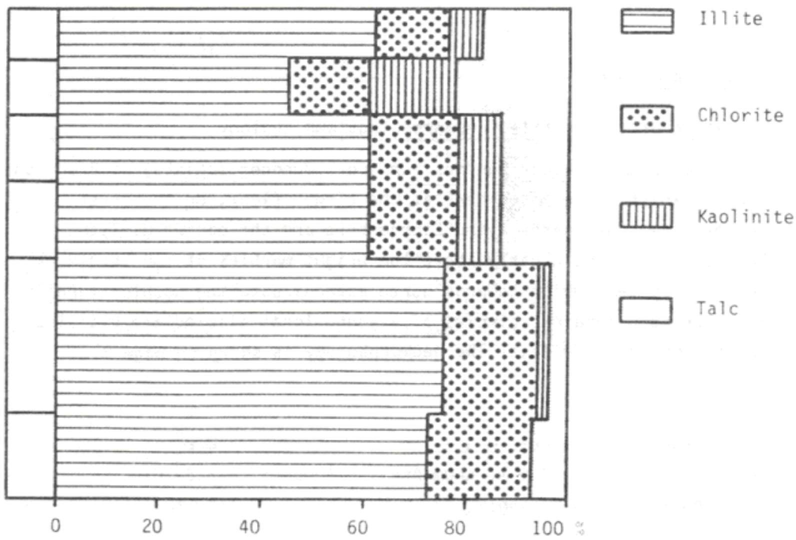


Figure A.4.2. : Clay mineral distribution profile 1CH/A-4.

Soil profile Fallbichl (1CH/A – 5), Carinthia: Gleyic Podzol

Site characterisation:

The same carbonate-poor Bündner Schiefer (Bündner schists) of Brennkogel-facies, which are exposed here ant the cirque floor, on the crest between the south-ward-lying Lacknerberg and the eastwards-lying Schareck are lying clearly above the bright marbles of the Seidlwinkl Triassic System, which towards North extends up to the Hochtor tunnels. Moreover some moraine circles of a young local glacier are visible, which came from the East. The gemorphological situation is shown on fig. A.5.1.

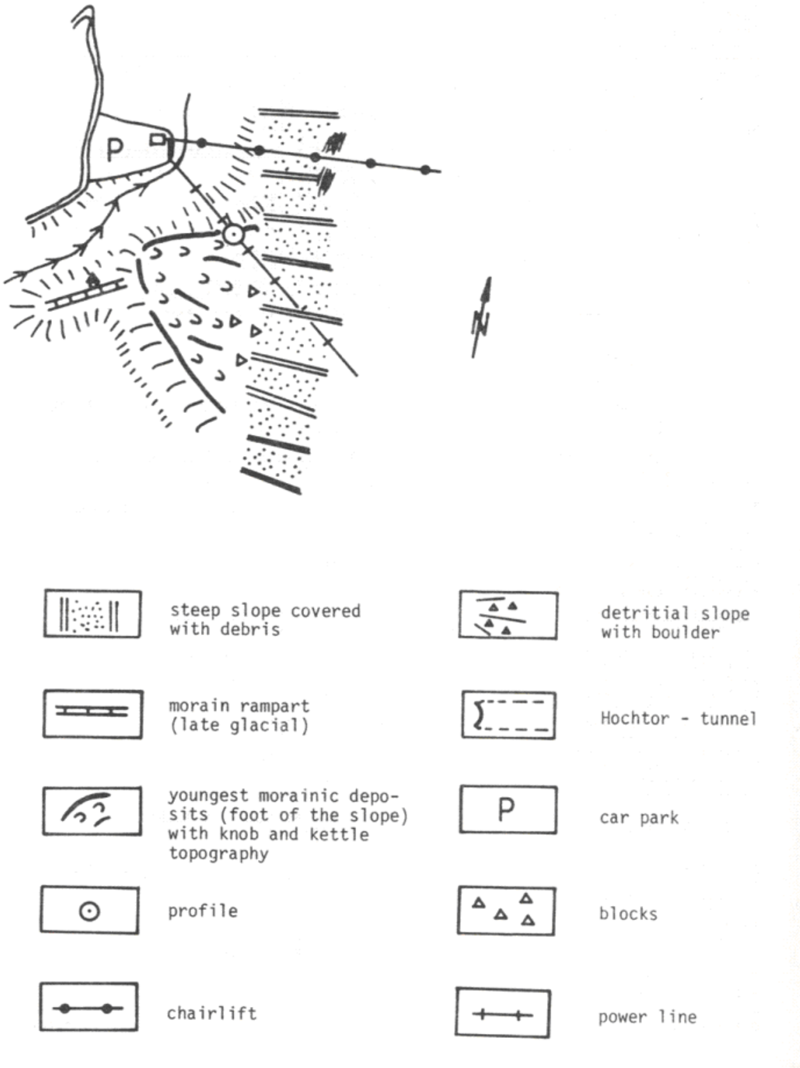


Figure A.5.1. : Geomorphological situation about the site Fallbichl.

Location: 2, 250 asl.

Climate: cool temperate climate with strong humid conditions.

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
<1.5°C	<10°C	<165	1,500-2,000mm

Relief: small ridge.

Landuse: alpine pasture.

Soil profile description:

AE (0-5 cm)	Sandy loam with some gravels, moist: dark gray (10 YR 4/1), granular structures, very friable, non plastic, non sticky, distinctive light-grayish and brown stains, abundant roots, clear boundary
Bs (5-20 cm)	Sandy loam, moist: very dark brown to dark yellowish brown (10 YR 4/3 – 3/4), granular to subangular structure, very friable, non plastic, non sticky, abundant roots, gradual boundary
B (20-25 cm)	Sandy loam, moist: brown (10 YR 5/3), subangular structure, very friable, non plastic, non sticky many roots, gradual boundary
C (25-45+ cm)	Sandy loam with many skeletal fragments, moist: pale brown (10 YR 6/3).

Table A.5.1 : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-5	5-20	20-25	25-45		
Particle size distribution (%) S/Si/C (textural class)	62/24/14 (SL)	71/23/6 (SL)	71/22/7 (SL)	71/24/5 (SL)		
Dry bulk density (g/cm^3)	0.92	n.d.	1.38	1.22		
Total porosity (%) water content (%) at pF 0.6 pF 1.8 pF 2.5 pF 4.2	64 63 54 37 17	n.d.	51 47 41 27 7	58 51 36 22 3		
Saturated water conductivity (cm/d)	33	n.d.	52	326		
pH ($CaCl_2$)	3.8	4.0	4.2	4.5		
$CaCO_3$ (%)	0	0	0	0		
Organic matter (%)	7.2	2.5	1.3	0.5		
Ntot (mg/g)	3.2	1.2	0.7	0.4		
C/N-ratio	13.1	12.1	10.8	7.3		
CEC_{eff} (cmol$_c$.kg^{-1}, $BaCl_2$) Ca (cmol$_c$.kg^{-1}, %) Mg (cmol$_c$.kg^{-1}, %) K (cmol$_c$.kg^{-1}, %) Na (cmol$_c$.kg^{-1}, %) Base saturation (%)	13.6 3.5 (26) 0.9 (7) 0.2 (1) 0.1 (1) 35	13.7 0.9 (7) 0.2 (1) 0 0.1 (1) 9	6.9 0.5 (8) 0.1 (1) 0 0.1 (1) 10	4.2 0.4 (10) 0 0 0.d (2) 12		
Pedogenic Fe-Oxides (mg/g) Fe_d Fe_o Fe_o/Fe_d	 13.0 1.6 0.12	 33.1 20.1 0.61	 33.9 8.5 0.25	 28.7 7.4 0.26		

Soil profile Hintersteineralm (1CH/A – 6), Upper Austria: Technic Leptosol (Calcaric)

Site characterisation: recultivated area after gypsum quarrying.

Location: 1,090 m asl, near the Pyhrnpass on the border between Styria and Upper Austria.

Climate: cool temperate climate with moderate humid conditions.

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
5-6°C	16°C	185	1,700mm

Relief: slope 23° WSW.

Landuse: grassland, pasture.

Soil profile description:

A (0-20 cm)	Loam, common coarse fragments (coarse and fine gravel), low content of organic matter, moist: yellowish brown (10 YR 5/6), slightly calcareous, moderate fine blocky, few roots, none biological activity, few Fe and pale mottles, diffuse boundary
Cv (23-30 cm+)	Deposited materials.

Table A.6.1 : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-23	23-30+
Particle size distribution(%)		
S/Si/C (textural class)	44/36/20 (L)	n.d.
Coarse fragments	37	n.d.
pH($CaCl_2$)	6.9	
$CaCO_3$ (%)	0.3	
Organic matter (%)	1.0	
"plant avaible"		
P (mg/1000g).	10	
K (mg/1000g)	50	
Mineralogical composition (%)		
Quartz	44	
Muskovite	28	
Plagioklase	5	
Potash feldspar	3	
Chlorite	1	
Dolomite	-	
Calcite	-	
Gypsum	tracers	
Sum	81	

Mapping of vegetation: 6th August 2005.

Sowing: 200.

Covering degree: 70%, grass species: 31%, herbs: 1%, legumes: 38%.

Number of species: 28, and a high covering degree.

For this reason this site is protected against erosion and suitable for pasturage.

Grass species	
Agrostis capillaris	1a
Agrostis stolonifera	+

Carex hirta	+
Cynosurus cristatus	1a
Dactylis glomerata	1
Festuca pratensis ssp. pratensis	1
Festuca rubra agg.	1
Lolium perenne	2b
Phleum pratense	1
Herbs	
Cirsium palustre	R
Leucantheum vulgare agg.	R
Lysimachia nummularia	R
Plantago lanceolata	+
Potentilla anserina	+
Potentilla reptans	r
Ranunculus acris ssp.acris	R
Ranunculuis repens	R
Rumex abtusifolius	+
Taraxacumm officinale agg.	r
Tussilago farfara	+
Tripleurospermum inodorum	+
Legumes	
Latyrus pratensis	+
Lotus corniculatus	2a
Medicago lupulina	+
Trifolium hybridum	2
Trifolium pratense	+
Trifolium repens	2a
Vicia cracca	+

r… solitary, with small cover,
+…..(pronounced cross) few, with small cover,
1…..numerous, but less than 1/20 cover, or scattered, with cover up to 1/20 of the reference area (<5%),
1a with cover between 1.0-1.9%
2 …any number (of individuals), with cover between 1/20 and ¼ of the reference area (<5-25%)
2a…
2b covering degree 2.0-3.9%.

LITERATURE:

Ch. BAUER, Ch. (2005): Untersuchungen über die zeitliche Entwicklung von Vegetation und Boden, dargestellt an den Begrünungsmaßnahmen im Gipsbau der Fa. Knauf am Pyhrn/Oberösterreich. Diplomarbeit an der K.-F. Universität Graz.

Furth: The Geological Study Trail

This Geological Study Trail begins in the Zellergraben; this is a defile with a depth until 12 m. On the walls of it we can study the Loess-Stratigraphy of the Krems region.
On twelve Aluminium board are described origin and entities of loess, extension of the glaciers during the ice ages, origin of terraces, soil genesis during the warm times, settlement by the men in this region, and the development of flora and fauna.
A few titles: Climate as ride on the big dipper – What is loess ? – Genesis of loess and distribution of ice – Loess-stable and sensible – Danube terrace and loess profile – Tracks of ice-age hunter – Loess and its wines – Bloom splendour in the Zellergraben – What you can find in the loess ?.

LITERATURE:

KRENMAYR, H. G., M. BRÜGEMANN-LEODOLTER, M. Geologische Bundesanstalt, Wien.

Soil profile Pottenbrunn (1CH/A – 7), Lower Austria: Haplic Luvisol (Siltic)

Site characterisation: Jounger Cover Gravel, terrace.

Location: 287 m asl, brick pit 2 km in the North of Pottenbrunn (St. Pölten).

Climate: warm temperate climate with semi-humid conditions

Mean annual temperature	Mean temperature at 2 p.m. from April to August	Mean number of vegetation days	Mean annual precipitation
9,5°C	21°C	245	700mm

Relief: flat, 1° WNW.

Landuse: arable land, stubble field after wheat.

Soil profile description:

AEp (0-30 cm)	Silt loam, medium content of organic matter, moist: brown (10 YR 4/4) slightly calcareous, moderate crumbly, common roots, common biological activity, plowpan, clear boundary
Bt (30-60 cm)	Silt loam, moist: brown (10 YR 4/6), slightly calcareous, strong blocky subangular, firm, very few roots, few biological activity, few Fe and Mn mottles, common coatings, diffuse boundary
C (60-100 cm+)	Silt loam (loess loam), moist: yellowish brown (10 YR 5/8), strongly calcareous, strong blocky angular, firm, few Fe and Mn mottles, very few roots.

Table A.7.1 : Soil physical, chemical and mineralogical analyses.

Horizon (cm)	0-30	30-60	60-80			
Particle size distribution (%) C/Si/S (textural class)	27/67/6 (SiL)	36/58/6 (SiL)	17/69/15 (SiL)			
Dry bulk density	n.d.	n.d.	n.d.			
Total porosity (%):	n.d.	n.d.	n.d.			
Saturated water conductivity	n.d.	n.d.	n.d.			
pH ($CaCl_2$)	6.0	7.0	7.7			
$CaCO_3$ (%)	<1	<1	19			
Electric conductivity	n.d.	n.d.	n.d.			
Organic matter(%)	2,5	0	0			
Ntot	n.d.	n.d.	n.d.			
C/N-ratio	n.d.	n.d.	n.d.			
Corg						
"plant avaible" P CAL(mg/kg) K CAL (mg/kg)	 62 193	 <18 57	 <18 <50			
CEC_{eff} ($cmol_c.kg^{-1}$, $BaCl_2$) Ca ($cmol_c.kg^{-1}$, %) Mg ($cmol_c.kg^{-1}$, %) K ($cmol_c.kg^{-1}$, %) Na ($cmol_c.kg^{-1}$, %) Base saturation	16,0 11.9 (75) 3.3 (21) 0.7 (4) <0.1 100	23.5 17.2 (73) 6.0 (26) 0.3 (1) <0.15 100	17.5 13.8 (79) 3.4 <0.25 <0.15 100			
Total contents in aqua regia	n.d.	n.d.	n.d.			
Pedogenic Fe-Oxides	n.d.	n.d.	.d.			