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Guidebook Tour C

Soils and Landscapes in the Alps
Switzerland and Austria

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Part II AUSTRIA

Foreword

The joint excursion of the Swiss Society of Soil Science and the Austrian Society of Soil Science following the Congress of the International Society of Soil Science in Hamburg is entitled "Through the Alps from Switzerland to Austria". Its aim is to afford an impression of the many soils and related landscapes, and also of the utilisation problems, in the Alpine regions of both countries.

The main theme of the excursion is the effect of elevation and exposure on soil formation above different substrates in Alpine regions, and is illustrated by visits to a number of stations.

The various stations have been selected for their relevance to current work or previous research findings and are intended to provide material for discussion.

A large number of people have been involved in the research work, the presentation of the findings, and the preparations for the excursion. Through their intensive efforts in the field, in the laboratory, and in the office they have all contributed to the smooth running of the preparations.

We hope that the route and stations we have selected will give participants an opportunity of getting to know the Alps in all their beauty more closely, and we extend a warm welcome to all.

Peter Lüscher (BGS/Switzerland)
Othmar Nestroy (OeBG/Austria)

General Programme

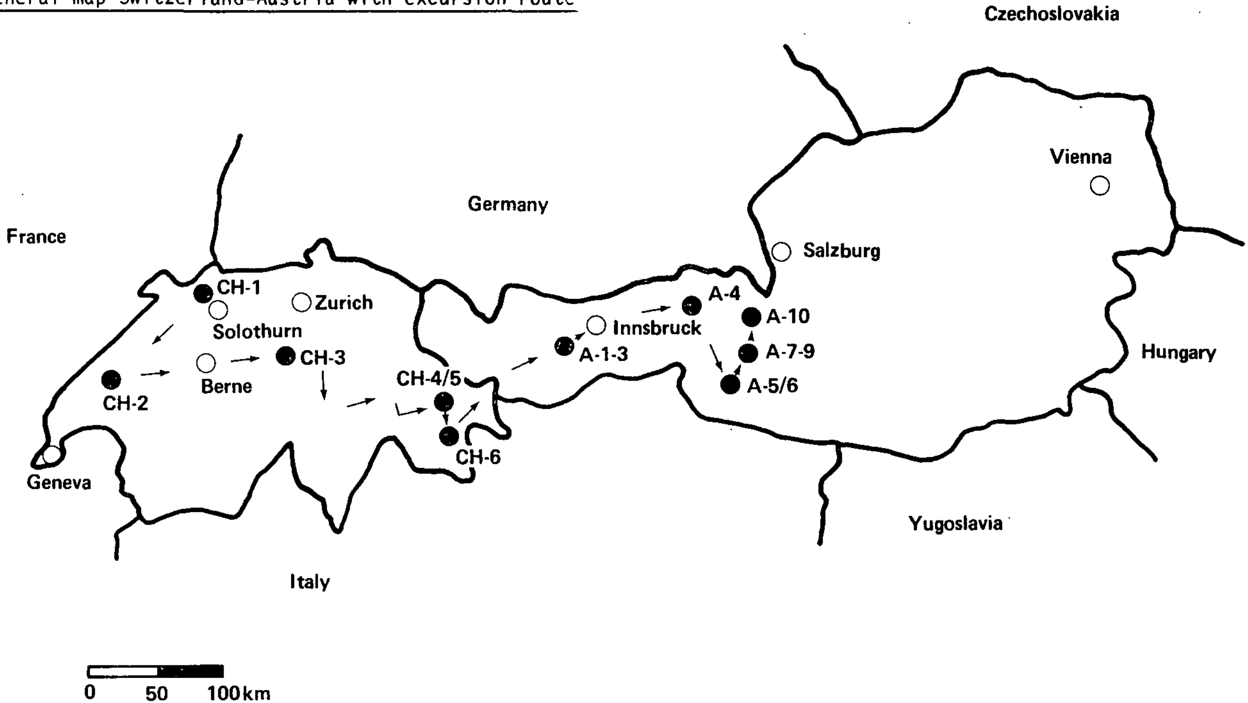
Switzerland (21/22-25.8.86)

Thursday	21.8.86	Transfer from Hamburg to Switzerland (Solothurn)
Friday	22.8.86	Station CH-1, Schitterwald, Weissenstein, SO
		Station CH-2, Chassagne, Orbe, VD
Saturday	23.8.86	Station CH-3, Guberwald, Schwarzenberg, LU
		Selection forest and protected forest
Sunday	24.8.86	Station CH-4, Gotschnagrat, Klosters, GR
		Station CH-5, Delenwald, Davos, GR
Monday	25.8.86	Station CH-6, Muottas Muragl, Pontresina, GR
		Transfer to Austria through the Engadine

Austria (26-29.8.86)

Tuesday	26.8.86	Stations A-1, A-2, A-3, Haiming
Wednesday	27.8.86	Station A-4 Oberndorf
		Station A-5 Döllach
		Station A-6 Senfteben
Thursday	28.8.86	Station A-7 Fallbichl
		Station A-8 Hochtor
Friday	29.8.86	Station A-9 Rossboden
		Station A-10 Maishofen

General map Switzerland-Austria with excursion route



Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 48, 9-13, 1986

THE ALPS

by Th. Mosimann*

The Alps constitute a unique, clearly demarcated, and amazingly 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 greatest 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.

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Tectonically, the Alps are a young mountain range. They form part of the immense fold system that includes the Atlas Mts. in North Africa, and the mountains in southeastern Spain, the Pyrenees, the Apennines, the Dinaric Alps, the Carpathians, the Caucasus, the Pontine Mts., and the Taurus Mts. 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. 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). Further characteristics of the Alps are found in the pre-Alpine trough: the flysch deposits in the north dating from the main phase of folding, and the sandstone deposits and huge gravel fans of molasse laid down later. In general terms, then, the Alps can be divided into several units, each having its characteristic composition.

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/yr and more) falls on the northern margins and the main ridges, while the heaviest in the Alps as a whole (400 cm/yr 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 as low as 1800 m. 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 northernmost 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 throughout 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.

The Alps were long ago invaded by man and were already inhabited in prehistoric times. Since they are so narrow, they undoubtedly experienced what is, for a mountain range, a heavy amount of traffic from earliest times. During the Roman era, for instance, the passes were highly frequented, while the epoch of the migration of nations saw the Teutons penetrating and spreading through the mountains. The Alps constitute at once a barrier and a communication route between Central Europe and the Mediterranean. Since the Middle Ages the different regions of the Alps have undergone various political developments, from which the present national boundaries have gradually evolved. That has also naturally given rise to cultural and sociological differences. As in all mountainous regions, the isolation of the valleys has led to the development of particular indigenous cultures. In the Alps this diversity is perhaps most clearly manifested in terms of language: within the Alps as a whole there are four official languages and countless dialects, the linguistic boundaries by no means coinciding with political ones. The cultural and linguistic differences are by far most pronounced in Switzerland.

Despite their apparent diversity, however, the cultural lanscapes of the Alps have many features in common, particularly in the heart of the mountains, where natural conditions channel human activities. Alpine settlements can be divided into three main groups: those in the valleys which are occupied the year round; those on the intermediate pastures at altitudes up to 1500 m which are normally only inhabited during late spring and early summer; and those at very high elevations (up to 2500 m) which are occupied only during high summer. In many cases settlements are located according to exposure. Traditional farming was governed by the demands of self-sufficiency and accessibility for mule-trains. Alpine farming is, in the nature of things, basically dairy farming. In the days when self-sufficiency was essential, grain cultivation was also very important, but in the past decades it has become far less so, although it is still carried on up to altitudes around 2000 m in the dry inner alpine valleys. In some areas transhumance continued to be a major factor until well into this century.

The main settlement areas within the Alps are, of course, the major valleys. This is especially true of the main longitudinal valleys such as the Val d'Isère and the valleys of the Rhone, the Rhine, the Inn, etc. Large settlements are also found in the transverse valleys opening onto the main passes. Within the Alps proper there are only a few sizeable towns (Grenoble, Innsbruck, Bolzano). Today the largest and most important settlements are situated along the base of the Alps or in the foothills (Turin, Lyons, Geneva, Lausanne, Berne, Zurich, Munich, Salzburg, Milan and other north Italian cities, Udine, Graz, and Vienna). Settlements in the Alps tend to be concentrated in particular valleys or along ribbon developments rather than round individual centres.

With the onset of industrialisation in the nineteenth century, and above all with the advent of the railways, the Alps entered a new era. In the latter half of the century north and south were connected by 6 main railway lines, which are still very important today, and numerous secondary and feeder lines were built. For the first time it became possible to cross the mountains within a few hours. In more recent times, road construction has been no less intensive, and today there are a number of motorway connections and road tunnels.

In many valleys the economic situation has changed drastically within the past few decades. Industrialisation is concentrated in particular valleys and still tends to be localised. One far-reaching development has grown from the increasing demand for electricity since the First World War. Countless hydro-electric power stations have been built and today produce over 200×10^9 kilowatt hours a year. In many areas almost all the available water is used for electricity, and in some valleys the power corporations, apart from the railways and the tourist industry, are the only major source of employment.

The tourist industry is by far the most important branch of the Alpine economy. Tourism actually began in the middle of the past century and at first developed only slowly, so that the existinq structures could easily absorb it. Only with the growth of mass tourism after the '50s did the situation change drastically. In many areas the number of overnight visitors has increased more than tenfold, while numerous other areas have been opened up for the first time. This has resulted in a corresponding development of the infrastructure. Today the ski areas extend to the nival zone and some of them are open the year round. Consequently, tourism today constitutes not only a major branch of the economy but also an unprecendented ecological stress for the high mounains. Just like all other mountain ranqes, the Alps form a very delicate ecosystem. What has to be done now is to bring the manifold technical and economic changes of the past few decades into balance with the natural conditions.

Switzerland

21/22 - 25.8.86 Swiss Society of Soil Science

BGS
SSP

Swiss Society of Soil Science

Contents

Introduction and Acknowledgements

The first part of the excursion (Switzerland, 21/22 - 25.8.86) takes us through the major topographical regions of Switzerland: the Jura (CH-1), the Swiss Mittelland (CH-2), the northern pre-Alps (CH-3), and the Central Swiss Alps (CH-4 to 6). The stations to be visited are specific but nonetheless typical for each of these regions, especially in terms of soil types and utilisation. Each cases focusses on a particular topic:

CH-1 Weissenstein, SO, Station Schitterwald: Water regime and structure of a stony rendzina soil.

CH-2 Orbe, VD, Station Chassagne: Soil formation and water regime in a luvisol.

CH-3 Malters-Schwarzenberg, LU, Station Schitterwald: Soil, ecological conditions, and tending of forest.

CH-4 Klosters, GR, Station Gotschnaboden: Soil formation on dolomite with raw humus.

CH-5 Davos-Wolfgang, GR. Station Delenwald: Dynamics of chromium and nickel in a soil on serpentine.

CH-6 Pontresina, GR, Station Muottas Muragl: Soil formation above timberline.

We are indebted to members of the following institutions for their help in the preparations for this part of the excursion: Swiss Federal Institute of Technology, Zurich; Swiss Federal Institute of Technology, Lausanne; Geographic Institute of the University of Basle; Swiss Federal Research Station for Agronomy, Zurich-Reckenholz and Nyon-Changins; Swiss Federal Institute of Forestry Research, Birmensdorf. The authorship of the various articles and commentaries is given on the respective title pages. We would like to express our warmest thanks to all concerned. A special acknowledgement is due to the Swiss Academy of Sciences for its financial support. We are grateful to Mrs. M. J. Sieber for translating and editing the English texts.

We hope that the excursion will prove successful, and on behalf of the Swiss Society of Soil Science we extend a warm welcome to all.

Peter Lüscher

Programme (21/22 - 25.8.86)

Except for scheduled departures of mountain railways and cable cars, the times given here are tentative, but to prevent hitches we hope to keep to the timetable as closely as possible.

A general map of Switzerland showing the excursion route can be found in the following section.

Thursday 21.8.86	c. 17.00	Arrival in Solothurn, hotel registration
	17.30	Welcoming speeches, sightseeing tour, orientation on the excursion, supper
Friday 22.8.86	07.45	Departure from Solothurn
	08.45	Arrival on the Weissenstein (with commentary on the landscape if the weather is clear)
	09.45	Schitterwald (CH-1)
	11.15	Return to Solothurn, transfer to Orbe along the foot of the Jura via Grenchen, Biel, Neuchâtel, Yverdon (packed lunch in coach)
	14.00	Arrival in Orbe, Chassagne (CH-2)
	16.00	Departure; via Yverdon, Estavayer, Avenches, Murten to Berne (short sightseeing tour, possibly supper). Continuation via Langnau, Wolhusen to Schwarzenberg
Saturday 23.8.86	08.00	Departure from Schwarzenberg
	08.15	Guberwald (CH-3), with visits to and commentary on local forest forms - selection forest management
	10.15	Departure to Lucerne, Altdorf
	11.00	Visit to the protected forest of Altdorf
	12.30	Continuation via Gotthard motorway (N2) to Göschenen, Andermatt
	13.15	Lunch in Andermatt (hotel)
	14.30	Continuation via Oberalp Pass to Vorderrhein Valley, Disentis, Ilanz, Bonaduz, Thusis, Tiefencastel, Davos (arrival c. 17.45, hotel registration)

Sunday	08.00	Departure to Klosters
24.8.86	08.45	Cable car to Gotschnagrat (as far as midway station Gotschnaboden)
	09.15	Gotschnagrat (CH-4); commentary on landscape and soil station
	11.15	Walk or cable car to Wolfgang
	12.30	Lunch in Hotel Kulm, Wolfgang (Davos)
	14.00	Walk to station Delenwald (CH-5)
	c. 17.00	Return from Wolfgang to Davos (arrival c. 17.15); supper
Monday	07.45	Departure to the Engadine via the Flüela Pass,
25.8.86		Susch, Zernez, Zuoz, Samedan to the lower station of the Muottas Muragl mountain railway
	09.30	(or 10.00) mountain railway to Muottas Muragl (CH-6)
	10.30	Commentary on landscape if the weather is clear; visit to soil station.
	12.45	Lunch in mountain restaurant Muottas Muragl
	14.00	Return with mountain railway to lower station
	14.45	Departure to Martina via Samedan, Zuoz, Zernez, Susch, Schuls (with brief stops and commentary on the landscape of the Lower Engadine)
	17.00	Continuation to Imst (Tyrol) in Austria

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PHYSIOGEOGRAPHIC FEATURES OF THE LANDSCAPES ALONG THE TRANSECT "JURA - GOTTHARDGEBIET - CHURER RHEINTAL - ENGADIN"

by Thomas Mosimann*

1 Introduction

Starting at the border of the Jura Mountains and going eastwards to the Engadin, there is an immense wealth of landscape types within a distance of only 250 km (as the crow flies). The main reasons for this great variety are varying types of rock, substrata and relief forms as well as several different belts between altitudes of 400 and 4'000 m above sea level combined with mountain chains divided into fine structures. This variety may hinder the familiarity with the regional structures and functions of the Swiss Alps and their borderlands, but it is also a challenge: a clear sequence - presented more or less like a model - of landscape types may be established here within a relatively small region. In order to clarify the various impressions which will be met during the excursion, a spatial background is needed. This paper aims at giving the reader a framework in term of rock types, morphogenesis, climate, soils and their relevant vegetation; in particular, the main features of the landscape types, transversed during the excursion, are discussed. In order to give a short and clear description, some simplifications have been made and certain singularities, variations and aspects of no pedologic interest have been neglected.

2 Tectonics and Types of Rock

Switzerland is characterized by the following five main geotectonic units: Rhine Graben (the most northwesterly region of Switzerland, surroundings of Basle), the Tabular Jura, the Folded Jura, the Molasse Basin (Mittelland) and the Alps. The Alps cover more than half, the Molasse Basin about a quarter, of the surface area of Switzerland. Both are tectonic as well as geomorphologic landscape types which clearly influence the main features of Switzerland (see Fig. 1).

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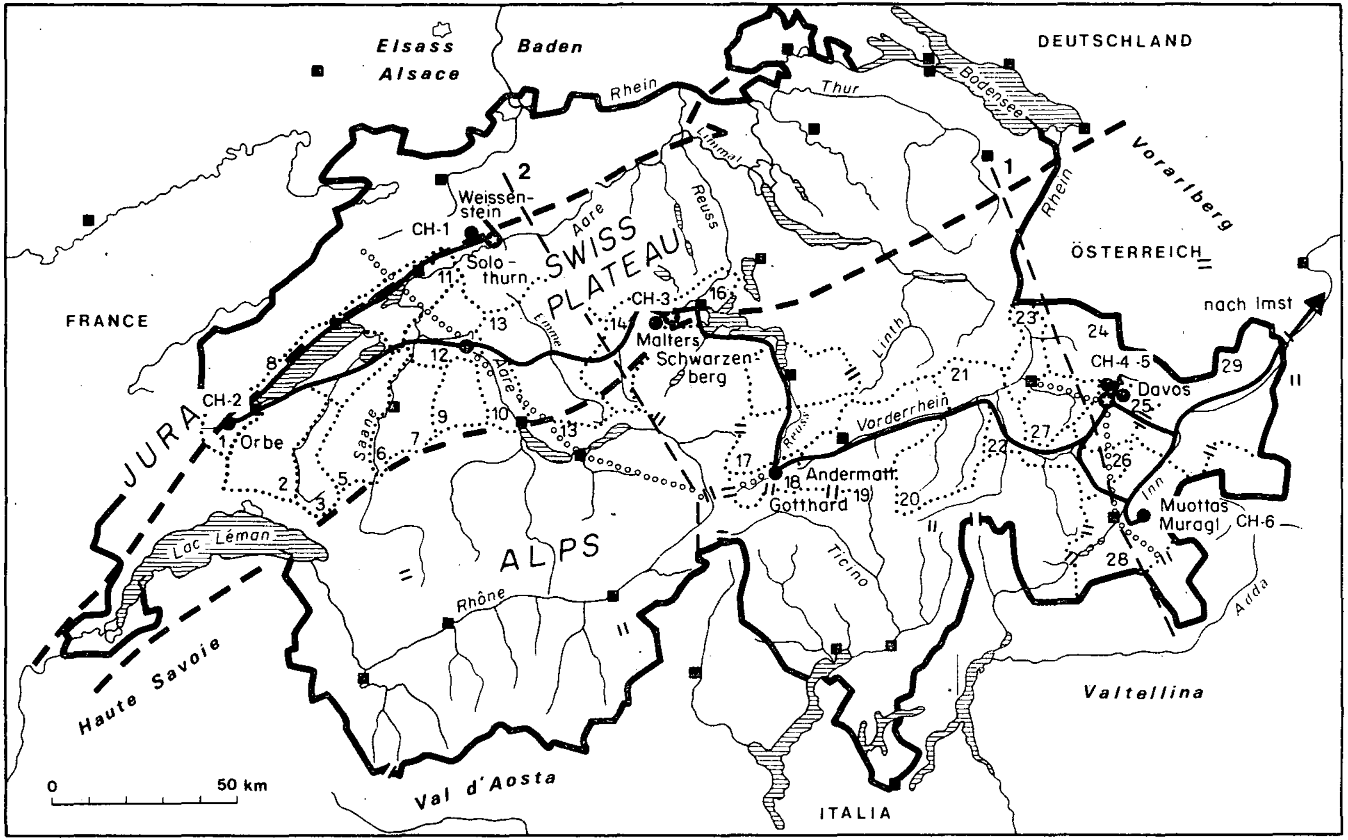
Elsass
Alsace
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DEUTSCHLAND
Rhein
Thur
Bodensee
Limmat
Reuss
Vorarlberg
Rhein
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FRANCE
Weissen-
stein
CH-1
Solo-
thurn
SWISS
PLATEAU
Aare
CH-3
Malters
Schwarzen-
berg
Linth
CH-4 -5
Davos
Vorderrhein
CH-2
Orbe
JURA
Saane
Emme
Andermatt
Gotthard
Inn
Muottas
Muragl
CH-6
Lac Léman
ALPS
Rhône
Ticino
Adda
Haute Savoie
Val d'Aosta
ITALIA
Valtellina
0
50 km

General map of Switzerland with main landscapes and landscape units along the excursion itinerary

All geographical names in original language.

II	important pass
▬ ▬	borders of main landscapes
⁘	landscape units
oooooo	approximate line of the clima-profile (Fig. 2)
— —	approximate line of the tectonic profiles (Fig. 1)
●	stop (soil profile)
CH-1	Station Weissenstein SO, Profile Schitterwald
CH-2	Station Orbe VD, Profile Chassagne
CH-3	Station Schwarzenberg LU, Profile Guberwald
CH-4	Station Klosters GR, Profile Gotschnaboden
CH-5	Station Davos GR, Profile Delenwald
CH-6	Station Pontresina, Profile Muottas Muragl
✪	overnight stop
▬▬	itinerary

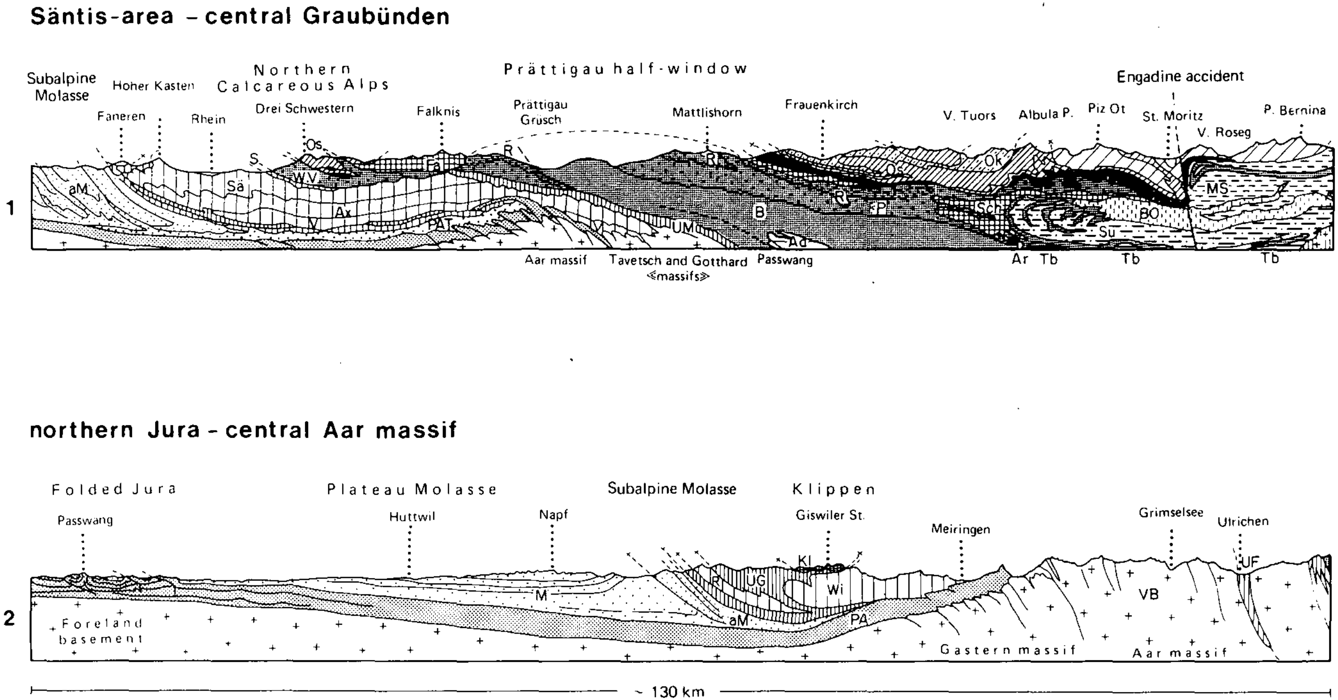
1 subjurassic plateau
2 Joratplateau
3 upper Broye
4 lower Broye
5 western Freiburger Plateau
6 Saane-valley
7 Sense-region
8 southern foot area of Jura mountains
9 Schwarzenburg-region
10 Aare-valley between Thun and Bern
11 Lake region
12 Bern and Frienisberg-Rapperswiler-plateau
13 Emme-valley
14 Entlebuch
15 Stanser Boden
16 region of Luzern
17 Uri
18 Urseren
19 Surselva
20 Lugnez
21 Flims and Rhein-valley between Rhäzüns and Chur
22 Domleschg
23 Rhein-valley near Chur and "Bündner Herrschaft"
24 Prättigau
25 Landschaft Davos
26 Albula-valley
27 Schaufigg and Lenzerheide
28 upper Engadine
29 lower Engadine

From the tectonic point of view Meso-Europe is a young formation and the forces from which the Rhine Graben and the young folded mountains and nappes originate, are still active today. The subsiding movement of the Rhine Graben began only in the early Tertiary epoch, the climax of the orogeny of the Alpine massif took place in the Oligocene, and the folding of the Jura Mountains began at the transition from the Miocene to the Pliocene. The actual tectonic movements (subsidence of the Rhine Graben, orogenesis) amounts to one cm per year. The relatively frequent local earthquakes - especially in the northern part of Switzerland and in the Alps - are an important indicator of the continued activity of the different earth crust layers.

Fig. 2 clearly illustrates the tectonic units of the areas visited during the excursion. The crystalline basement complex was strongly deformed and subjected to metamorphoses. This crystalline basement crops out in the region of the Central Alps because of the long-term erosion of the formerly overlying nappes. Northwards the Helvetic nappes override the Alpine basement complex; within the Molasse Basin they are covered by molasse sediments followed by the Jura Mountains, thus being able to crop out again only at the "Hochrhein", at the northern border of the Tabular Jura. The various overlying nappes are 7'000 m thick, and even thicker in the Eastern Alps.

The half-moon-shaped Folded Jura reaches from Baden near Zurich to the Rhone Valley (outermost limits: Geneva and Lyon). Because of its fairly low altitude (up to 1'700 m) it must be spoken of as a "low mountain range". The Jura (breadth varies from a few km to 70 km) shows a clear middle Jurassic to Early Cretaceous stratigraphy.

A big sedimentation basin, the Molasse Basin (termed "Mittelland"), lies between the Jura Mountains and the Alps. From the times of the Alpine orogeny onwards eroded materials accumulated in this basin. The actual thickness of the molasse sediments - where thickness decreases from S to N - may reach 4'000 m, the most frequent being about 2'000 to 2'500 m. The molasse mainly consists of sandstone, nagelfluh (hardened conglomerates of gravel from large river deltas), marl and clay. Normally it has been slowly folded and has built up plateaus which are transected by large valleys filled with accumulations of glacial sediment. In the region of the Alpine borderlands the molasse is intensively folded, sliced and no longer flat-lying, but now steeply inclined. This modification (during the excursion it will be encountered E of Thun) is termed the subalpine molasse and is supposed to be a residual of a nappe.



aM	Subalpine Molasse	Ok	Upper Austroalpine (Basement)	UF	Urseren-Garvera Zone
Ax	Axen nappe (Helveticum)	Os	Upper Austroalpine (Mesozoic)	UG, UM	Ultrahelvetic nappes
b	Triassic and Bundnerschiefer (Penninicum)	P	Flysch of Prättigau-Oberhalbstein (Penninicum)	V	Verrucano nappes (Helveticum)
BO	nappes with Bundnerschiefer and ophiolites (Penninicum)	PA	Autochthonous and Parautochthonus (sediments) (R = Ruchberg sandstone)	VB	Variscan basement
Fa	Falknis-Sulzfluh-nappe (Penninicum)	S	décollement sheats of Helveticum	Wi	Wildhorn nappe (Helveticum)
Kl	Klippen nappe (Penninicum)	Sa	Säntis nappe (Helveticum)	Wv	Wägital-Flysch (Penninicum)
M	Molasse ("Nagelfluh" and Sandstone)	Sch	Schams-nappe (Penninicum)		
MS	Margna nappe (Penninicum)	Su	Suretta nappe (Penninicum)		

Fig. 1 Tectonic profiles through the northern and central part of the Swiss Alps and the foreland
(Source: Atlas der Schweiz, 1972, slightly simplified sections)

The tectonic structures of the Alpine nappes are very complicated. Nevertheless some typical main units can be distinguished, some of which are characterized by typical rocks. The following tectonic units are important with reference to the excursion route (see also Fig. 2):

tectonic units	location	typical rocks
"Klippendecke" (Reuminikum) and ultrahelvetic flysch	"stomach" between E Lake of Geneva N Lake of Thun and Lake of Lucerne	flysch (narrow sequences of clayey marl, sandstone and coarse conglomerates), limestone, marl
helvetic Calcareous Alps	a band about 15-25 km wide between Diablerets and Säntis	limestone and marl
Massif of Aare and Gotthard	Central Alps between Lötschental - Jungfraugebiet - oberes Reusstal - Surselva - Gotthard - Goms	gneiss and granite
East of the massif of Aare and Gotthard	Grisons between Rätikon and Hinterrhein	schist, flysch, limestone, marl
nappes of the eastern Alps	Davos - Albulatal - Engadin	in additon: paragneiss, dolomite, amphibolite

3 Relief and Morphogenesis

The main units of relief coincide with the tectonic units. The Jura Mountains, the Molasse Basin, and the Alps have their own typical multiple relief features. In general, the following four main process-groups have formed the landscape types of Switzerland: glacial, periglacial, fluvial and karst. The Jura mountains are characterized by various karst forms and periglacial slope formations. Glacial forms and young valleys predominate in the Molasse Basin. A "fine-limbed" fluvial relief is typical for the Alpine borderlands in the region of the subalpine molasse (e.g. "Napf", "Hörnli"). In the Alps glacial forms which have been modified by fluvial processes and mass-slidings during the last 10'000 years, after the retreat of the Wurmian glaciation are dominant.

The excursion route only traverses regions which have been covered by glaciers in former times. Therefore, the main geomorphological forms are glacial ones; consequently the following descriptions are restricted to glacial morphogenesis.

For the region of the Alps, four main quarternary glaciation periods are known to have occurred, and there may have been a fifth and a sixth in the early and middle Quarternary. The glaciation sequence begins with the Gunz glaciation, about 1 mio years BP, followed by Mindel, Riss and Wurm. The great retreat of the Wurmian glacier ceased about 12'000 years BC. During each of the major glaciation periods the Alpine glaciers intruded far into the Molasse Basin and smaller local glaciers were formed in the higher Jura Mountains, in the Black Forest etc. The most extensive glacial advance took place during the Rissian glaciation during which glaciers overran the whole Molasse Basin and even advanced into the "Hochrheintal". The terminal moraines of the Wurmian glaciation can be found between Solothurn and Olten (Rhone glacier), S of Baden (Reuss glacier), in the valleys of the Limmat and the Glatt (Linth glacier) and around the Lake of Constance (Rhine glacier). Most of the glacial relicts within the Molasse Basin are of Wurmian age.

The Molasse Basin is characterized by various forms of moraines. The retreat of the Wurmian glaciers did not take place continuously; it was interrupted several times and even some periods of advance are known to have occurred. Therefore, sequences of terminal- and lateral moraines are typical for the formerly glaciated regions with their large glaciers and numerous side-branches and lobes. During the excursion some of the different retreat phases of the Aare glacier will be encountered: e.g. "Gurten-Baniger" phase, "Bern" phase, "Wichtrach" phase, "Strättligen-Thun" phase, "Krattigen-Thun" phase). Fine-limbed, hilly, undulating ground moraine regions can be seen everywhere in the Molasse Basin. The glacial series of the Molasse Basin would not be completely described if kames, drumlins and boulder fields (linked with moraine sediments) were not mentioned. Molasse ridges and plates as well as gravel fields of Rissian age are overlain in part by a 1 - 3 m thick ground moraine cover.

All alpine valleys have been modified by large glaciers, which, however, at the beginning of the glaciation epoch flowed along existing tectonic weakness lines and tectonic border zones, a phenomenon which finds its clear expression in the two large longitudinally orientated valleys of the Rhone and the "Vorderrhein". The typical relief shape of the alpine glacial valleys (in the excursion e.g.: "unteres Haslital", "Hochtal Urseren", "Vorderrheintal" and "Rheintal" near Chur) is the trough. These troughs, however, are often not developed in their classical forms, because the partly not very resistant types of rocks were extensively modified (e.g. by development of gravel) in the following non-glacial period, or because different types of rock on either slope of the valley favoured an irregular shape. A typical feature of the alpine valleys is the sequence of several valley-steps, especially at the head of the valley (e.g.

"Haslital"). These valley steps generally occur at junctions with side-valleys (sudden increase in ice-depth, junction of glacier masses).

In the Alps the following glacial forms dominate: cirques, striated uncovered rocks (termed "Rundhöcker") and moraines. The Grimsel is a good region to study all kinds of such striated rocks, as areas where the glaciers traversed passes are rich in classically shaped glacial forms. Incidentally the recent glaciers are also rich in young moraines. Notably clear sequences of different phases of moraines can be found in the glacier forelands exposed by the glacial retreat following the most recent glacial advance of 1850/60. (On the excursion route e.g. the young forelands of the Rhone glacier and of the Morteratsch glacier).

4 Climatic Features

From the climatical point of view Switzerland belongs to the "cool-temperate" zone at the transition from the sub-oceanic to the subcontinental type. The mean annual temperature (reduced to sea-level (0 m) amounts to about 10.5 °C in southern Middle Europe. There is precipitation throughout the year; maximum monthly precipitation falls during the summer months. Dry periods lasting one month (Northern Alps) or longer (Southern Alps) are rare. Although these climatic features describe the general position of Switzerland within its climatic belt, they by no means characterize the Swiss climate. It is obvious that in a country where the altitudes above sea-level range from 193 m (Lake Maggiore) to 4'634 m (Dufourspitze, Monte Rosa Gruppe) there is a great variation in the characteristic climatic features. The Alps, the main climatic barrier, influence the climate of their forelands as well as of their hinterlands. The Molasse Basin can be considered as an almost closed climatic basin. The following regional phenomena are also important factors of the Swiss climate: föhn, pools of cool air in the Molasse Basin, Swiss bise, systems of mountain wind and valley breeze in the alpine valleys.

Switzerland can be divided into seven main climatic regions (SMA, 1978): 1. Southeastern part of the Jura Mountains and northern foothills of the Jura Mountains. 2. Southwestern part of Switzerland. 3. Central and eastern part of the Molasse Basin. 4. Northern foothills of the Alps. 5. The Valais. 6. The Grisons, southern valleys excluded. 7. Southern part of Switzerland. The excursion covers regions no. 2, 3, 4 and 6. It is obvious that a detailed description of these regions would go beyond the scope of this paper. Nevertheless Fig. 3 shows the altidudinal variation of those climatic values which are of pedological interest. The profile in this figure, which is also valid for the excursion route, illustrates the following points:

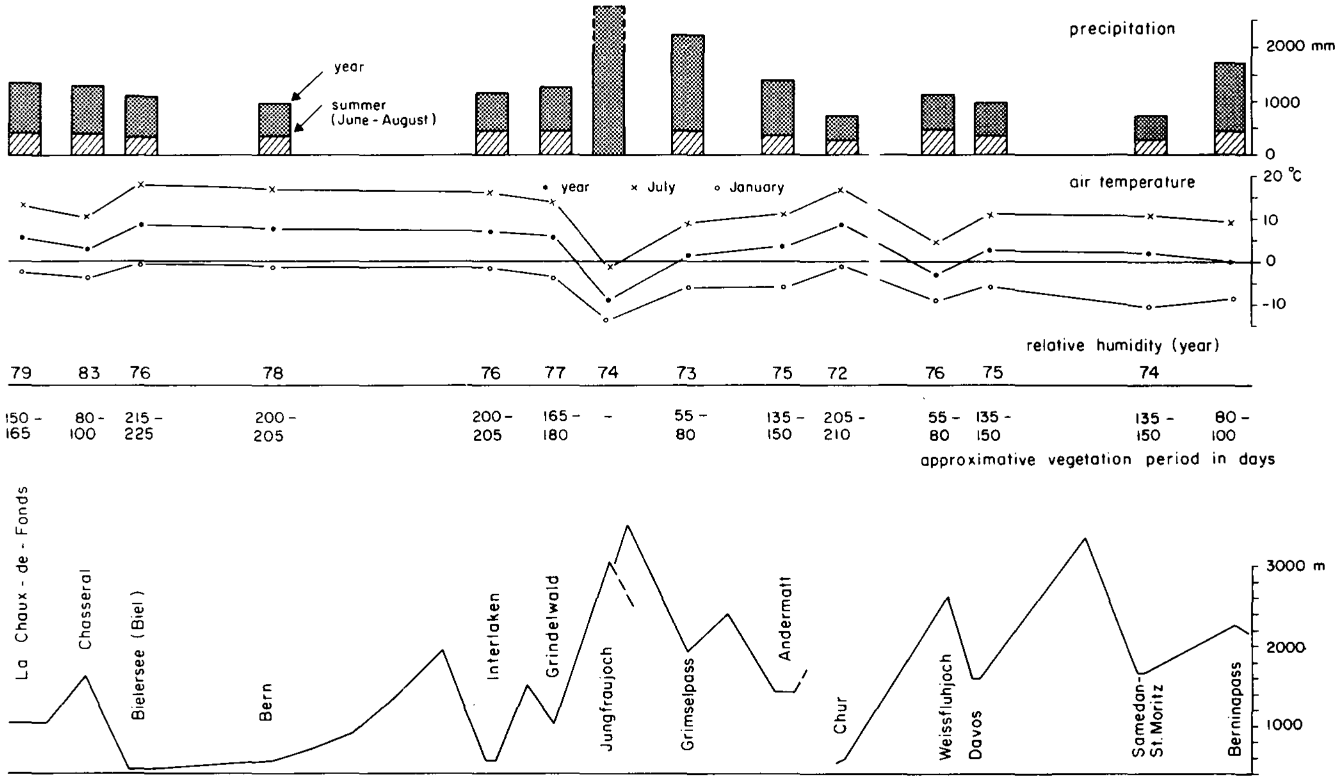


Fig. 2

Climatic features of the transect Jura-Gotthard-Engadin

Precipitation

The mean annual precipitation amounts to 1'000 - 1'200 m in the Molasse Basin, 1'800 m in the Alpine borderlands and, in some cases, to 2'000 m in the Alps. Precipitation depends on the one hand on the altitude (m above sea-level), on the other hand on the position of the region within the alpine massif (compare the values for Interlaken, Grindelwald, Andermatt and Chur, Davos, Samedan-St. Moritz). The influence of the Alps on the amount of precipitation is much more distinct in the northern part of the Alps, as the NW-SW winds are forced to get deposit precipitation by the alpine barrier ("Steigungsregen"). In the inferior part of the Alps and especially in the valleys, however, there are many climatic islands characterized by low precipitation. The most extreme situation with reference to this phenomenon occurs in the central Valais, which will not be visited by the excursion.

Temperature

In Switzerland the average abatement of the temperature amounts to 0.55 °C/100 m. Depending on the position, mean annual temperatures of 0° C or below occur in the inferior part of the Alps or in the borderlands above 2'000 - 2'200 m. The altitudinal decrease in temperature is smaller in winter than in summer, as cold air often gathers in lowlands and the sun only warms the regions above the inversion layers (low stratus at 700 - 900 m). In addition pools of cold air are characteristic for high alpine valleys (and depressions of the higher Jura Mountains). Their influence on temperature can clearly be seen in the example of the Engadin (see station Samedan-St. Moritz in Fig. 3). The valleys of the Southern Alps are warmer (about 2° C) than those of the northern alpine borderlands. Due to the ascending gradient of mass effects ("Massenerhebungseffekt") the temperature increases from the alpine borderlands to the inferior parts of the Alps, as can be seen by studying the course of the altidude isopleths (Fig. 5).

5 Soils

Due to the great variation in rock, climate, and relief, the soil pattern of Switzerland is highly differentiated. Besides all types of carbonate and silicate rock, many frequently occurring characteristic light substrata serve as important parent materials in which soil formation took place. The main light substrata of the Jura Mountains are periglacial loam on slopes ("Hanglehm"), debris mantles and debris of all kinds. In the Molasse Basin ground moraines and debris

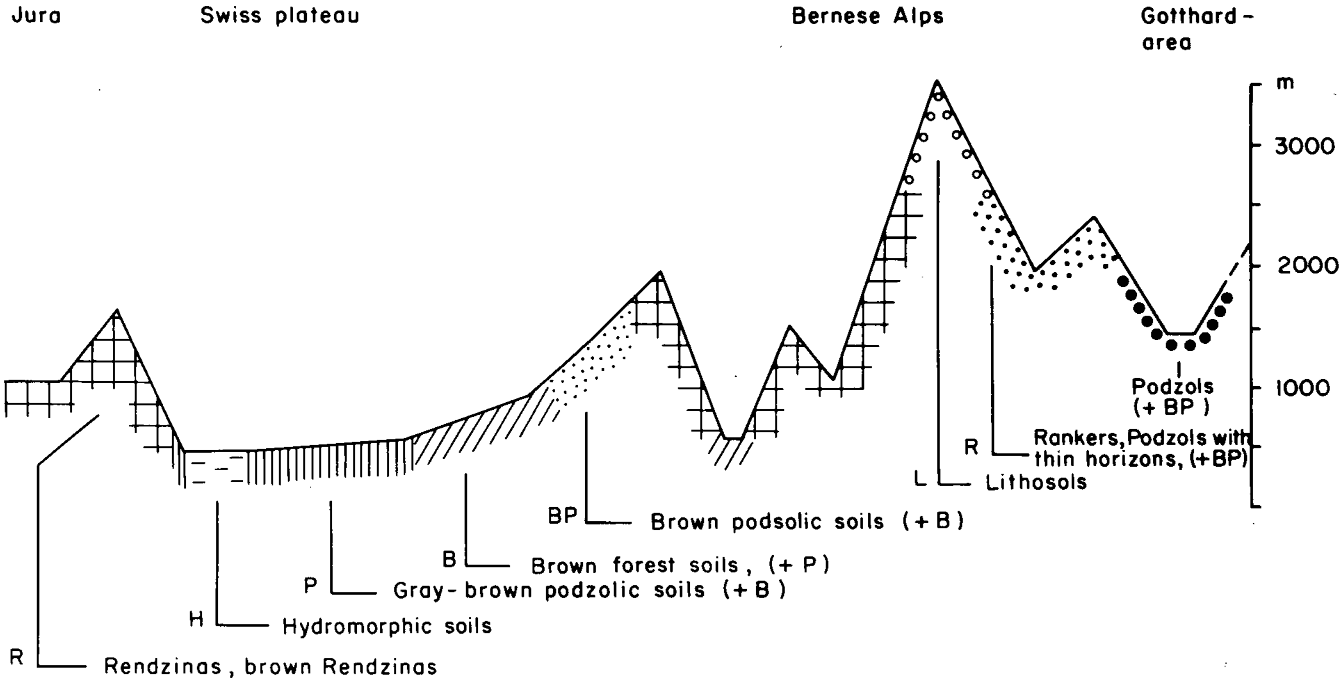


Fig. 3

Transect Jura-Gotthard and principles of soil type pattern
(basis: soil map of Switzerland, Atlas der Schweiz)

accumulations dominate, in the region of the "Seeland", marshes are typical, too; different types of moraine and alluvion in the valleys are characteristic for the Alps.

Fig. 4 shows a simplified profile of soil types from the Jura Mountains to the Central Alps (reference: Soil Map of Switzerland 1:1'000'000, by E. FREI, P. JUHASZ and R. BACH 1966). It is obvious that there is a close connection between the range of these soil types and that of the rocks and substrata: rendzinas can be found in the Jura Mountains and in the northern calcareous Alps, "Parabraunerden" are developed on ground moraines and debris within the Molasse Basin, "saure Braunerden" and "Parabraunerden" are found on ground moraines and Molasse substrata in the higher parts of the Molasse Basin and on alpine valley floors, "Braunerden" with a tendency to podsolisation as well as wet soils ("Pseudogleye") in the alpine borderlands and different types of podsols, "Braunpodsols" and "Ranker" in the alpine crystalline region. The profile Molasse Basin-Alps clearly documents the influence of the climate on the formation of soils. Due to the increasing amount of precipitation and the decreasing temperature the climate becomes more humid. Therefore, the tendency towards podsolisation in noncalcareous rocks increases with increasing altitude. In the alpine borderlands, where the weathering of flysch produces a lot of clayey material, wet soils can frequently be found. The large number of raised bogs in the higher parts of the Jura Mountains and the alpine borderlands (above 800 m), where the climate is cooler and more humid, is characteristic for these regions. Due to the different climates of the Jura and the Alps, the rendzinas of both regions have their own characteristic features: in the Jura Mountains "Mull-Rendzines" and especially "verbraunte (brownish) Rendzines" which are rich in fine material, and "Braunerde-Rendzines" as well as "Mergelrendzines" dominate, whereas in the northern Alps "Moderrendzines" which are superficially acid, and in the higher parts even rendzinas with thick layers of raw humus (so called "Tangelrendzines") are the typical soil types. In the crystalline region many of the podsols have been degenerated to "Braunpodsols" through alpine husbandry in the forest and dwarf shrub belts.

6 Vegetation

Fig. 5 shows the main vegetation belts of Switzerland and clearly illustrates the altitudinal zonation, especially at higher elevations. The main limiting factor for vegetation growth is temperature (esp. warmth). The above mentioned pattern of the vegetation belts is the result of the increase in temperature

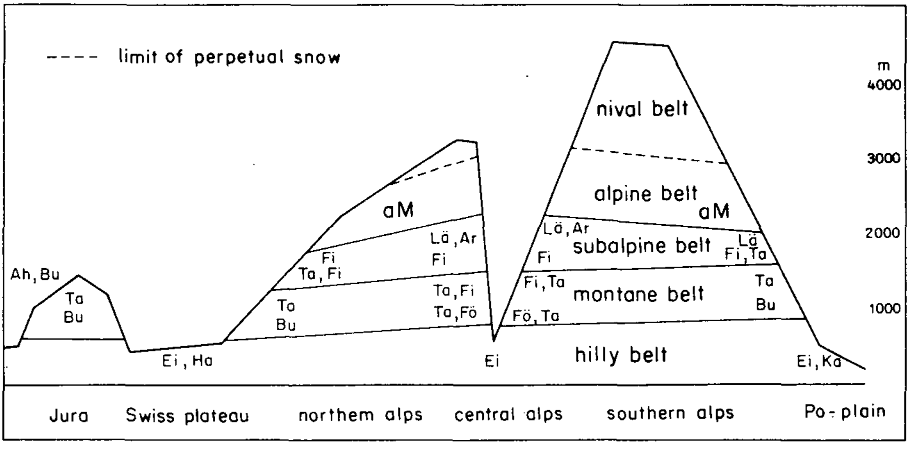


Fig. 4

Vegetation belts (source: H.E. HESS, E.LANDOLT & R.HIRZEL 1976)

Ah = maple
Ar = Arolla pine
Bu = beech
Ei = oak
Fi = spruce
Fö = pine
Ka = sweet chestnut
Lä = larch
Ta = silver fir

due to the ascending gradient of the mass effects ("Massenerhebungseffekt"). The forest limit, the most important vegetation borderline, rises from about 1'700 - 2'000 m in the exterior chains of the Alps to about 2'400 m in the Valais.

The main features of the different vegetation belts are as follows:

belt	vegetation type	utilization
colline belt	north: oak-hornbeam mixed forest at warmer sites also pubescent oak forest, in "dry regions" Scots pine south: oak mixed forest, sweet chestnut forest	arable farming fruit culture (in part special crops, vegetable culture, vine)
montane belt	beech forest, beech-silver fir forest, silver fir forest, in the Central Alps also Scots pines	grass culture some arable farming and fruit culture
subalpine belt	spruce forest, larch-Arolla-pine forest (Central Alps: mountain pine forest, dwarf shrubs (especially towards the alpine belt), green alder shrub association	meadow and pasture
alpine belt	alpine meadows (Curvuletum Elynetum, Seslerietum, Firmetum and so on), "Schuttflora" (vegetation units on debris mantles) towards the subalpine belt dwarf shrubs	alpine husbandry

Below the natural forest limit Switzerland was completely wooded until Neolithic times, marshes and rock sites excluded. Human activities (shifting cultivation) lowered the forest line further and further until the 19th century. Nowadays about 25 % of Switzerland is wooded, the main part of the forests occurring in the Alps and the Jura Mountains. Almost "natural" forests can be found in the montane and the subalpine belts. The actual forest limit lies about 500 m below the potential one due to the extension of alpine husbandry.

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WATER REGIME AND STRUCTURE OF A STONY RENDZINA-SOIL

STATION CH-1, PROFILE S C H I T T E R W A L D

by Lüscher,P.+, Buchter,B.++, Richard,F.+++, and Flühler,H.++++

1 General information

1.1 Location

The profile Schitterwald is located on the northern slope of the first ridge of the Jura (Weissenstein) in the canton of Solothurn.
Map (1:25 000) no. 1107 Balsthal
Coordinates: 603 600/234 200 Altitude: 980 m a.s.l.

1.2 Climate

It is difficult to find a meteorological station really comparable in terms of altitude and exposure. Precipitation data are taken from Weissenstein (1285 m), Gänsbrunnen (735 m), and Herbetswil (524 m). Long-term temperature data are obtained from the SMA stations at Solothurn and Weissenstein (Fig. 1). Mean annual precipitation on the north-facing slope of the first Jura ridge considerably exceeds that of the Mittelland. Temperatures are also influenced by the exposure, being markedly lower than at similar altitudes on the southern flank.

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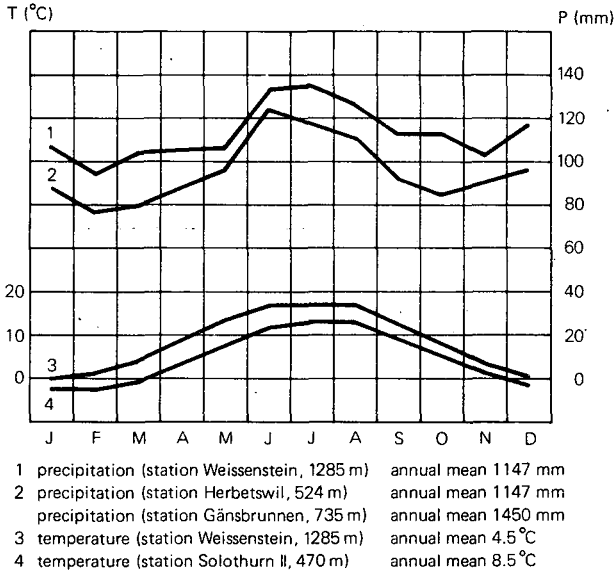

Figure 1 Diagram of the climate: precipitation and temperature

1.3 Geology

A large part of the north flank of the Weissenstein consists of Kimmeridgian malm colluvium (Fig. 2)

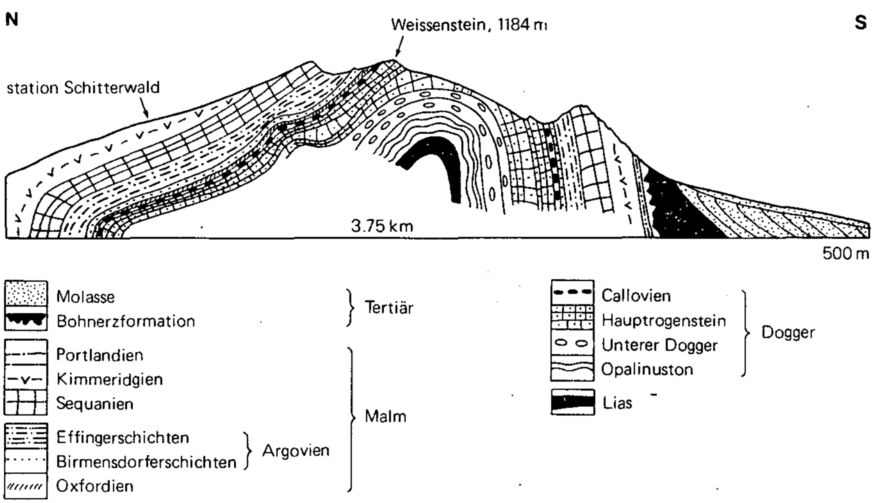

Figure 2 Geological profile through the Weissenstein (Buxtorf, 1936)

1.4 Relief

In the area where this profile occurs the north face of the first ridge of the Jura has a slooe inclination of 35-45%.

1.5 Vegetation

According to ELLENBERG and KLOETZLI (1972), the vegetation here is an Abieti-Fagetum typicum (typical fir-beech forest). The present composition is 90% beech (Fagus silvatica), 10% fir (Abies alba), 80-90 years old.

2 Morphology of the soil profile

L 0-2 cm	Litter from preceding year, mainly beech litter and remains of herbs.
(F) 2-3 cm	Localised patches of litter from previous years.
(Ah1) (2-)3-5(10) cm (only locally)	Most superficial mineral earth horizon with much humus; loose but stable cluster structure; fine soil neutral, calcic usually only near skeletal limestone components; dark brown to black (10 YR 2/1).
Ah2 up to 30(35) cm	Analogous to Ah1, carbonaceous fine soil, content of organic material decreasing with depth, much skeletal material material (50%), sandy clay; brownish black 10 YR 2/2 (3/3).
AhC (30-)35-60(-65) cm	Sandy clay, much skeletal material, polyedral (in part single grain), slightly alkaline, rich in carbonates, dark brown (10 YR 3/3).
Cv1 (60-)65-90(-105) cm	Clayey sand, much skeletal material; polyedral (partly single-grained), slightly alkaline, rich in carbonates; brown (10 YR 4/4), skeleton partly weathered.
C2 (95-)105-150(-200)cm	Analogous to Cv1, yellowish brown (10 YR 5/6), somewhat coarser skeleton, less weathered.
C3 from (150)200 cm	Rock, in part weathered

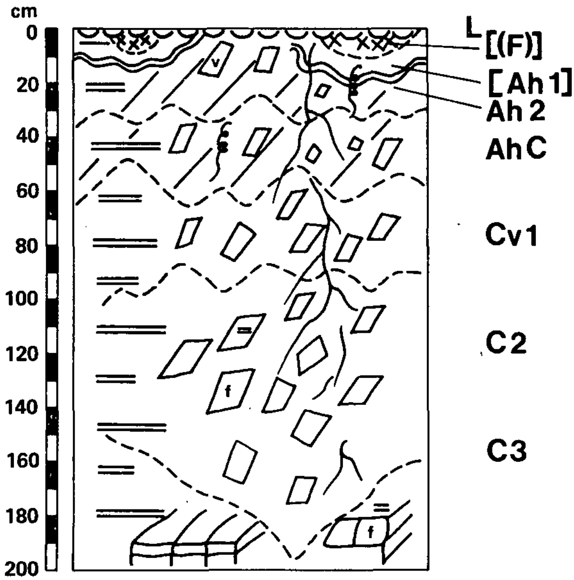

Figure 3 Schematic representation of the profile

3 Nomenclature

CH:	Schwach ausgeprägte kolluviale Rendzina
FAO:	Orthic Rendzina
US Soil Tax.:	"Eutrochreptic" Rendoll (typic)

4 Findings concerning the soil profile

4.1 Physical characteristics

Values for real density range from 2.66-2.69 g/cm^3. The high proportion of skeletal material reduces the volume of soil in the root zone accessible to plant roots for the absorption of water and nutrients. Fig. 4 shows the variation in skeletal material with depth.

Because of the irregular distribution of the skeleton (Fig.5), the distribution of fine soil material in which capillarity is effective is inhomogeneous and anisotropic. In some places the capillary system may be discontinuous.

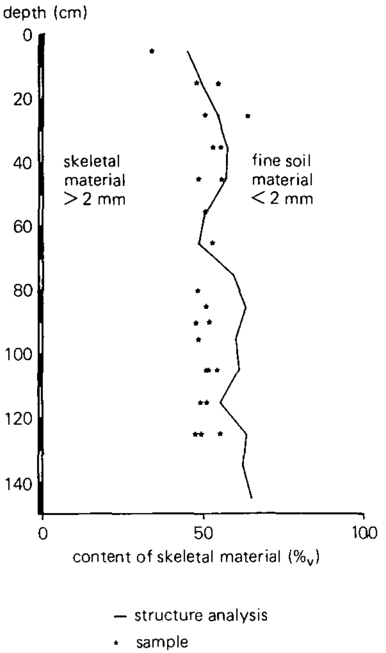

Figure 4 Content of skeletal material

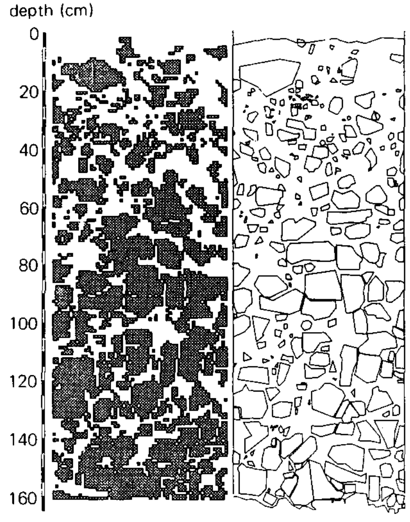

Figure 5 Plan of the skeletal material (>10 mm) after analysis in the field (left) and after analysis of the stereoscopic photo (right) (Buchter, 1984)

The relatively high proportion of large pores results in a high overall permeability in the zone of saturation (Table 1). Even after intensive precipitation or snow melt, the soil is seldom saturated, since the macropores, particularly those at the fine soil/skeleton boundary, allow rapid drainage (see Fig. 6, irrigation trials).

Measurements of hydraulic conductivity in unsaturated soil show that even at moisture tensions of around 30-40 mbar the water flow is as low as 1 cm/d (see Fig. 7).

Moisture tensions close to water saturation may occur in small patches for limited periods. Figs. 8 and 9 show that low moisture tensions (10-20 mbar=1-2 kPa) may occur when transpiration ceases. Percolation through the conducting system of the fine soil takes place mainly at such times (plant dormancy, snow melt, heavy precipitation), assisted by a macropore system through which water rapidly drains to the deeper levels.

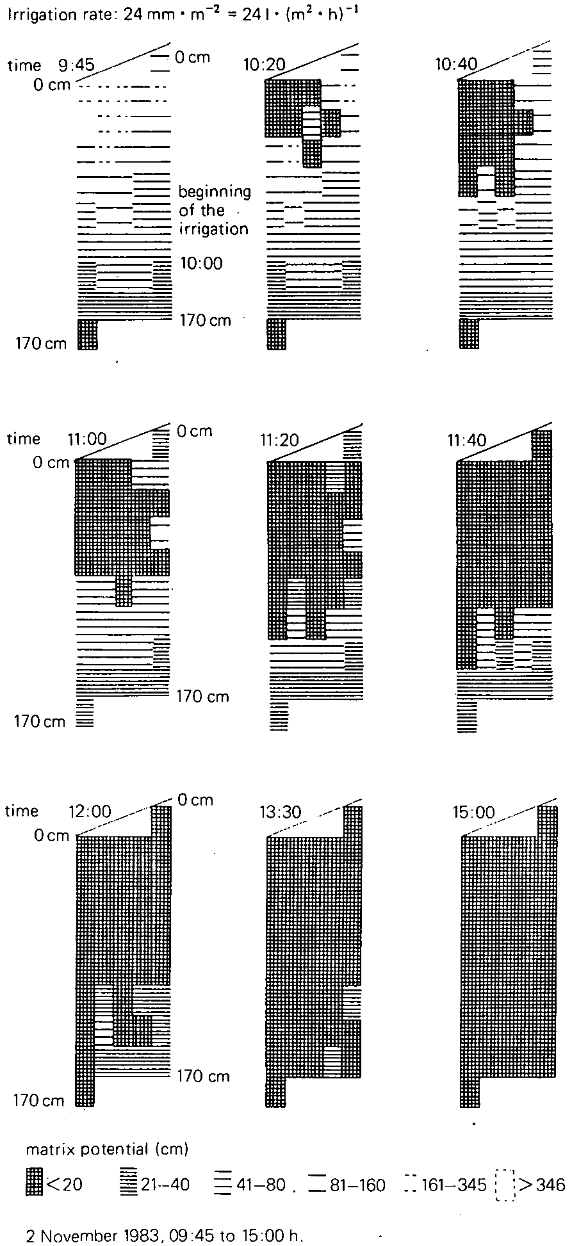

Figure 6 Irrigation trials in the field for the determination of permeability (Buchter, 1984)

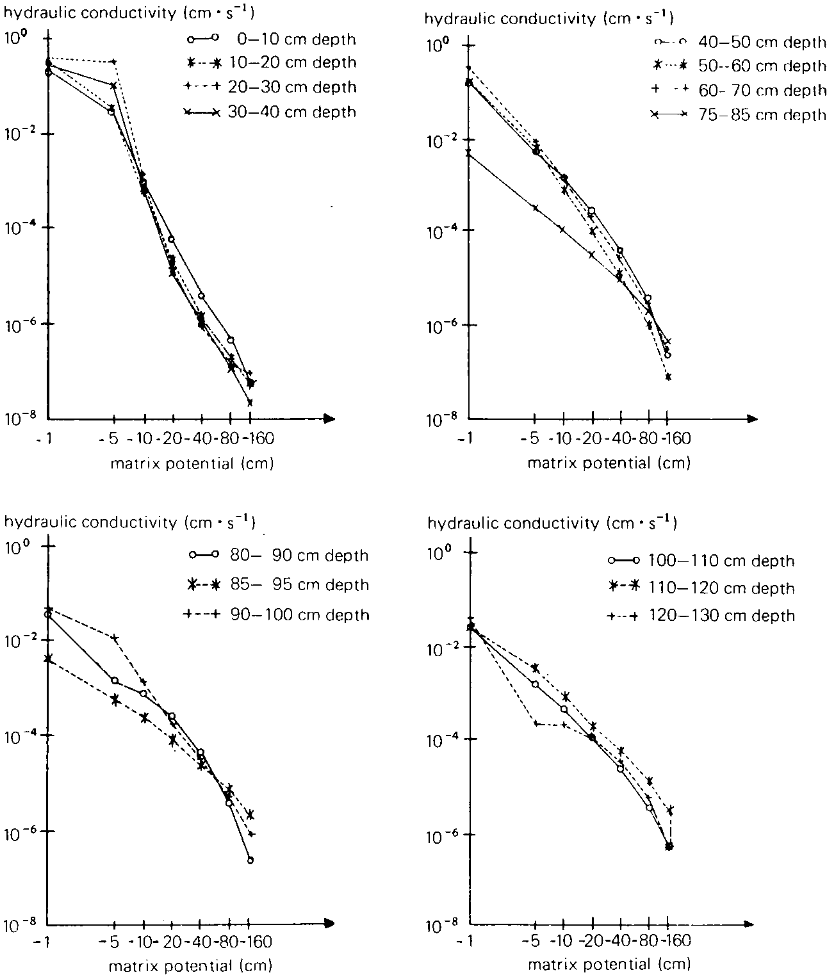

Figure 7 Hydraulic conductivity in unsaturated soil (14 depths) (Buchter, 1984)

In saturated soil of this type, the permeability of the porous, calcareous skeleton displays a k value of around 1-10 x 10^{-7} cm/s, such as may well occur in a soil with low permeability.

Changes in water balance dominate the overall thermal relationships in the soil. For instance, periods of heavy precipitation, such as that at (the end of the vegetation period in 1981, may cause marked and relatively rapid cooling up to 8°C over the whole profile) (Fig. 10).

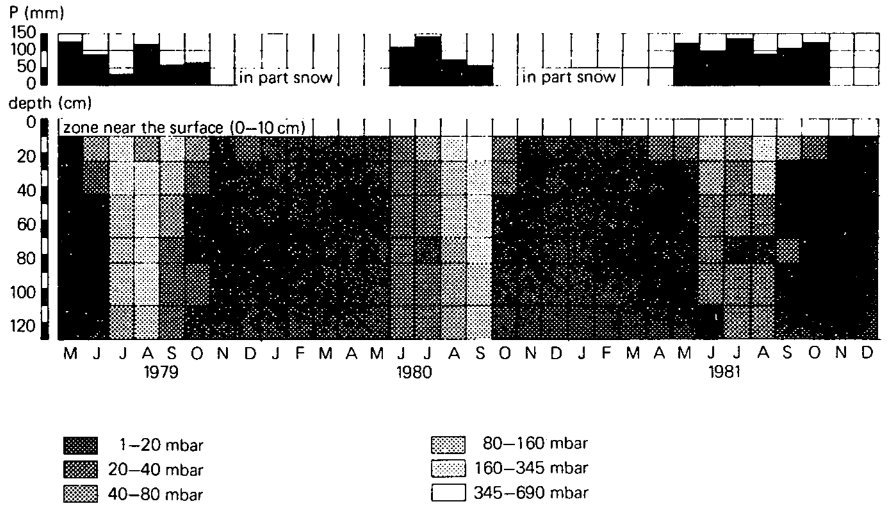

Figure 8 Moisture tension distribution in the soil (May 1979 - December 1981)

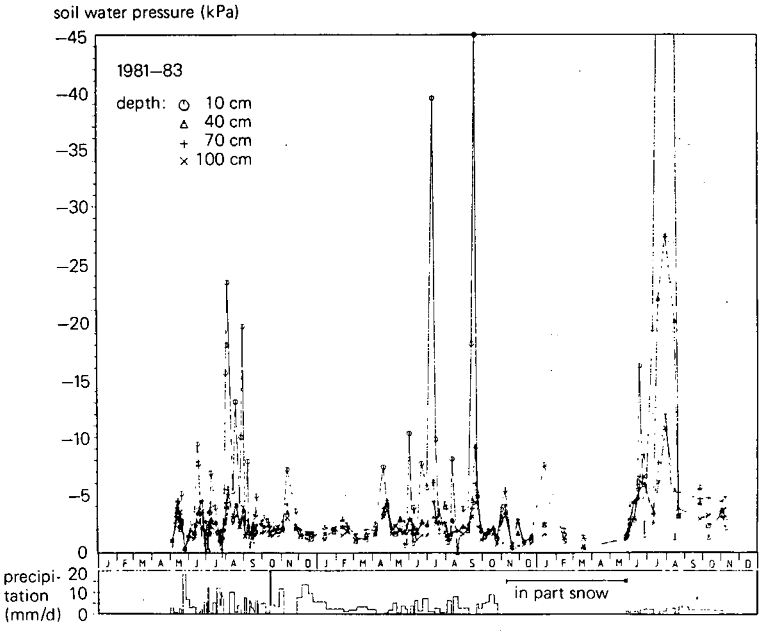

Figure 9 Soil water pressure development and precipitation 1981 - 1983 (Buchter, 1984)

Table 1 Physical and chemical properties of the profile

No	hor.	depth cm	sto. % v	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k sat. cm/d	k sat. cm/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0-30	51	12	6	21	39	18	10	15	43	18	$6,7 \cdot 10^{4}$	$7,8 \cdot 10^{-2}$
2	AhC	30-60	61	-	-	-	40	-	-	-	44	16	$8,3 \cdot 10^{3}$	$9,7 \cdot 10^{-2}$
3	C1	60-95	50 59	18	12	28	58	20	8	8	36	6	$3,3 \cdot 10^{3}$	$3,8 \cdot 10^{-2}$
4	C2	95-150	63	-	-	-	62	-	-	-	30	8	$1,4 \cdot 10^{3}$	$1,6 \cdot 10^{-2}$
5	(C3)	>150	Fig.4	-	-	-	-	-	-	-	-	-	$8,5 \cdot 10^{2}$ Fig.7	$9,8 \cdot 10^{-3}$

No	hor.	bulk dens. g/cm^3	poro-sity E	water content in %v at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fed mg/g	Feo mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	Ah*	0,52	74	67	53	40	27	7,1	6,9	-	3,5	-	$1,2 \cdot 10^{3}$	-
	**	1,41	36	28	18	-	-							
2	AhC*	1,13	57	49	35	27	18	7,7	7,3	-	1,5	-	$0,5 \cdot 10^{3}$	-
	**	1,72	34	19	10	-	-							
3	C1*	1,25	54	46	32	24	15	7,9	7,4	-	1,1	-	$0,3 \cdot 10^{3}$	-
	**	1,81	34	27	17	-	-							
4	C2*	1,30	52	45	29	19	11	8,0	7,5	-	0,8	-	$0,2 \cdot 10^{3}$	-
	**	1,93	29	19	13	-	-							
5	(C3)*	1,32	51	44	32	21	10	-	-	-	-	-	-	
	**	1,97	27	-	-	-	-							

*fine soil **with skeleton

No	hor.	org. %	N_t mg/g	C:N	carbo-nate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ah	19,6	11	17,8	6,6 15,7	807	-	798	2	6	1	-	-	75
2	AhC	2,4	1,5	16	25,8	211	-	210	0,4	0,3	0,7	-	-	90
3	C1	0,9	0,7	-	50,0	159	-	157	0,5	0,2	0,8	-	-	100
4	C2	0,9	0,4	-	59,1	137	-	135	0,7	0,2	0,9	-	-	100
5	(C3)	-	-	-	65,2	-	-	-	-	-	-	-	-	-

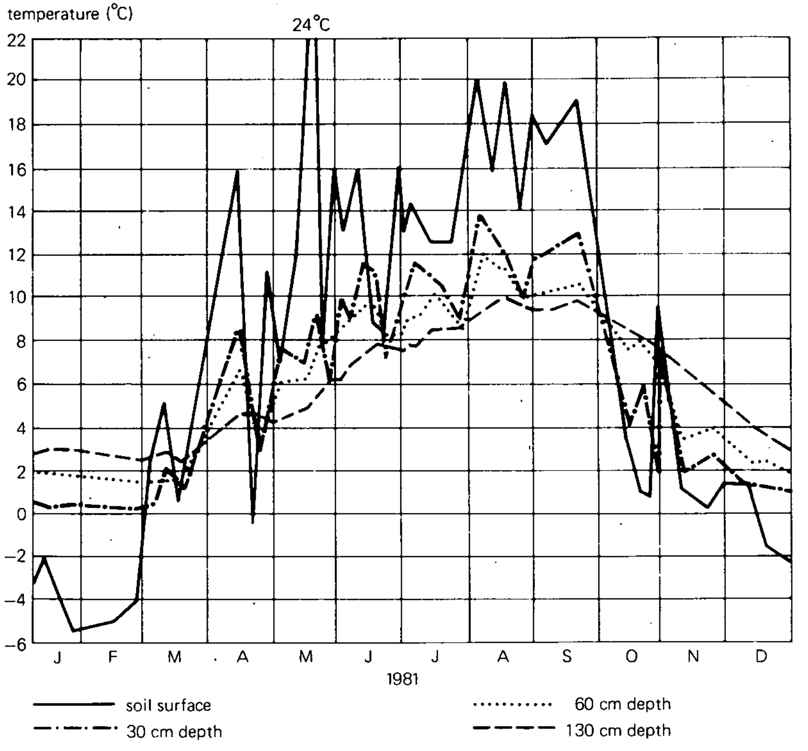

Figure 10 Temperature 1981

4.2 Chemical characteristics

Acidity decreases with depth from pH 7.1 to pH 8.0 (H_2O). Only beneath the patches of fermentation horizon, where the fine soil is without carbonate for some centimetres, does it drop to the slightly acid to acid range.

The Ah horizon contains a high proportion of organic material. In the lower zones of the parent rock, up to a depth of 160 cm or more, the proportion of organic material depends on the degree of root penetration.

The limestone contains 99.41% calcium carbonate and 0.16% magnesium carbonate. The remaining components consist mainly of quartz, kaolinite, mica, traces of feldspar, vermiculite, and oxides of iron.

4.3 Biological characteristics (after Bieri)

Species	Biomass (g/m^2)
Lumbricus terrestris L.	2.40
Lumbricus rubellus Hoffmeister	1.08
Allolobophora caliginosa Savigny	0.10
Allolobophora riparia Bretscher	0.13
Octolasium cyaneum Savigny	5.85
Dendrobaena rubida Savigny	0.03
Various juvenile stages	0.35
Total	9.96 (≅100 kg/ha)
Average count	20.75 individuals/m^2

In this soil, decomposition of litter is mainly carried out by the two Lumbricus species. It is surprising that Allolobophora longa does not occur here, since the high pH at this altitude would be favourable.

5 Silvicultural implications

Only those tree species should be cultivated that require or can at least tolerate a neutral soil and that are deep-rooting, this last feature being important for stand stability. In addition the trees must be able to withstand periodic water shortages in the root zone. The choice of species is also limited by the altitude. The major species of the typical fir-beech forest growing on this type of soil are: silver fir (Abies alba), beech (Fagus silvatica), spruce (Picea abies), and sycamore (Acer pseudoplatanus). Subsidiary species are: wych elm (Ulmus scabra), ash (Fraxinus excelsior), whitebeam (Sorbus aria), and mountain ash (Sorbus aucuparia). Scots pine (Pinus silvestris) and European larch (Larix decidua) may also be cultivated.

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Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 48, 55-62, 1986

LUVISOLS ON MORAINE NEAR ORBE

STATION CH-2, PROFILE C H A S S A G N E

by Gratier, M.+

1 General information

1.1 Location

The Orbe district is situated in the canton of Vaud, at the foot of the Jura mountains and at the southern end of the Lake of Neuchâtel, on map no. 1202 1/25.000.

Coordinates: 528 010/176 720 Altitude: 622 m a.s.l.

1.2 Climatic record

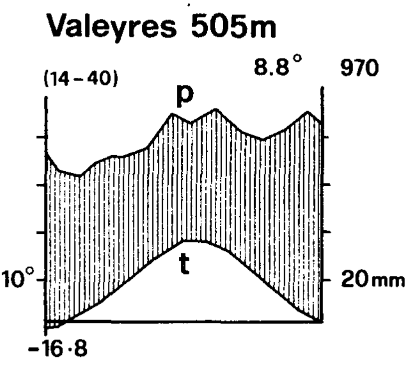

Figure 1 Climatic diagram from VALEYRES s/RANCES (WALTER et LIETH Atlas)

+ Swiss Federal Institute of Technology Lausanne, CH-1015 Lausanne

1.3 Geology

We are situated within the glaciated area of the last glaciation, where soil formation began only after the retreat of the ice sheet, that is about 15,000 years ago. This ice sheet was of alpine origin, as we can see from the petrographic composition of its deposits, but as it stopped at the foot of the Jura during its retreat, kame terrace deposits of mixed petrographic origin (up to 60-70 % jurassic limestone) were laid down.

These deposits are more or less stratified fluvioglacial sands and gravels. Parts of the terraces are of a less gravelly facies which is more like ablation till and in which the proportion of alpine material is a little higher. These differences have had an influence on soil characteristics which we can sum up with 2 profiles as follows:

	ISSS profile	Local form
Facies of moraine deposit	sandy loam till	sandy gravel
Depth of decalcification	90 cm	50 cm
Color of the argillic horizon	7,5 YR	5 YR

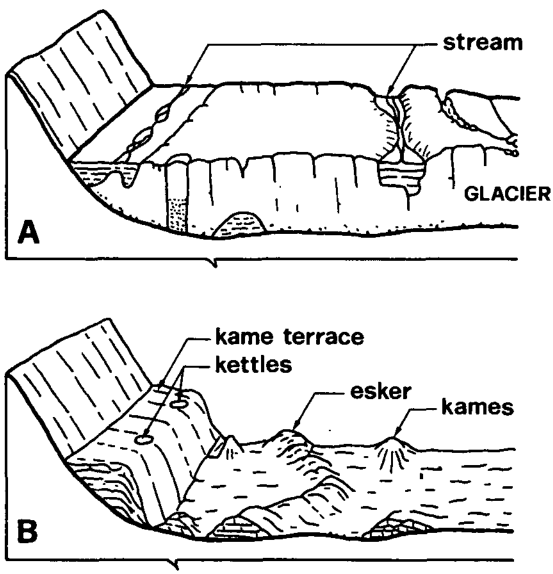

Figure 2 Diagram showing kame terrace deposition (after FLINT 1971)

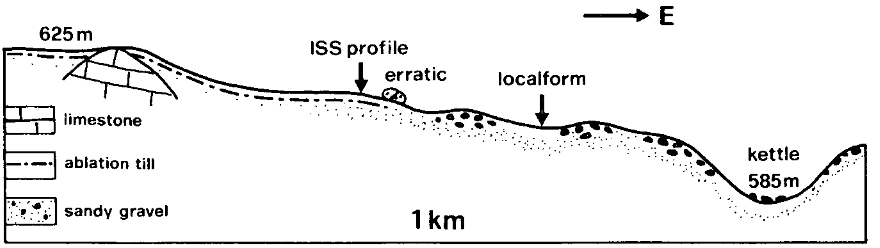

Figure 3 General section in the Chassagne woods near Orbe

1.4 Relief
Slightly convex gentle slope towards SW

1.5 Vegetation
Oak forest belonging to the Galio-carpinetum luzuletosum association.

2 Morphology of the soil profile

Ah	0-2 cm	very dark brown (7,5YR 2/3) fine crumby acid mull somewhat moder-like
A(E)	2-10 cm	transition
(E)	10-25 cm	yellowish brown (10YR 5/6) medium crumby sandy loam with numerous quartz gravels and pebbles at the base of the horizon
(E)Bt	25-55 cm	transition
Bt	55-73 cm	bright brown to reddish brown (7,5YR 5/6) fine subangular loam with various alpine stones, few roots and a few manganic stains. Clay skins are difficult to trace.
BC	73-90 cm	brownish (10YR 3/4) very fine subangular sandy loam with a few limestone pebbles and manganic stains.
C	>90 cm	yellowish (10YR 6/4) medium platy calcareous sandy loam (till), no roots.

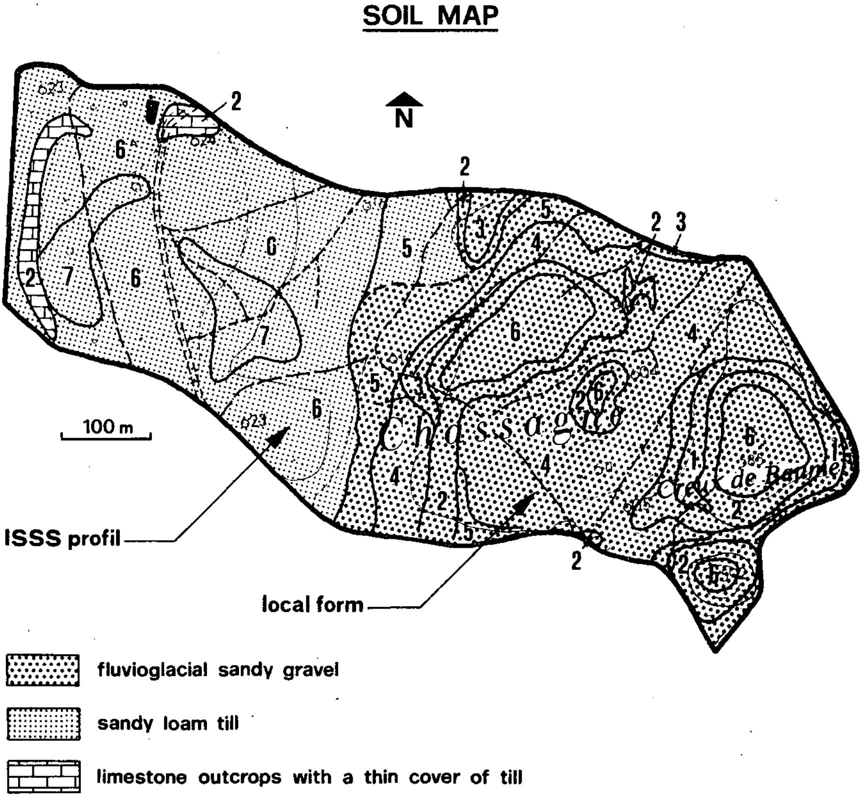

Figure 4 Legend of the detailed soil map of Montcherand scale 1/5000

1. rendzina
2. braunerde, teilweise entkalkt
3. braunerde
4. rötliche parabraunerde (5YR in Bt)
5. saure parabraunerde (7,5YR bis 5YR in Bt)
6. saure parabraunerde (7,5YR in Bt)
7. saure parabraunerde, schwach hydromorph.

fluvioglacial sandy gravel
sandy loam till
limestone outcrops with a thin cover

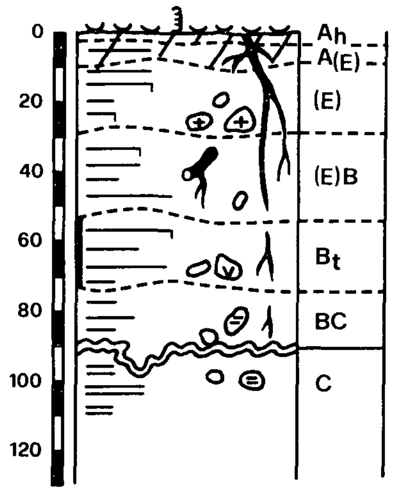

Figure 5 Schematic representation of the profile

3 Nomenclature

CH:	Saure Parabraunerde
FAO:	Dystric Luvisol
US-Taxonomy:	Coarse loamy, mixed, mesic dystreptic Hapludalf

4 Findings concerning the soil profile

4.1 Physical characteristics

The stone content is higher in the parent material because most of the limestone pebbles have been decalcified. Locally stones are concentrated at the basis of the E-horizon. Cumulative grain size curves of fine earth without clay and carbonates from the various horizons show the homogeneity of soil with respect to parent material.

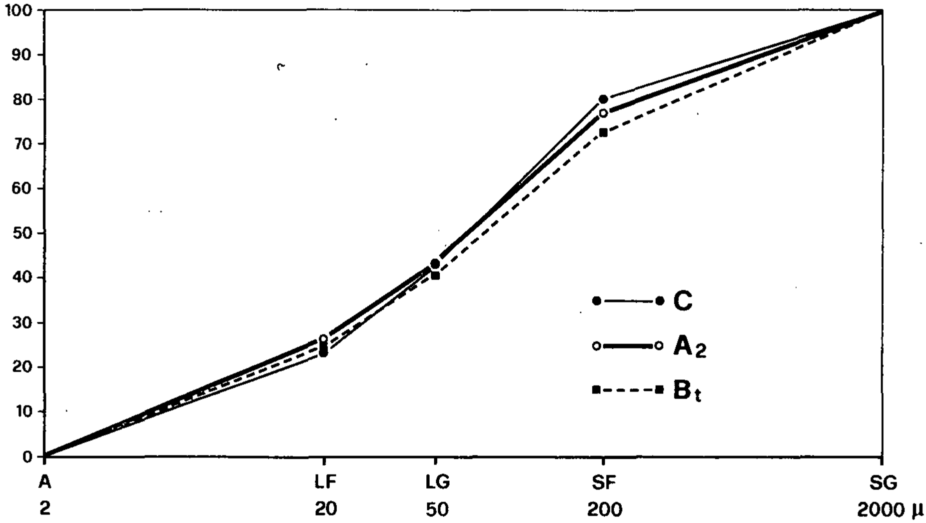

Figure 6 Cumulative grain size curves from various horizons without clay and carbonates showing the homogeneity of soil with respect to parent material

4.2 Chemical Characteristics

The pH values seem abnormally low for such soil because illuviation processes cannot take place under such conditions. We are led to suppose that acidification became stronger after illuviation had taken place. The humus layer is thin, turnover is satisfactory, but acidity prevents deep incorporation. Because the soil is not very thick and moraine contains calcium carbonate, Ca and Mg are dominant ions. Due to biological recycling values are highest in the Ah horizon.

4.3 Mineralogy

In local morainic deposits the clay minerals are dominated by illite which is replaced in soil by chlorite and mixed layers. Feldspar is abundant in the fraction<16μ

Although clay cutans are not easily identified in the field, they have been observed in thin sections.

4.4 Biological characteristics

Worm activity is moderate due to acidity and temporary dryness.

Table 1 Physical and chemical properties of the profile

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	kf cm/d	kf var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Ah	0.2		15.9		27.5	46.4	16.9		23.7	40.6	13		
2	E	2.30	7	19.7		29.4	49.1	14.4		22.7	37.1	13.8	311.6	
3	E(B)	30.55		18.4		28.8	47.2	14.3		20.5	34.8	18		
4	Bt	55.73	17	20		23	43	12.1		18.9	40	27	57.3	
5	BC	73.90		21.5		29.1	50.6	14.7		22.2	36.9	12.5		
	" without $CaCO_3$			17.7		32.2	49.9	16.5		21.2	37.7	12.3		
6	C	>90	30	22.2		26.4	48.6	15.1		27.5	42.6	8.8		
	C without $CaCO_3$			20.5		29.5	50	15.6		20.5	36.1	13.9		

No	hor.	bulk dens. g/cm³	GPV %	water content in % vol. at pf 0.6	1.8	2.5	4.2	pH H_2O	pH KCl	Fe_d mg/g	Fe_{ox} mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Ah							5	4.1	6	1.7	0.28		
2	E	1.65	55	47.6	41.6	24.3	13.9	4.8	3.8	8.43	2.09	0.25		
3	E(B)							4.8	3.6	12.08	2.23	0.18		
4	Bt	1.38	47	52.9	37.7	27.7	14.9	4.8	3.5	21.63	2.71	0.13		
5	BC							7.9	7.1	11.93	1.61	0.13		
6	C							7.9	8.3	4.18	0.4	0.10		

No	hor.	$C_{org.}$ %	N_t mg/g	C/N	$CaCO_3$ %	CEC meq/kg		Exchang. cations in meq/kg: Ca	K	Mg	Na	H ↔ Al		V %
												H	Al	
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	Ah	11.0	5.3	20.7		233	132	113	4.9	12	2.1	5.5		
2	E	1.0	1.1	15.2		69	42	7.9	0.9	2.5	1.6	29.4		
3	(E)B	0.6	0.7			69	50	7.3	0.7	4.9	2.3	34.5		
4	Bt	0.3	0.6			110	77	23.3	1.3	7.0	1.5	44.1		
5	BC	0.5	0.8		4	110	170	163.2	1.1	4.6	1.5			
6	C	0.1	0.4		52.9	110	139	134.7	0.6	2.2	1.8			

5 Silvicultural implications

Although the soil is acid it is not thick enough to prevent the growth of a few calcicolous shrubs.
Sessile oak is well suited to this kind of site. Its quality can be improved once the present day full grown trees (on the stock of old copsewood) has been rejuvenated. Its maximum height is rather moderate, 20-22 m, and productivity in volume is about 5 to 6 m^3/ha and year (4 to 5 m^3 on gravelly soils). Silver fir (Abies alba), a shade-loving species, can easily invade the site but it is not adapted because of the periodical dryness of the air and soil. Here it grows slowly (20 m for 60 years old) and declines at the age of 80.

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Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 48, 63-75, 1986

SOILS, ECOLOGICAL CONDITIONS AND TENDING OF FOREST

STATION CH-3, PROFILE G U B E R W A L D

by Lüscher, P.[+], Richard, F.[++] and Flühler, H.[+++]

1 General information

1.1 Location

The profile Guberwald lies in the commune of Schwarzenberg in the canton of Lucerne.

Map (1:25 000) no. 1150 Luzern

Coordinates: 657 925/206 880   Altitude: 960 m a.s.l.

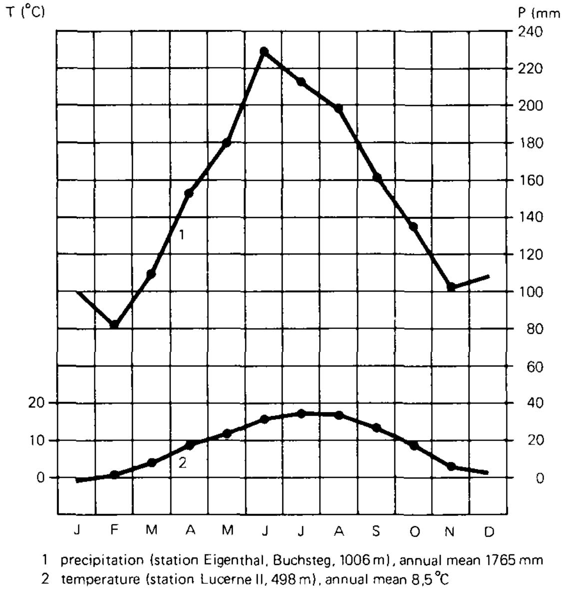

Figure 1 Diagram of the climate: precipitation and temperature

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++ Swiss Federal Institute of Technology Zürich (†1984)

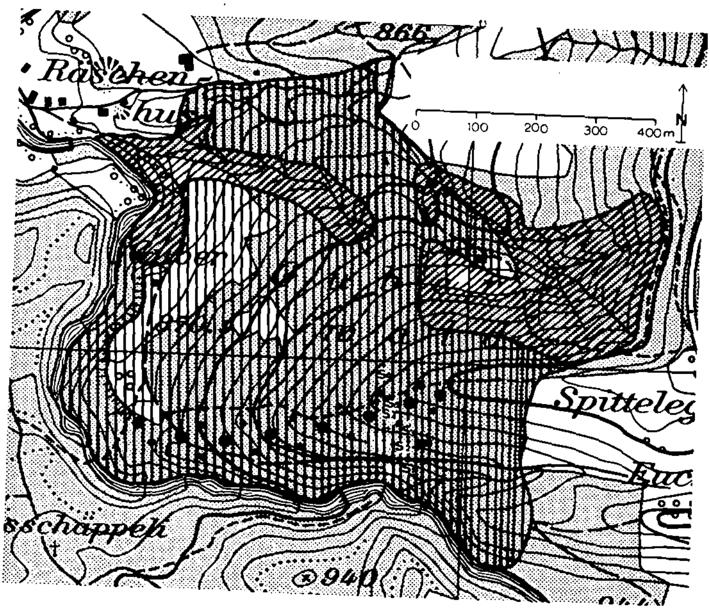
+++ Swiss Federal Institute of Technology Zürich, CH-8092 Zürich

1.2 Climate

Mean annual precipitation as measured at the station Eigenthal (1006 m) is 1765 mm. Long-term temperature data were taken in Lucerne at 498 m. The estimated mean annual temperature is 8.5°C.

1.3 Geology

The bedrock consists of partly noncalcic molasse sand from the Aquitaine period. There are patches of superimposed moraine material from the Würm period, as shown on the map (Fig. 2).



"Würm moränen" from glaciers coming from the north side of the Mt. Pilatus

"Untere Süsswasser-Molasse (Aquitanien)", granite, sadnstone or multicoloured marne

morainic wall

erosion bank

forest

profile Guberwald

Figure 2 Geological map of Guberwald (Kopp, Bendel and Buxtorf 1955)

1.4 Relief

The profile lies on a slope with S exposure and inclination 40-50%.

1.5 Vegetation

According to ELLENBERG and KLOETZLI (1972), the plant association is a Bazzanio-Abietetum.

The forests in this area are traditionally typical selection forests.

2 Morphology of the soil profile

L 0-5 mm	Litter from preceding year, mainly needles, some leaves, and remains from shrubs, herbs, and mosses.
F 0.5-3-5(-10) cm	Partly decomposed organic material some years old, loose, partly matted.
H 5-10(-15) cm	Partly grainy, decomposed fine organic material, brownish black (5 YR 2/1-2), dense root network in places.
Ah 10-15(-20) cm	Organic material with isolated mineral components (quartz grains), gradual transition to eluvial horizon, clayey sand, grayish brown (7.5 YR 4/2, highly acidic.
E (15-)20 - 45(-60) cm	Gradual transition from Ah, light gray (10 YR 8/2), sandy soil (quartz), single-grained.
(Bh) 60-70 cm	Slight humus enrichment, dark brown (7.5 YR 3/4), somewhat diffuse transition to Bfe.
Bfel 70-120 cm poss.(S)Bfe	Enrichment of sesquioxides, oxidative mottling highly acidic, single-grained to lightly polyedral depending on local granulation, orange (7.5 YR 6/8), sandy to sandy clay.
Bfe,t2 120-250 cm	Increase in fine clay fraction, otherwise analogous to Bfe^{1}, little skeleton, heavily weathered.
BC from 250 cm	Transition to parent rock, somewhat scattered carbonaceous skeleton; brown (10 YR 4/6), with skeleton, partly single-grained.

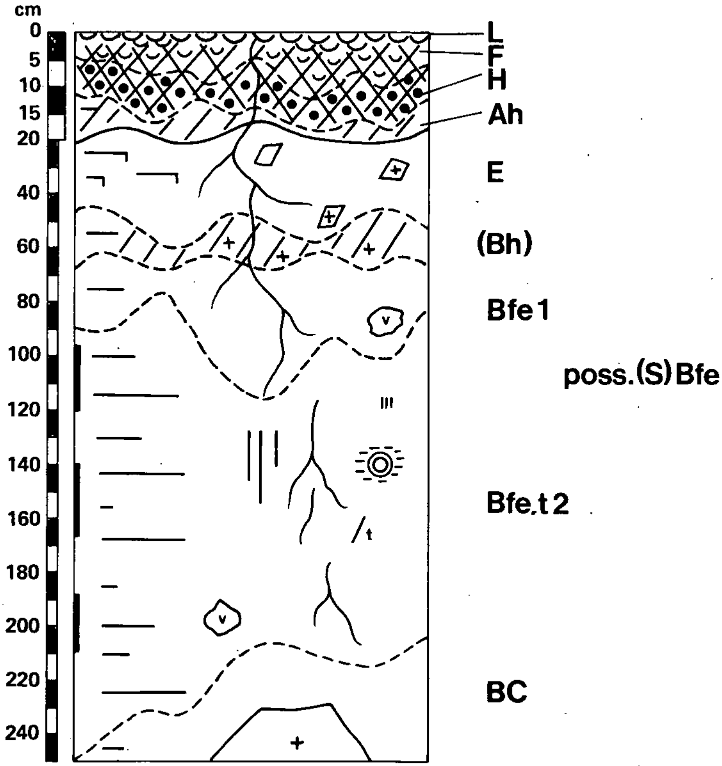


Figure 3 Schematic representation of the profile

3 Nomenclature

CH:	Rohhumoses Humus- Eisenpodsol
FAO:	Orthic Podzol
US soil Tax:	"Humic" Haplorthod

4 Findings concerning the soil profile

4.1 Physical characteristics

In the raw humus layer (0-10 cm, Table 1) the pore space constitutes 90% of the total volume, a very high proportion. In the Ah horizon (10-20 cm), which is rich in mineral materials, it decreases rapidly to 54%. The adjacent eluvial horizon displays a porosity of 0.433, i.e., the pore space per dm^3 is 433 cm^3. This somewhat denser structure results from the predominantly single-grained arrangement. Between 95 and 105 cm a slight increase to 50% occurs. This applies to the (S)Bfe1 horizon, which has a more pronounced polyedral structure. In the (S)Bfe,t2 horizon (140-150 cm), which has more clay and thus slightly impeded drainage, the porosity decreases to around 39%.

The hydraulic conductivity of the organic horizons L and F (samples from 0-10 cm) at water saturation is extremely high (22.9 m/d, see table 1). The loose, coarsely matted structure of the horizons is a major cause of the high level of seepage. Since these organic components have a large pore space (E=0.907), they also retain much water. At times of heavy precipitation, surface water runoff is therefore delayed or even impeded. However, in the Ah horizon at 10-20 cm the k value drops to 0.633 m/d. This reduction in permeability presumably results from the presence of the compacted layers.

Permeability is still high enough to allow percolation of rain falling at 25 mm/h.

The lowest k value, at 0.123 m/d, occurs at 50-60 cm (E horizon). The k value increases to 2.08 m/d at 95-105 cm but then drops to 0.745 m/d at 140-150 cm.

It is quite possible that variations in the k value up to a factor of 10^1 are due to inhomogeneity within a particular horizon, and not directly related to changes in the layers.

Such inhomogeneity is probably also the cause of the localised patches of saturated soil with pseudogley formation (50-170 cm) which can be clearly recognised in Fig. 3.

Areas of compaction occur only locally in the B horizon (general term) and are scarcely reflected in the values given in Table 1. Saturation does not necessarily arise from a decrease in the porosity of a deeper horizon. Even where porosity remains constant, marked decreases in the proportion of large pores with a concomitant increase in medium and fine pores can, at times of heavy precipitation such as occur here (1800 mm per year), result in occasional saturation with anaerobic phases and subsequent pseudogley formation (Fig. 5).

It is noticeable that between 50-60 cm the decrease in the k(S) value with increasing moisture tension is considerably slower than in the deeper

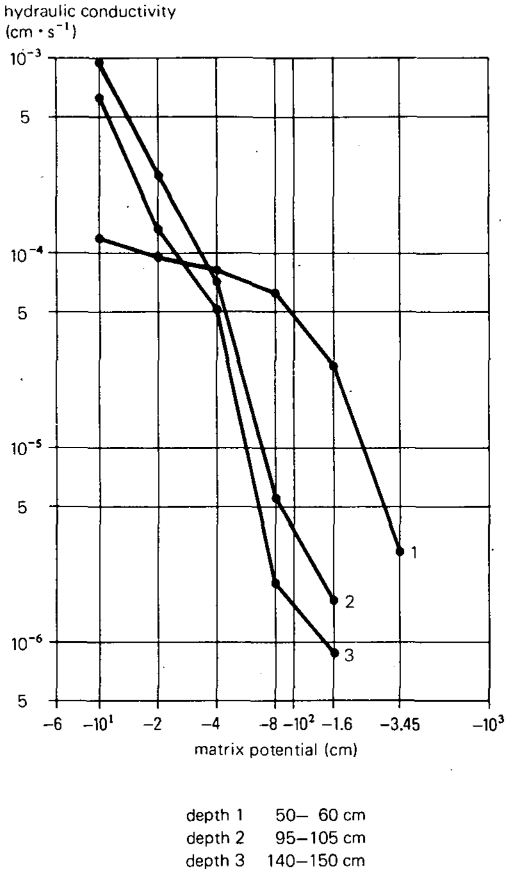


Figure 4 Hydraulic conductivity in unsaturated soil

horizons mentioned above (Fig. 4). For instance, at a matrix potential of -160 cm the unsaturated hydraulic conductivity is greater by a factor of approximately 10 to 100 than at depths of 95-105 cm or 140-150 cm. The saturated hydraulic conductivity of the Bh horizon (ksat=12 cm/d) limits the otherwise free drainage of the profile. The rainless period from mid-June to mid-July 1976 was one of the most pronounced drought periods of the last decade. Even under such conditions the profile was still in the moist range. Under the more typical climatic conditions of the rest of 1976 the soil water pressure varied between saturation and approximately 8 kPa. This is a further indication of local pseudogley formation. Such

Table 1 Physical and chemical properties of the profile

No	hor.	depth cm	sto. %v	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k sat. cm/d	k sat. cm/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	F	3-5	-	-	-	-	-	-	-	-	-	-	2,3·10^{3}	2,7·10^{-2}
2	H	5-10	-	-	-	-	-	-	-	-	-	-		
3	Ah	10-20	7	33	27	19	79	5	6	2	13	8	6,3·10^{1}	7,3·10^{-4}
4	E	20-60	4	-	-	-	86	-	-	-	10	4		
5	(Bh)	60-70	5	-	-	-	-	-	-	-	-	-	1,2·10^{1}	1,4·10^{-4}
6	Bfe1	70-120	12	29	32	18	79	4	5	3	12	9	2,1·10^{2}	2,4·10^{-3}
7	Bfet2	120-(250)	15	-	-	-	76	-	-	-	11	13	7,5·10^{1}	8.6·10^{-4}
8	BC		20	-	-	-	-	-	-	-	-	-		

No	hor.	bulk dens. g/cm^3	porosity E	water content in %v at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fed mg/g	Feo mg/g	Feo:Fed	Mno mg/kg	Pa mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	F	0,15	91	-	-	-	-	4,7	4,1	-	-	-	-	-
2	H							3,0	2,3					
3	Ah	1,14	54	50	34	26	8	3,4	2,4	1,9	0,6	0,32	0,01	
4	E	-	-	-	-	-	-	4,1	3,3	0,2	0,03	0,15	0	-
5	(Bh)	1,48	43	39	24	14	4	3,6	3,0	13,1	7,7	0,58	0,01	-
6	Bfe1	1,3	50	47	34	29	13	4,3	3,8	11,4	2,9	0,25	0,03	-
7	Bfet	1,6	39	37	33	29	16	4,3	3,7	16,0	3,5	0,22	0,14	-
8	BC							7,1	6,3	25,6	4,6	0,18	0,36	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	F	31,4	10,5	30	-	160	-	135	5	15	0,5	-	-	29
2	H	43,9	13,4	33	-	164	-	145	5	11	3	-	-	
3	Ah	17,8	5,7	31	-	11,4	-	9	1	1	0,4	-	-	12
4	E	0,2	0,1	20	-	0,8	-	0,4	0,1	0,1	0,2	-	-	-
5	(Bh)	2,6	1	26	1	3,4	-	1,4	1	0,6	0,4	-	-	-
6	Bfe1	0,4	0,2	-	-	1,4	-	0,2	0,6	0,1	0,5	-	-	9
7	Bfet2	0,2	0,1	-	-	2,8	-	1	1,2	0,3	0,3	-	-	-
8	BC	0,4	0,3	-	-	135	-	130,7	1,2	2,4	0,4	-	-	-

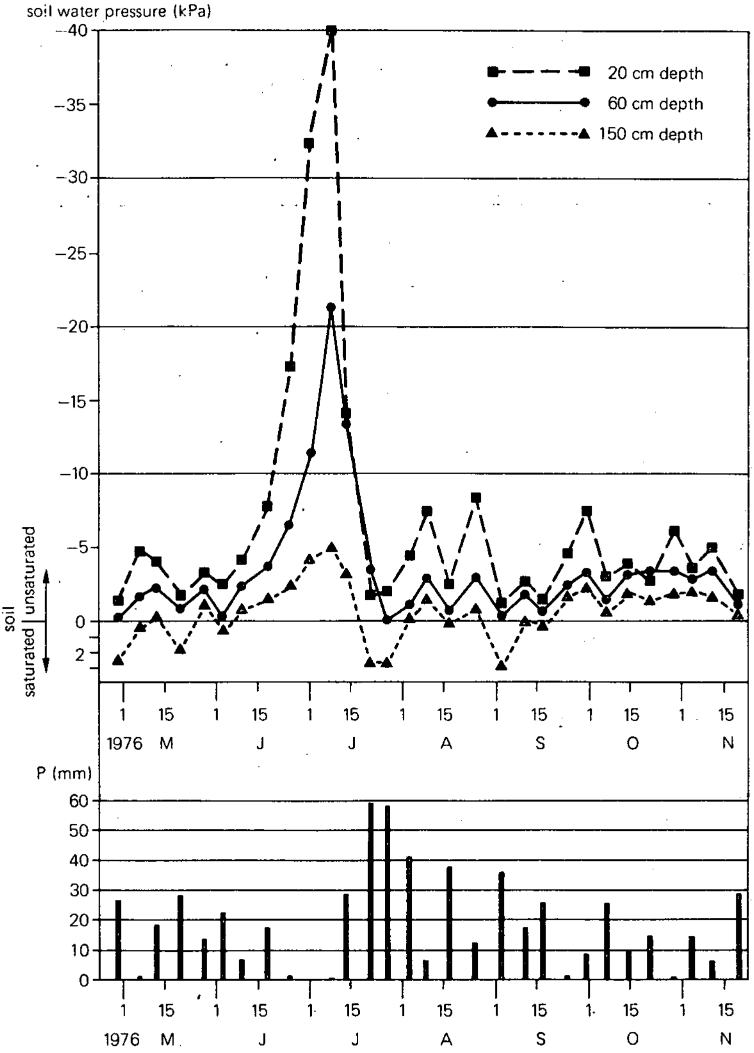


Figure 5 Soil water pressure and precipitation during the vegetation period 1976

intermittent phases of saturation were observed in late July, mid-August, and early September of 1976. It is to be presumed that local variations in permeability are greater than those reflected in our data.

4.2 Chemical characteristics (see Table 1)

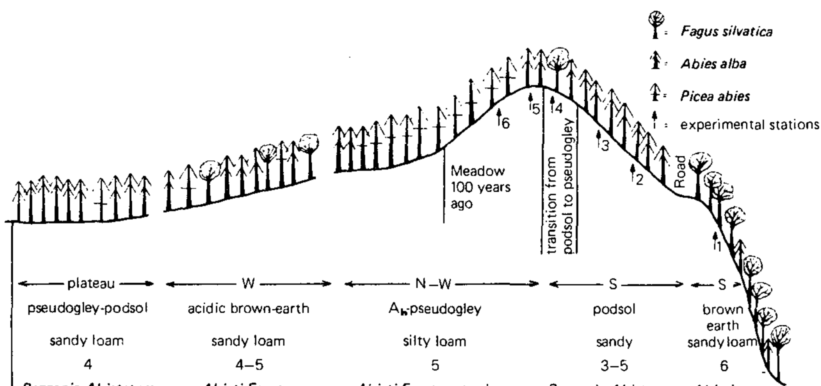
4.3 Biological characteristics

Not a single earthworm was found at this site; the high acidity of the upper layers totally precludes the survival of this species, and excessive dryness in the upper organic layers during summer is a further inhibitory factor. -

5 Site evaluation (Ecological conditions)

5.1 Soil characteristics

The soil type "Guberwald", which is a podzol with local pseudogley formation, occurs at the foot of Mt. Pilatus on the southern flank of a steep, extended ridge, at an elevation of 960 m a.s.l. The parent rock consists of noncalcic molasse sand with scattered sandstone blocks of varying size. Where podzol formations predominate, the profile is of normal permeability. Localised patches of compaction result in periodic saturation at times of heavy precipitation. This is reflected in the pseudogley formations found in the profile.



exposition	plateau	W	N–W	S	S
soil type	pseudogley-podsol sandy loam	acidic brown-earth sandy loam	A_h-pseudogley silty loam	podsol sandy	brown earth sandy loam
pH in 0–5 cm	4	4–5	5	3–5	6
community	*Bazzanio-Abietetum typicum*, typical var.	*Abieti-Fagetum luzuletosum*	*Abieti-Fagetum typicum*, *Carex remota*-variant	*Bazzanio-Abietetum typicum*, *Leucobryum* variant	*Abieti-Fagetum typicum*, *Carex alba*-var.
tree cover, %	*Abies* 90 *Picea* 10 *Fagus* 0	*Abies* 60 *Picea* 20 *Fagus* 20	*Abies* 40 *Abies* 95 *Picea* 55 *Picea* 5 *Fagus* 5 *Fagus* 0	*Abies* 95 *Picea* 5 *Fagus* <1	*Abies* 30 *Picea* 10 *Fagus* 60
regeneration individuals/ 4 m²	*Abies* 25 *Picea* 15 *Fagus* 0	*Abies* 15 *Picea* 6 *Fagus* 5	*Abies* 10 *Abies* 12 *Picea* 8 *Picea* 2 *Fagus* 2 *Fagus* 0	*Abies* 30 *Picea* 2 *Fagus* 0	*Abies* 7 *Picea* 3 *Fagus* 20

Figure 6 Ecological conditions in Guberwald (Gadekar, 1975)

Physiologically, this soil is extremely deep. In overall terms the relatively small proportion of nutrients per unit volume of mineral earth is at least partially compensated for by the great physiological depth of the main and lateral root zones.

In general, this soil type is valuable for forest cultivation, although the local occurrence of pseudogley must be borne in mind (Fig. 3). Due to the slope inclination (40-50%), however, this is less important here than in analogous soils on flat terrain; natural drainage is more rapid and more thorough, and thus reduces the effects of the periodically perched water tables.

5.2 Tree species in relation to soil

For silver fir (Abies alba), conditions are very favourable for germination and stand formation. Even the localised formation of pseudogley does not seriously affect its vitality. The root system is very dense, penetrating, with some attenuation, to around 200 cm. Fir exploits the soil very efficiently in terms of both nutrient supply and mechanical support; the trees are securely anchored and thus increase the storm resistance of the whole stand.

Norway spruce (Picea abies) is fairly sensitive to water saturation of the soil. The closer to the surface the pseudogley formation occurs, the more roots tend to spread out in the remaining zone of raw humus available to them, which here is (10)-20-30-(40)cm deep; the root system thus assumes a plate-like form.

Where the podzol formations predominate (Fig.6), cultivation of larch (Larix decidua) may be advantageous: the fine litter it produces intermingles with that of fir, spruce, and any subsidiary species and produces a mixed layer. Biological activity and decomposition are generally higher in such mixed layers than in horizons of uniform composition. Thus a certain proportion of larch litter is beneficial to the soil.

On this site, beech (Fagus silvatica), exhibits very reduced vitality and suffers similar disadvantages to spruce. Gadekar (1975) studying the distribution of beech at Guberwald, found that, at this elevation, the seeds can germinate in the raw humus of the podsol, but the seedlings cannot develop. From the ecological viewpoint, regeneration of beech on such soils is therefore doubtful. Fir, in contrast, is able both to germinate and to develop successfully.

On the whole, then, there are only a limited number of species suitable for stand establishment on the soil type "Guberwald".

Large-scale regeneration and extensive clear-cutting should be avoided because they increase the risk of soil saturation. At regeneration sites raw humus should not be removed in large amounts, as this would increase the risk of erosion by heavy rain and also destroy an important potential nutrient source.

From the viewpoint of soil husbandry, management should be such that it ensures thorough penetration of the soil by roots with as few gaps as possible. Selection forest management is very suitable, since it ensures that trees of all ages are present within a small area, and the root zone is uniformly occupied over both time and space. It also results in better drainage, even where pseudogley formation tends to occur. Fir, with its relatively insensitive root system, is particularly effective in increasing biological drainage, which is of great ecological importance. Spruce, with its deeper root system and greater vitality also benefits from this, as do beech (Fagus silvatica), larch (Larix decidua), sycamore (Acer pseudoplatanus), and Scots pine (Pinus silvestris). Other species beneficial to the soil such as grey alder (Alnus incana), aspen (Populus tremula), mountain ash (Sorbus aucuparia), and black honeysuckle (Lonicera nigra) have similar effects: the biological activity of the raw humus layer is enhanced.

Gadekar (1975), conducting ecological studies on marginal sites for beech and fir in the middle montane zone of the pre-Alps, sought to identify the factors limiting the distribution of beech.

On sites with podsols of the Guberwald type, fir is dominant, while beech is very weak and in many cases has completely disappeared due to human activities. Gadekar (1975) attributes this to difficulty in germination and the near-impossibility of further development in raw humus. In podsolic soils beech seedlings can establish only very loose contact with the fibrous organic material of the L-F raw humus layers, so that it is difficult for them to establish a tap root.

5.3 Soil husbandry

Since the raw humus contains large amounts of nutrients not directly available to the plants, the biological activity of the soil should be enhanced, so as to ensure a better nutrient supply and thus better root development in both the raw humus and the deeper mineral layers. It must be accepted that, with increased biological activity, some of the newly released nutrients presumably percolate out of the root zone due to high precipitation and low pH. Nevertheless, the more efficient level of organic decomposition is ecologically more beneficial than the slow breakdown occurring in deep, matted F and H horizons. The following shrubs and secondary trees may help to enhance biological activity: grey alder (Alnus incana), mountain ash (Sorbus aucuparia), silver birch (Betula pendula), sycamore (Acer pseudoplatanus), and black honeysuckle (Lonicera nigra).

Silvicultural operations should be aimed at improving light conditions and increasing the temperature of the soil surface so as to promote biological activity and accelerate the decomposition of organic material and the circulation of matter. Even-aged stands which have remained closed for long periods are unsuitable in this respect.

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Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 48, 77-80, 1986

MAINTENANCE OF MOUNTAIN FOREST IN SWITZERLAND

by Pfister, F.+

1 Importance and problems of maintaining the forest in the mountains

Forests in mountainous regions, as is well known, play an essential role in protection against natural hazards. This is particularly important for Switzerland, where mountains cover 70% of the total area. Furthermore, the loss of forests in the mountains would alter the river drainage pattern to such an extent that the risk of floods in the Mittelland would be greatly increased. Such a situation occurred somewhat more than a hundred years ago; it was then that the disastrous consequences of over-utilisation of the mountain forests were first recognised, and as a result the Forest Bill of 1876 introduced the first statutory steps towards protection by federal supervision through the Forest Police. Also, intensive efforts to re-establish the forests were made, and were in many cases successful. The task, however, is far from completed. Whatever has been achieved so far can only be regarded as steps towards a total success. Furthermore, a number of factors are now endangering the success of the first efforts. For one thing, due to economic considerations, some 12% of the mountain forests in Switzerland now receive only irregular tending, and 10% none at all. For another, forest damage is by far most severe in the inner alpine valleys, as surveys have shown. Consequently, a broad spectrum of the public is asking: How far and how long can the mountain forests go on providing the same degree of protection for settlements, roads, railways, and farmland? People expect forestry to slow down, if not halt, the decrease in the forests' protective capacity. Here, however, one thing must be clearly understood: no matter what efforts are made, whether in forestry or in engineering, they can only

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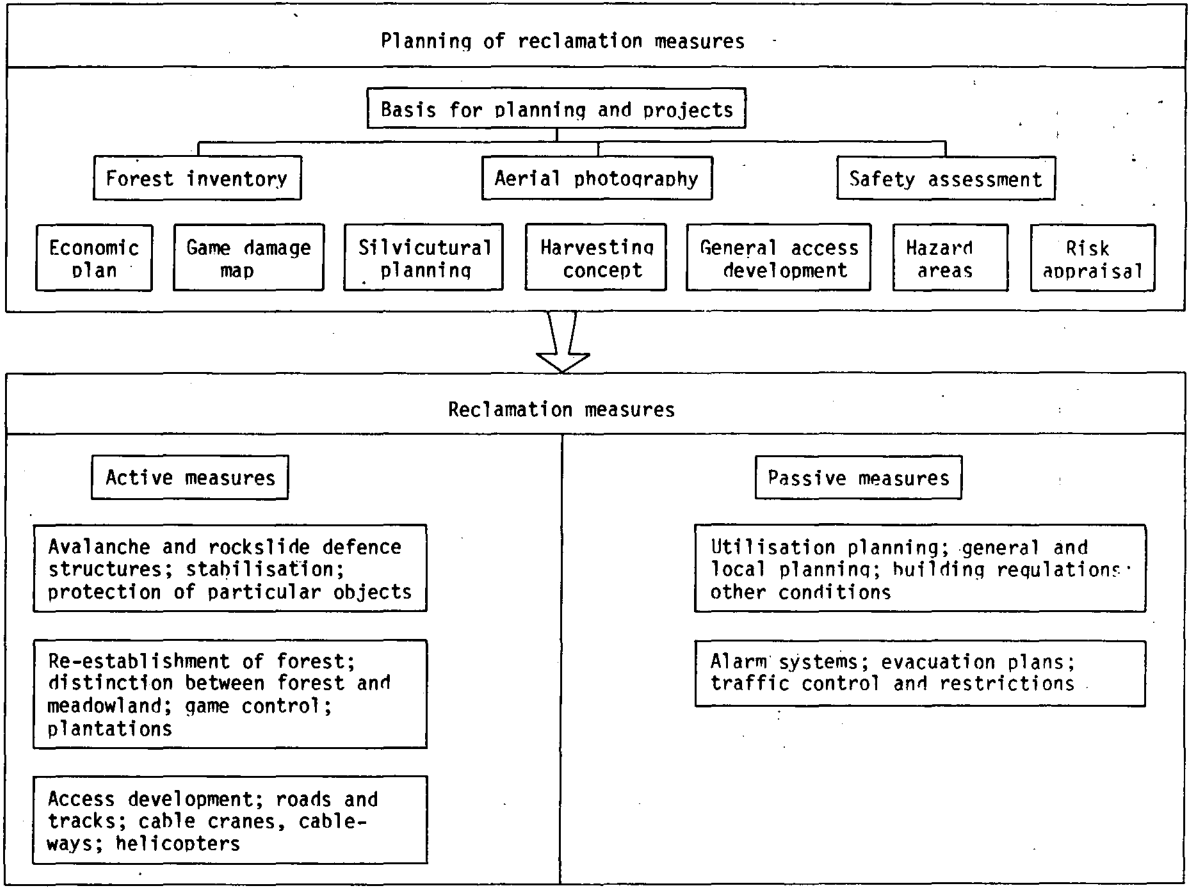

Figure 1: Procedure for planning reclamation measures, as tested in case-studies in the canton of Uri.

succeed in the long run if the level of air pollution is rapidly and drastically reduced. The urgency of this increases in proportion to the growing overutilisation of mountainous regions by traffic arteries, tourism, settlement growth, etc., such as is occurring in many areas. Increasingly unstable forests are expected to provide an unreasonably high degree of protection. That is a dangerous situation.

2 Foundation for reclamation planning following forest damage

The foregoing outline of the situation clearly shows that reclamation measures in terms of forestry, engineering, and land-use planning must be rapidly formulated and integrated in comprehensive planning. Ways and means are limited, and if they are to be applied effectively and in the right place, then those responsible must be provided with a sound basis for decision-making without delay.

We are using case-studies in the alpine cantons of Uri and the Valais to develop a planning procedure which will efficiently meet the complex requirements of mountain forest reclamation. Using the protected forests of Altdorf and Göschenen/Wassen as examples, we are investigating how forest inventories, aerial photography, and safety assessment can be used to derive basic planning components, as shown in Figure 1.

The protected forest above Altdorf acts as a shield against rockslides, while the "Naxwald", between Göschenen and Wassen, protects long strectches of the Gotthard road and rail arteries from avalanches.

We are assessing the condition of the forest by means of inventories using a dense sample grid (100 x 10 m or 150 x 150 m), and comparison of the results with those from aerial photography and tree-ring analysis. Our initial results clearly indicate a decrease in regeneration. They also show that over 80% of the trees, mostly the medium and large timber trees, are severely damaged.

As regards the planning of safety measures, a number of questions must be considered. What are the present risks due to natural hazards? How could forest damage affect these risks? How can these risks best be combated with respect to cost effectiveness? The steps in the planning of safety measures are shown in Figure 2.

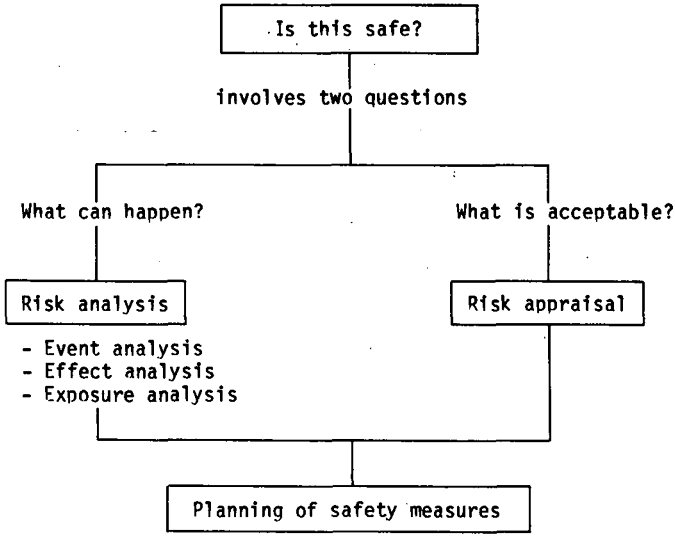

Figure 2: Steps in the planning of safety measures as tested in case-studies in the canton of Uri

We have not yet established a complete system for assessing and planning reclamation and safety measures, but our findings so far confirm the great importance of forestry measures supported by mechanical structures. The present situation seems unfavourable, and a considerable increase in state contributions towards access development, forest tending, and mechanical defence structures is needed. Nevertheless, the efforts to re-establish the mountain forests which were begun over a hundred years ago must not be abandoned now.

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PROFILE KLOSTERS: RAW HUMUS LAYER ON DOLOMITIC COBBLER TALUS (Station CH-4)

by

M. Müller and K. Peyer*

1 Introduction

1.1 Geographical location

The profile lies in the "Gotschnaboden" on the left valley slope of the upper Prättigau above Klosters (Canton of the Grisons, Switzerland).

Coord. 784 860 / 192 540; 1720m above sea level

1.2 Geology

Tectonically, the Gotschnaboden region belongs to the Platta-Arosa-nappe (Upper penninic units).

The Profile KLOSTERS' parent material is a coarse cobbler talus formed of Triassic Dolomite. The analysis results gave the proportion of dolomite at over 98% (Table 1).

Table 1. Gotschnaboden Triassic Dolomite analysis.

$CaMg(CO_3)_2$ (dolomite)	98.6%
Quartz-silt	ca 0.5%
Illite	ca 0.5%
Montmorillonite (smectite)	ca 0.5%
Feldspar (plagioclase)	traces

1.3 Climate and topography

Profile KLOSTERS lies on a NNE-facing slope in a shady, wind-protected trough. The slope varies greatly, but averages 45%.

Due to the shady situation, temperatures at ground level are probably appreciably lower than those given in Figure 1. The soil has a frigid temperature

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regime: it has no frost for the 2 months following summer solstice, but in winter it is frozen to a depth below 5cm. The snow cover's average duration is estimated to be more than 6 months. Because the humidity is constantly high, the soil rarely dries out.

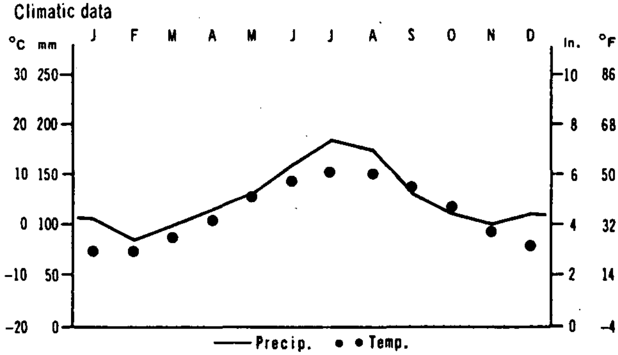


Figure 1. Temperature and Precipitation at 1700m above sea level in the Gotschnaboden region. Calculated from data gathered at the Klosters, Tschiertschen and Arosa stations.

Table 2 shows the effective mean temperatures at 5cm soil depth during different periods; measured using the Sucrose Inversion Method.

Table 2. Profile KLOSTERS: effective mean temperatures at 5cm soil depth (°C). Standard deviation is given in parentheses.

Periods of Measurement	Effective Mean Temperatures
July 31 - August 29, 1984	7.81 (0.07)
August 29 - September 27, 1984	4.23 (0.23)
September 27, 1984 - June 7, 1985	-0.26 (0.03)

1.4 Vegetation

Profile KLOSTERS is located just below the timberline under a subalpine Norway Spruce forest with abundant blue berry bushes (Piceetum subalpinum myrtilletosum Br.-Bl.). Besides species of this association, numerous ones present in adjacent pastures are also found.

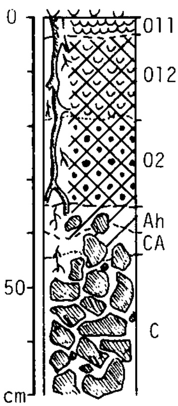
According to Braun-Blanquet, the subalpine Norway Spruce wood is the climax community in the subalpine zone of the middle and northern Grisons. It establishes itself anywhere as soon as the soil becomes free of carbonates. The myrtilletosum subassociation is limited to an elevation of 1500-1900m on northerly exposures with shortened vegetative periods, an average snow-cover of 6-7 months and high humidity.

2 Profile description

Horizon designations according to FAO. Colors are for moist soil.

The horizon depths vary greatly within a small area. Large blocks of dolomite often extend to the surface.

Profile KLOSTERS



011
(USA: 011; CH: 01)

0-3cm; dark brown (7.5-10YR 3/3-4/3), partially decomposed plant remains, mostly from mosses (Hylocomium splendens, Polytrichum formosum, Rhytidiadelphus triqueter), also leaves from dwarf bushes and spruce needles; original form of 90% of the organic matter is visible to the naked eye; layered, white fungal hyphae between the layers; shrub roots common, up to 3mm diameter; a few fine and coarse (some more than 10cm diameter) roots.

Clear wavy boundary.

012
(USA: 012; CH: Of)

3-19cm; brownish black to reddish brown (7.5YR 2/2 - 5YR 2/3), partially decomposed, matted plant remains; original form of 50-70% of the organic matter visible to the naked eye; upper part of the horizon layered, white fungal hyphae between the layers; up to more than 10cm thick, dead, dark reddish brown (5YR 3/6), decomposed tree roots; numerous shrub and a few fine and coarse roots.

Gradual wavy boundary

02
(USA: 02; CH: Oh)

19-35cm; black (10YR 2/1-1.7/1), considerably decomposed, grainy to smeary (when moist) organic material; very weak crumb structure; dead tree roots as in 012; a few medium and fine roots.

Abrupt wavy boundary

Ah
(USA: A1; CH: Ah)

35-40cm, discontinuous; very dark brown (7.5YR 3/2) sandy loam; 10-20% by volume skeleton, slightly weathered, with brown crust; weak fine crumb structure; a few roots.

Clear wavy to irregular boundary

CA
(USA: AC; CH: AC)

40-44cm; dull yellowish brown (10YR 4/3) sandy loam; 30-50 % by volume skeleton, unweathered; structureless to very weak crumb structure; a few roots.

Gradual wavy to irregular boundary

C
(USA: C; CH: C)

44-70cm; dull yellow-orange (10YR 6/4) dolomitic cobbler talus; boulders up to a few meters in size; sandy loam; 75% by volume skeleton; structureless, loose; no roots.

3 Classification of the profile

CH: Rohhumoser Humus-Karbonatgesteinsboden

GFR: Tangel-Rendzina, Tangelmoder-Rendzina

FAO: Dystric Histosol (or Dystric Regosol?)

USA: Typic Borofolist (More or less freely drained Histosol, consisting primarily of O horizons derived from leaf litter, twigs and branches resting on fragmental materials that consist of gravel, stones and boulders. Not having frost within the control section about 2 months afther the summer solstice, but having frost deeper than 5cm in the soil in winter.)

4 Soil profile analysis

4.1 Physical soil properties

The bulk density of the raw humus layer is $0.2gcm^{-3}$; its porosity lies between 0.8 and 0.9 (Tab. 3, 4; Fig. 2). Because of the high proportion of coarse pores permeability is very high, resulting in good aeration. The noticeably large proportion of fine pores could be due to the method of analysis.

Profile KLOSTERS remains moist during the entire vegetation period. The large proportion of medium pores (25-35% by volume) and the cool, shady location with a high humidity and low evaporation are responsible.

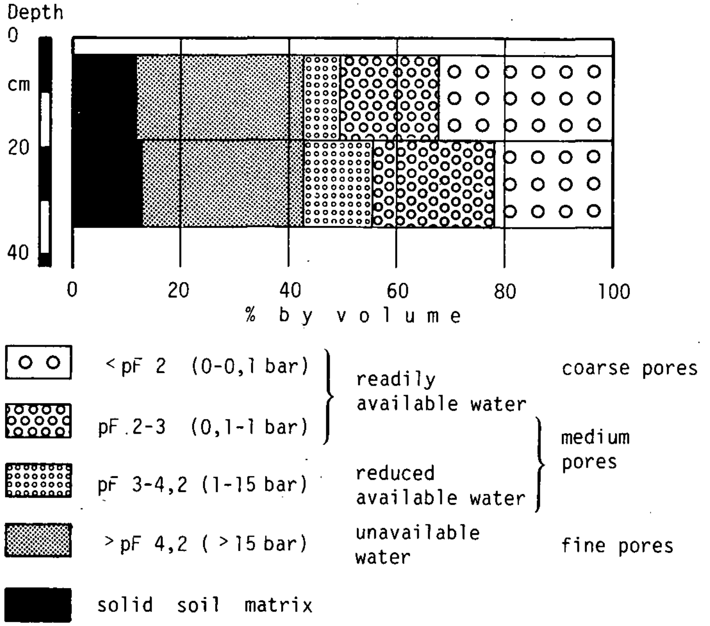


Figure 2. Profile KLOSTERS: Pore-size distribution as defined by the corresponding soil moisture tensions.

Table 3. Density, porosity, pore-size distribution and permeability of the KLOSTERS profile. Measurements were made on core-samples 4,2 cm high by 5,5 cm diameter.

Horizon	Depth cm	Bulk density a oven-dry g cm^{-3}	Particle density r oven-dry g cm^{-3}	Porosity E $E=1-\frac{r}{a}$	Water content in % by vol. at pF (bars) 2(0,1)	3(1)	4,2(15)	kf cmd^{-1}
012	3-19	0,19	1,61	0,882	56,0	37,8	31,1	3500
02	19-35	0,22	1,71	0,872	65,1	42,9	29,9	350

4.2 Chemical soil properties

The very acid raw humus layer has an organic matter content between 90 and 95% (calculated on the basis of ignition loss) (Tab. 4,5; Fig. 3). The highest proportion of extractable carbon was measured in the upper 3cm. A change in pH of more than 3 units marks the transition from the organic to the mineral horizons.

Corresponding to the high organic matter content, the cation exchange capacity in the O-horizons is very high. The calcium and magnesium ions of the dolomitic parent material are the dominant exchangeable bases.

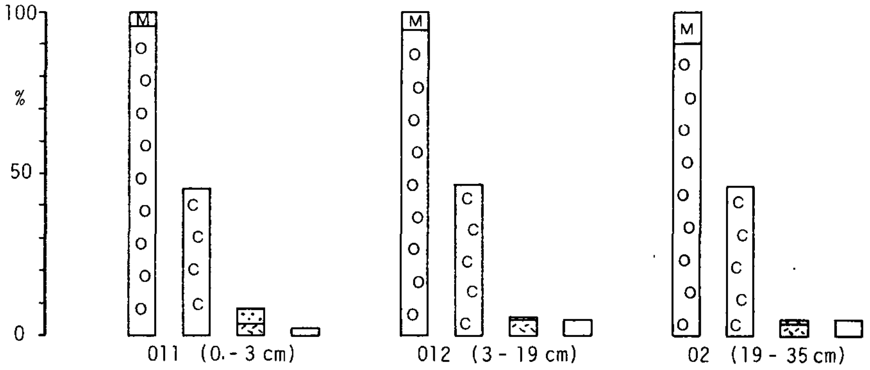


Figure 3. Profile KLOSTERS: Chemical characteristics of the raw humus layer's organic matter.

O O Organic matter (ignition loss)

M Mineral material (ash)

C C Organic Carbon

Humic acids

Fulvic acids

Pyrophosphate extractable Carbon

Table 4. Results of analysis for Profile KLOSTERS

No	hor.	depth	skel.	texture; % of humus-free fine earth (particle diameter in mm)							kf	
				s a n d					silt	clay		
		cm	%	coarse 2-0,5	med. 0,5-0,2	fine 0,2-0,1	very f. 0,1-0,05	Σ			cm/d	cm/sec
1	2	3	4	5	6	7	7a	8	12	13	14	15
1	011	0-3										
2	012	3-19									3500	$4x10^{-2}$
3	02	19-35									350	$4x10^{-3}$
4	Ah	35-40	10-20	9,8	4,2	7,6	17,9	39,5	42,7	17,8		
5	CA	40-44	30-50	10,6	4,5	8,9	18,9	43,0	43,0	14,0		
6	C	44-70	75	37,4	8,4	5,3	9,5	60,6	29,2	10,2		

No	hor.	bulk dens. g/cm^3	porosity %	water content in % at pF 2,0	3,0	4,2	pH H_2O	pH $CaCl_2$	Fe_d	Fe_o	Al_d	Fe_o/Fe_d	Mn_o	$P_{citr.}$
									mg/g min. fine earth (*g/litre soil)				mg/kg (*mg/l soil)	
1	2	16	17	19a	20a	21a	22	23	24	25		26	27	28
1	011						4,3	3,8	<0,1*	<0,05*	<0,05*	0,51	ca. 8*	ca. 20*
2	012	0,19	88,2	56,0	37,8	31,1	4,1	3,4	0,25*	0,19*	0,20*	0,75	0,4*	11*
3	02	0,22	87,2	65,1	42,9	29,9	4,3	3,9	0,36*	0,34*	0,19*	0,96	0,3*	5*
4	Ah						7,3	7,1	9,6	2,8	1,6	0,29	54	2
5	CA						7,7	7,2	8,1	2,4	1,0	0,29	27	
6	C						7,6	7,2	9,5	1,3	0,6	0,13	2	

No	hor.	$C_{org.}$ %	$N_{tot.}$ mg/g	C/N	carbonate %	CEC pot. meq/kg	exchangeable cations in meq/kg Ca	K	Mg	Na	H	V %
1	2	29	30	31	32	33	35	36	37	38	39	41
1	011	45,2	17	27	-	719	141	19,1	51		508	29
2	012	46,6	15	31	-	995	164	3,0	60		768	23
3	02	44,6	14	31	-	1027	307	1,4	120		599	42
4	Ah	4,5	3	16	70	341	243	1,0	97		-	100
5	CA	2,3	1	20	82	211	150	0,7	61		-	100
6	C	0,9	1	15	91	105	68	0,5	36		-	100

Table 5. Profile KLOSTERS: Chemical characteristics of the raw humus layer's organic matter.
C_{py}: Pyrophosphate extractable C

Horizon	Depth cm	Ignition loss %	Organic C (C) %	Fulvic acids (FA) %	Humic acids (HA) %	C_{extr} (FA+HA) %	C_{extr}/C	C_{py} %	C_{py}/C	N %	C/N
011	0- 3	95,3	45,2	4,8	3,3	8,1	0,18	1,9	0,04	1,7	27
012	3-19	94,1	46,6	1,2	4,0	5,1	0,11	4,8	0,10	1,5	31
02	19-35	90,0	44,6	1,3	3,7	5,0	0,11	4,9	0,11	1,4	31
Ah	35-40	9,5	4,5					1,7	0,39	0,3	16
CA	40-44	5,2	2,3							0,1	20
C	44-70	3,5	0,9							0,1	15

4.3 Soil biological properties and analyses (**by W. Jäggi***)

The accumulation of raw humus is a result of inhibited biological decomposition of organic material.

The presence of different groups of soil microorganisms was determined (Fig. 4). Results were compared with those of an arable RECKENHOLZ** soil. The fungal and bacterial numbers were determined by colony counts on solid nutrient media (fungi: on a dextrose-peptone-yeast extract agar [Papvizas and Davey, 1959]; total bacteria: on a diluted peptone-sodiumchloride agar [VDLUFA, 1986]; bacteria developing on a mineral substrate: on the basal medium [Lochhead and Chase, 1943]). The various nutrient groups were determined by the most probable number method (MPN) according to Pochon and Tardieux (1962).

The potential for microbial decomposition of organic material was examined by the rate of cellulose degradation (using filter paper) in the laboratory and the field during various time periods (Fig. 5.a). Also, the potential protease activity (gelatine hydrolysis) and N-mineralisation, with and without the addition of clover meal (5mg/g soil dry matter content), was analysed (Fig. 5.b). The number of soil organisms and the nitrogen mineralisation are given based on the soils' volumes because their bulk densities are very different. The cellulose degradation, on the other hand, was calculated based on the surf.ace area of filter paper in contact with the soil. The soil samples for the laboratory analyses were taken on July 31, 1984.

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** RECKENHOLZ (Zurich): Gleyic Cambisol (FAO), Ap-horizon 0-20cm. 25% clay, 35% silt, 3% skeleton, bulk density 1.27 g/cm³; pH(H_2O) 6.5, pH($CaCl_2$) 5.8, $C_{org.}$ 2.09%, $N_{tot.}$ 1.45 mg/g, C/N 14.4. 442m above sea level. Average annual temperature 8.9°C; annual precipitation 1000-1100 mm; vegetation period April-October (minimum average temperature 5°C). Cultivar: sugar beets; nitrogen fertilisation 56 kg N/ha.

The densities of all soil microorganisms, especially those of the fungi and cellulose decomposers, are much lower in Profile KLOSTERS than in the reference profile RECKENHOLZ (Fig. 4). Cellulose decomposition in Profile KLOSTERS is very low (Fig. 5.a). The relatively low temperatures and pH values and the type of organic material probably account for this. In addition, the low protease activity shows that the potential for microbial protein-breakdown is small (Fig. 5.b). This is approximately proportional to the N-mineralisation of the soil and the frequency of proteolytes (Fig. 4). The addition of an easily decomposable source of nitrogen in the form of clover meal causes a similar increase in the rate of N-mineralisation as in the reference profile RECKENHOLZ. This demonstrates that, besides other factors, nutrient availability exercises a great influence on a soil's microbial activity.

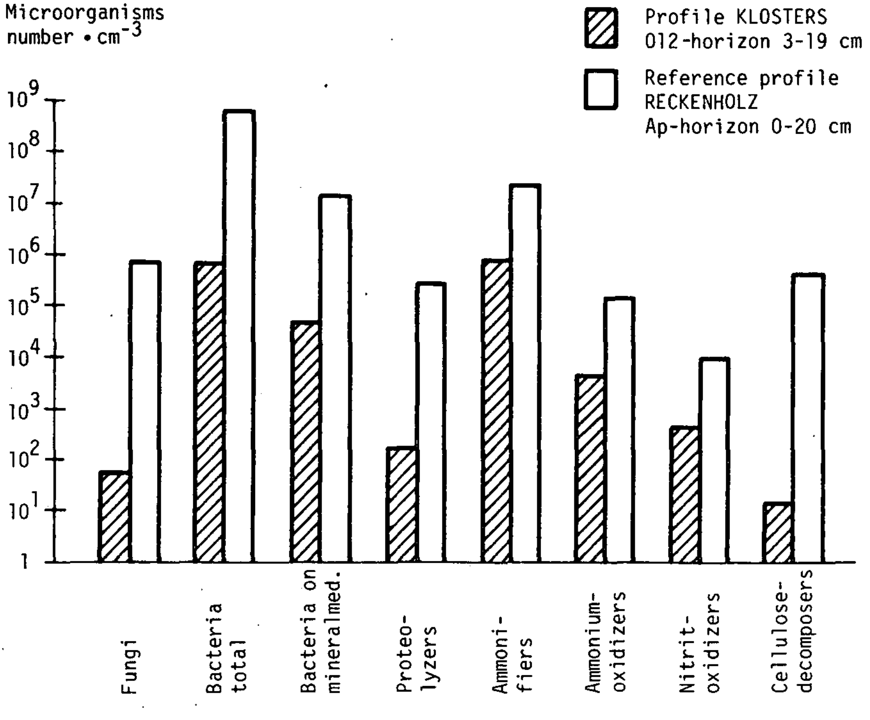

Figure 4. Presence of various groups of microorganisms in Profile KLOSTERS and reference profile RECKENHOLZ

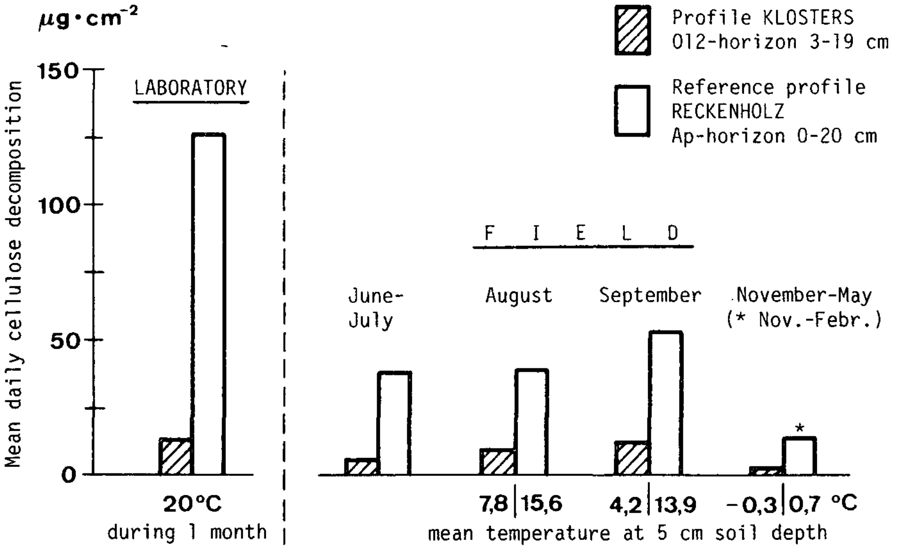

Figure 5.a) Cellulose degradation in Profile KLOSTERS and reference profile RECKENHOLZ in the laboratory and field during various time periods

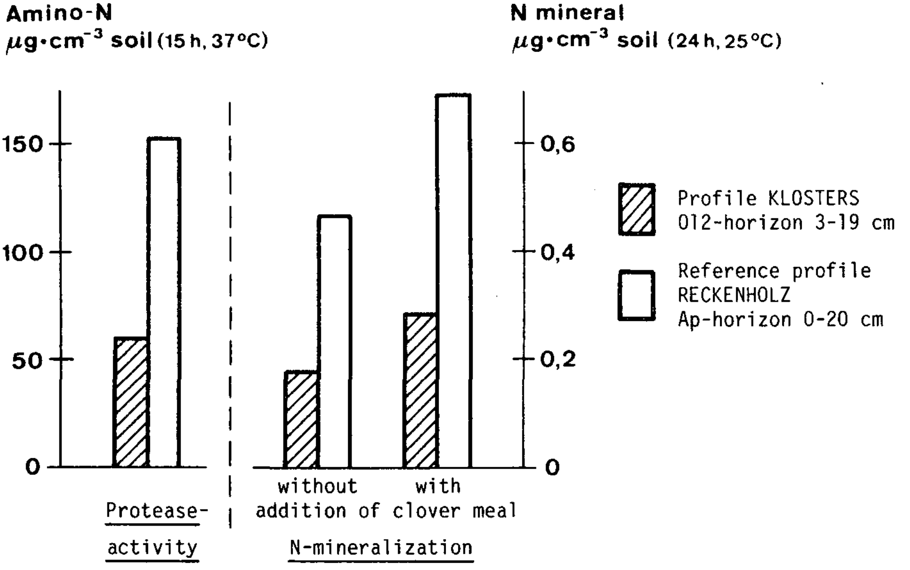

Figure 5.b) Protease-activity and nitrogen-mineralization in the laboratory analyses of Profile KLOSTERS and reference profile RECKENHOLZ

5 Discussion and Summary

Profile KLOSTERS is located just below the timberline at 1720m above sea level in a trough on a slope facing NNE. The parent material is a coarse-cobbler Triassic Dolomite (98.6% dolomite). The profile lies under a subalpine Norway Spruce forest with abundant blue-berry bushes (Piceetum subalpinum myrtilletosum).

Low temperatures, high humidity and meagre sunshine, together with the predominantly dolomitic parent rock, which is low in clay, gave rise to a deep, acid raw humus layer. Forest shade adds to the already adverse affects of the unfavorable local climate. Since a very small amount of material remains after the dissolution and leaching of the carbonates, only a thin Ah-horizon can develop. Underneath is a rapid transition to the parent rock.

The organic layer resembles peat somewhat, but the permeable parent material precludes the possibility of any wet phases. Cold, the absence of mineral fine earth necessary to the production of mull and poorly degradable Spruce needles are the main hindrances to decomposition. Pastures in the immediate vicinity show that better exposition to the sun or fertilization enhances decomposition of the raw humus.

Profile KLOSTERS represents an unusual soil-type which, due to the unique developmental conditions, covers only a limited area. Similar soils can be found in the region Klosters/Davos only on shady, wind-protected northerly slopes having a dolomitic substratum and a long snow cover.

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SOILS ON SERPENTINITE NEAR DAVOS/SWITZERLAND
Station CH-5, Delenwald

by S. Juchler and H. Sticher +)

1 Factors of soil formation

1.1 Location

The profile described here is situated at Delenwald (1620m above sea level), approximately 700m northeast of the summit of the Wolfgang Pass, which connects Klosters in the Prättigau with Davos in the Landwassertal.

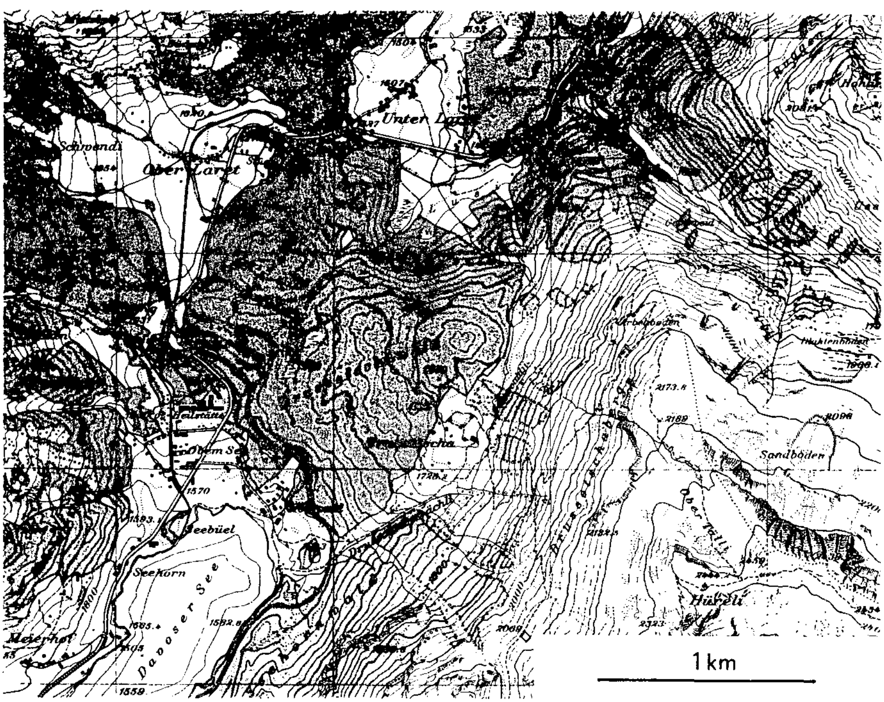

Figure 1: Map section of the Wolfgang-Davos region showing the location of the ISSS-profile (Permission for reproduction of the map was given by the Bundesamt für Landestopographie on December 30, 1985)

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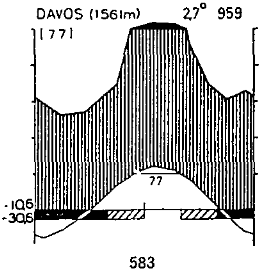

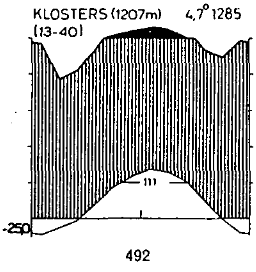

Figures 2 and 3: Diagrams of the climates of Davos (left) and Klosters (right) (Walter and Lieth 1960-67)

1.2 Climate

Wolfgang is located at the subalpine level in a zone of transition between the North alpine oceanic and the Central alpine continental climate. The mean annual precipitation lies between that of Klosters and Davos. The average temperatures are similar to those of Davos, though the winter temperatures are higher and the summer temperatures lower (Fig. 2 and 3).

1.3 Geology

Tectonically the area is situated between the east alpine and penninic nappes. During the folding of the Alps oceanic crust was imbedded between these two complexes. Augite-serpentinite was formed from lherzolite (rock consisting of olivine and pyroxenes) by partial metamorphosis. The serpentinite covers an area of approximately 6 km^2. It extends from Delenwald east of Wolfgang (1630m) up to Weissfluhjoch (2700m). Towards the end of the Würm glacial period a double rockslide with a total mass of 0,5 km^3 breaking off from the east slope of the Totalphorn blocked the valley with acid silicates and serpentinite between the present Lake of Davos and the village of Klosters (cf. Juchler and Sticher 1985).

The profile under discussion lies in the Delenwald area on the landslide debris, at a site where only serpentinite has accumulated.

Table 1: Mineralogy of the Augite-Serpentinite

Main components		
Chrysotile	(tubular)	$Mg_6Si_4O_{10}(OH)_8$
Lizardite	(lamellar)	same formula as chrysotile
Augite	(Diallage)	$CaMgSi_2O_6$
Enstatite		$MgSiO_3$
Trace components		
Garnet		$Ca_3(Fe,Cr)_2(SiO_4)_3$
Picotite		8 $(Fe,Mg)(Al,Cr)_2O_4$
Rutile		TiO_2
Magnetite		Fe_3O_4
Pentlandite		$(Fe,Ni)_9S_8$
Chlorite		$(Mg,Al,Fe)_{12}(Si,Al)_8O_{20}(OH)_{16}$

1.4 Relief and vegetation

The profile is situated on a NNW-facing slope with an incline of 45 %. According to Landolt et al. (1976) the vegetation is a mountain pine forest with heather (Erico-pinetum montanae).

2 Description of the profile (Delenwald I)

(see figure 4)

O organic horizon, black (10 YR 2/1) pH 4.0

(E)A leached transitional horizon, greyish yellow-brown, (10 YR 4/2) pH 4.4; silt loam, 10 % gravel and stones, superficially weathered

Bv1 weathering horizon, brown, (10 YR 4/6), pH 5.3; silty clay loam; fine subangular blocky; 15 % gravel and stones, weathered

Bv2 weathering horizon, brown, (1 Y 5/6), pH 5.6; clay loam; medium subangular blocky, partly single grained. 40 % gravel and stones, weathered

BC transitional horizon, dark olive brown, (1.25 Y 4/4) pH 5.9; loamy sand, coherent single grained; 30 % gravel and stones, fresh

C parent material, olive brown, (2.5 Y 4/3), pH 6.1; loamy sand, single grained. 50 % gravel and stones, fresh but covered with illuviated clay

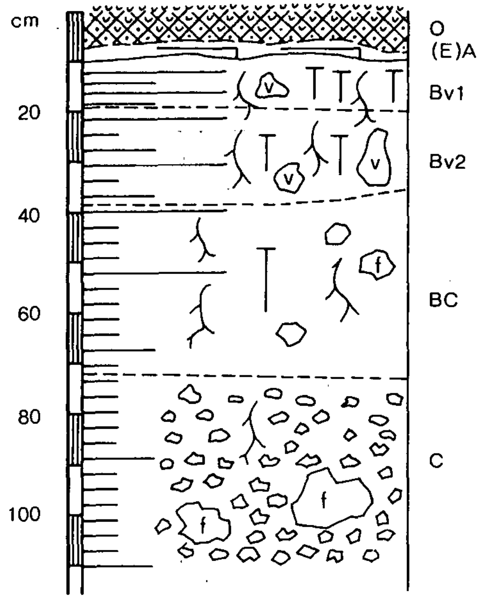

Figure 4: Diagram and short description of the profile Delenwald I

3 Classification (tentative)

CH: Saure Serpentin-Braunerde
FAO: Serpentinitic Cambisol
US-Taxonomy: Loamy-skeletal, serpentinitic, frigid, dystric Eutrochrept

4 Characterization of the profile

4.1 Soil physical properties

The stone content decreases gradually from the parent material (48% v/v) upwards, the (E)A-horizon still containing 5% v/v. It seems that either the rock debris in the BC-horizon was inhomogeneously deposited or the site was exposed to solifluction after deposition.

The soil texture can be described as follows: silt loam in the (E)A; silty clay loam in the Bv1; clay loam in the Bv2; loamy sand in the BC and in the C. The Bv1- and Bv2-horizons contain the greatest amount of clay, i.e. 27%, while the (E)A and Bv1 have the most silt (55%). The Bv1 has the lowest sand content (19%), which then increases continuously to the C-horizon (85 %).

Since the stone content was too high to allow homogeneous sampling, desorption curves and Kf-value could not be determined.

Bulk density was judged by determining the volume of an extracted sample with sand. Since the O- and (E)A-horizons are very thin, they were combined for this determination.

The porosity of the C-horizon is about 50 %. Intensive weathering and removal of soil components caused an increase of the porosity to 70% in the Bv1-horizon. The raw humus layer has a porosity of as much as 85%, due to the looseness of the plant litter.

4.2 Soil chemical properties

The O- and (E)A-horizons are acid with pH-values ($CaCl_2$) of 4 and 4,4 respectively, while the mineral soil is buffered at pH-values between 5,5 and 6.

The content of dithionite-soluble iron is highest in the Bv1-horizon (5,4 %), while the (E)A-horizon contains the most oxalate-soluble iron (1,6%). However, neither the (E)A- nor the Bv1-horizon can be classified as a spodic horizon according to the US-Taxonomy.

The climatically retarded decomposition of the plant litter is reflected in the high organic carbon content of the O-horizon and the (E)A-transition horizon. C/N-ratios of between 20 and 30 are typical for moder and raw humus respectively.

Protons, Mg and Ca ions dominate (V = 55%) the exchanger sites of the top soil, while in the lower soil Mg and protons prevail. The high Ca content in the top soil is caused by the biological Ca cycle as well as by the selectivity of the exchanger for Ca.

Table 2: Physical and chemical properties of the profile Delenwald I

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k sat. cm/d	k sat. var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0-3	5	-	-	-	-	-	-	-	-	-	-	-
2	(E)A	4-6	5	4	2	16	22	16	23	16	55	23	-	-
3	Bv1	8-15	13	2	2	15	19	19	21	14	54	27	-	-
4	Bv2	20-30	44	13	6	22	41	12	13	7	32	27	-	-
5	BC	50-60	33	34	17	30	81	5	4	2	11	8	-	-
6	C	80-90	48	50	15	20	85	5	4	2	11	4	-	-

No	hor.	bulk dens. g/cm^3	porosity E	water content in %v at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	0 } (with 2)	0,29	0,87	-	-	-	-	4,7	4,0	-	-	-	-	13
2	(E)A			-	-	-	-	5,1	4,4	39,7	15,7	0,40	1650	4
3	Bv1	0,79	0,70	-	-	-	-	6,0	5,3	53,7	12,1	0,23	770	2
4	Bv2	1,37	0,48	-	-	-	-	6,4	5,6	27,4	6,9	0,25	340	2
5	BC	1,37	0,49	-	-	-	-	6,6	5,9	13,8	4,9	0,36	250	1
6	C	1,44	0,46	-	-	-	-	6,8	6,1	11,8	3,9	0,33	280	1

No	hor.	C org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	0	36,8	12,7	29,0	-	410	-	82	6,8	136	1,5	184	< 2	55
2	(E)A	10,2	4,1	24,9	-	319	-	33	1,3	130	0,5	154	< 2	52
3	Bv1	3,0	1,4	21,4	-	216	-	11	0,5	117	0,4	87	< 2	60
4	Bv2	1,2	0,5	23,9	-	167	-	3	0,3	105	0,3	58	< 2	65
5	BC	0,4	< 0,1	-	-	106	-	4	0,1	70	0,3	32	< 2	70
6	C	0,2	< 0,1	-	-	96	-	3	< 0,1	61	0,3	32	< 2	67

4.3 Mineralogical properties

4.3.1 Weathering of Augite-Serpentinite

The augite-serpentinite contains zones of almost pure serpentine as well as zones with high augite and garnet content. On the basis of a detailed mineralogical analysis of the different particle size fractions and of the weathering crust of several stones taken from the Bv-horizon, we can describe the weathering behaviour of serpentinite as follows:

Augite:	breaks down into crystals of 200 µm which are chemically unstable. Therefore weathered soils seldom contain augite with a particle size < 20 µm (Fig. 5).
Serpentine minerals:	(Chrysotile and Lizardite) disintegrate into separate crystals of 2 µm or bundles of fibres (Fig. 7). The stability decreases rapidly with decreasing pH. Thus intensive weathering occurs under raw humus.
Garnet:	breaks down into single crystals of 1 to 125 µm, which are chemically relatively stable. Its concentration therefore increases strongly in the clay and silt fractions of the weathered zones (Fig. 5).

In contrast to other serpentinite soils (e.g. Rabenhorst et al., 1984), only a small amount of non-serpentine clay minerals (chlorite and smectites) were found (Fig. 7). Their presence can be satisfactorily explained through the accumulation of aeolic dust, and no neoformation or transformation need to be considered.

4.3.2 The occurrence of an eluvial horizon in serpentinite soils

Results from X-ray diffraction analysis show that the silt-rich (E)A-horizon contains mainly quartz and traces of mica and feldspar, but no serpentine minerals. This means that the (E)A-material must have been deposited as aeolic dust. The particle size distribution (rel.maximum of 20 µm) of the quartz fraction substantiates this theory (Fig. 8). In addition, phytolites constitute a considerable fraction of the particles in the eluvial horizon (Fig. 7b).

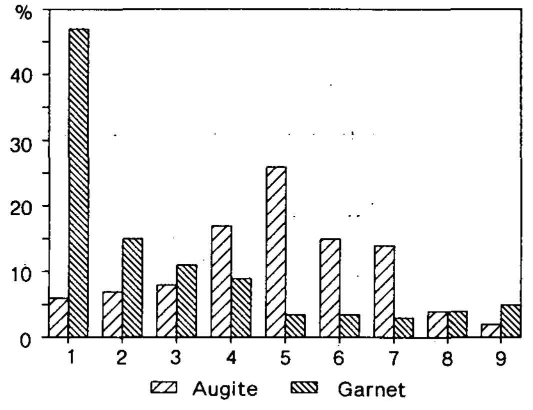

Figure 5: Percentual distribution of garnet and augite in the particle size fractions of the Bv1-horizon of profile Delenwald II

1 Clay	6 63 - 125 µm
2 2 - 5 µm	7 125 - 250 µm
3 5 - 10 µm	8 250 - 500 µm
4 10 - 20 µm	9 500 - 1000 µm
5 20 - 63 µm	

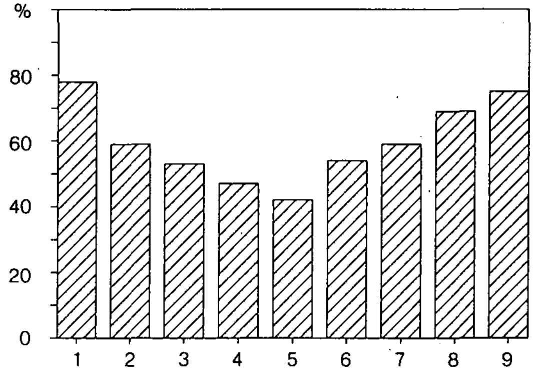

Figure 6: content of chrysotile/lizardite in the particle size fractions of the Bv1-horizon of profile Delenwald II (1-9 see figure 5)

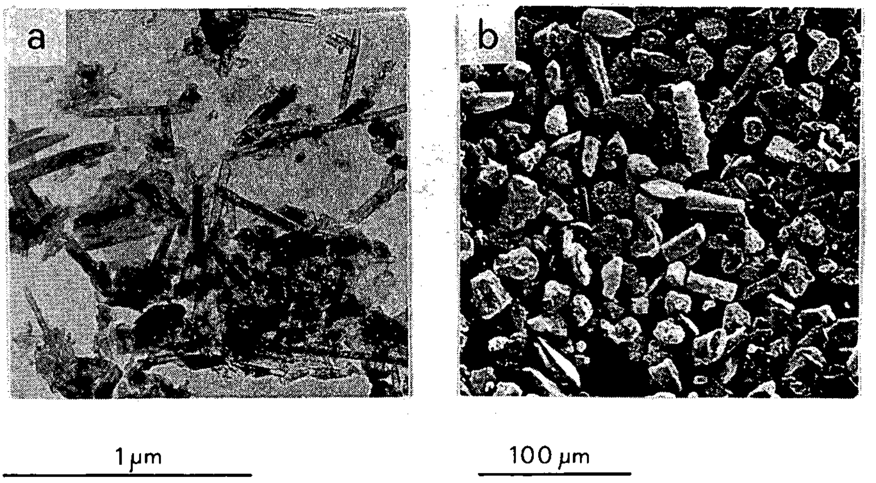

Figure 7:(a) Transmission electronmicrograph of the clay fraction separated from the Bv-horizon of profile Totalpbach.
Figure 7:(b) Scanning electronmicrograph of the silt fraction (20 to 63 μm) separated from the (E)A-horizon of the profile Totalpbach

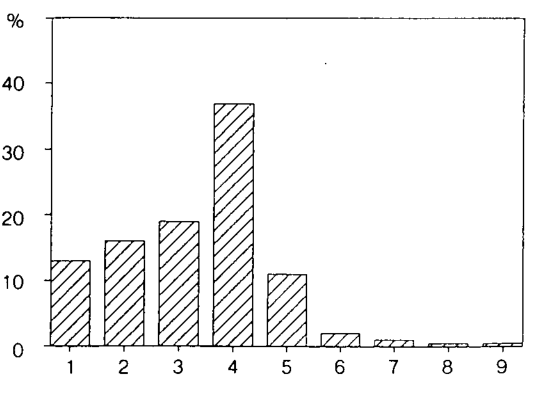

Figure 8: Particle size distribution of the quartz present in the Bv-horizon of profile Delenwald II (1-9 see figure 5)

5. Dynamics of Chromium and Nickel

5.1 Total chemical analysis

The parent rock contains 1700 and 1800 ppm Cr and Ni respectively. The distribution is not uniform in the parent rock: augite within the augite-serpentinite contains 6200 ppm Cr, but only 200 ppm Ni (Peters, 1963). On the other hand Ni is concentrated in the serpentine minerals. By the action of weathering and transport processes the relative content of these elements as well as of the other components has been substantially changed in the different horizons. According to Table 3 the elements may be divided into four groups:

maximum in vegetation:	Ca
maximum in (E)A-horizon:	Mn
maximum in Bv1-horizon:	Cr, Fe
maximum in C-horizon:	Mg, Ni

Table 3: Chemical analysis of shrub vegetation, O-horizon and the fine earth of the mineral horizons (Profile Delenwald I. Data on dry matter basis).

Element	Mg	Ca	Al	Fe	Mn	Ni	Cr
	o/oo	o/oo	o/oo	o/oo	ppm	ppm	ppm
Horizon							
Veget.	2,1	3,07	0,6	0,8	480	20	10
O	9,2	1,04	3,9	16,1	1320	110	280
(E)A	38,0	2,31	53,0	62,8	3400	380	2580
Bv1	52,0	1,82	57,6	91,2	1980	580	2620
Bv2	166,0	0,76	30,8	64,6	840	980	1940
C	206,0	0,16	17,5	58,2	880	1820	1740

5.2 Heavy metal content in particle size fractions

As was shown before, serpentinite disintegrates into its constituent minerals during weathering. Chrysotile breaks up into single fibres and fibre bundles occuring mainly in the clay fraction (Fig. 7), which is subjected to the most intensive weathering due to its large (specific) surface. Augite, whose crystal size lies between 100 and 200 um in the parent rock, is concentrated in the coarse silt and fine sand fraction of the weathered soil (Fig.5).

Garnet, which is rather resistent against weathering, is strongly enriched even though it occurs mainly in the clay fraction. As a result of these processes a decrease in nickel content and an increase in chromium content occur in the Bv1-horizon as compared to the BC-horizon and the parent rock (Table 4). Therefore Cr is more concentrated in the Bv1-horizon than Ni, particularly in the particle size fractions in which augite and Cr-containing minerals prevail. (Table 5).

Table 4: Ratios of the Ni and Cr content in the particle size fractions of the horizons Bv and BC (Profile Delenwald II, after removal of free iron oxides)

	Cr	Ni	B	BC
µm	B/BC	B/BC	Cr/Ni	Cr/Ni
2	2,1	0,7	2,0	0,7
2- 5	2,3	0,8	1,9	0,6
5- 10	2,8	0,8	1,9	0,6
10- 20	2,6	0,7	2,9	0,8
20- 63	3,6	0,6	9,7	1,5
63-125	2,9	0,9	3,0	1,0
125-250	3,0	1,0	2,3	0,8

5.3 The heavy metal fraction extracted with various solvents

In order to specify different heavy metal fractions the fine earth of the mineral horizons was extracted with various common solvents. The results are given in Table 5. The values are related to the weight of the fine earth.

With all extractants maximum chromium amounts were found in the uppermost part of the Bv-horizon. Towards the subsoil the values decreased continuously. This behaviour can be explained through the very low solubility of trivalent chromium in the pH-range above 4. Immediately after hydrolytic release in the course of weathering processes chromium is precipitated as hydroxide together with iron, forming the yellow-red weathering crust typical for Bv-horizons.

In contrast to chromium, the nickel content increased continuously towards the subsoil and reached its maximum in the C-horizon. Due to the higher pH in the subsoil nickel is increasingly adsorbed onto the surface of iron hydroxide particles (Gerth and Brümmer 1983), which seem to percolate with the gravitational water.

Table 5: Heavy metal content and ratios in different soil extracts (ppm)

	Fe	Ni	Cr	Fe/Ni	Fe/Cr	Ni/Cr
Bulk analysis						
O	16100	110	280	146	57	0,4
(E)A	62800	380	2580	165	24	0,1
Bv1	91200	580	2620	157	35	0,2
Bv2	64600	980	1940	66	33	0,5
C	58200	1820	1740	32	33	1,0
DCB (Mehra and Jackson)						
(E)A	39700	88	290	451	137	0,3
Bv1	53700	146	549	365	98	0,3
Bv2	27400	229	314	120	87	0,7
BC	13800	269	171	51	81	1,6
C	11800	295	93	40	127	3,2
Oxalate (Schwertmann 1964)						
(E)A	15700	47	68	334	321	0,7
Bv1	12100	44	116	275	104	0,4
Bv2	6900	72	98	96	70	0,7
BC	4900	169	74	29	66	2,3
C	3900	208	46	19	85	4,5
Na-Pyrophosphate (Loveland and Digby 1984)						
(E)A	3350	35	102	96	33	0,3
Bv1	1900	23	125	83	15	0,2
Bv2	950	24	77	40	12	0,3
BC	470	25	40	19	12	0,6
C	280	25	21	11	13	1,2

5.4 Gravitational water

Gravitational water was collected with lysimeters in two profiles (Budlerboden and Arelen) over one year. Nine lysimeters at three different depths were placed in each profile. The three collection points were situated below the O/(E)A-, Bv1- and Bv2-horizons respectively. Every month the heavy metal content of the collected solution was determined through AAS (graphite furnace).

In both soils the Ni content increased from the top to the bottom of the profile while Cr and Fe had their highest concentration in the top part of the Bv-horizon. Dialysis of the soil solution showed that the latter two elements, which are practically insoluble at slightly acid pH-values, are transported in solid form. The downward increase in pH causes a gradual coagulation and deposition of the respective particles. The different behaviour of Ni and Cr results in a steadily increasing Ni/Cr-ratio in the downward moving soil solution (Table 6).

Table 6: Mean annual heavy metal contents and heavy metal ratios in the soil solution collected from lysimeters in profile Delenwald III (Data given in ppb)

	Fe	Ni	Cr	Fe/Ni	Fe/Cr	Ni/Cr
Lysimeter below						
O/(E)A	520	15	23	34	22	0,6
Bv1	1670	52	56	32	30	0,9
Bv2	1600	70	51	23	31	1,4

5.5 Plant Analyses

The different solubility of the two elements in the soil solution is again expressed in the plant analyses. Although large differences in the Ni/Cr ratio occurred in the various plant species, the average uptake of Ni was appreciably higher than that of Cr. In spite of the low Cr content of the plant material, there was a strong accumulation of this element in the raw humus due to the formation of stable complexes with humic acids. (Table 7).

Table 7: Ni and Cr content of different plants, of roots and of the O-horizon of profile Delenwald II (in ppm on dry matter basis)

	Ni	Cr	Ni/Cr
Calmagrostis sp.	15,2	1,4	9,4
Luzula sp.	5,5	3,0	1,6
Deschampsia sp.	11,2	1,1	9,0
Vacc. myrtillis (leaves)	23,4	1,9	10,9
Erica carnea	14,5	0,9	15,9
Juniperus nana (needles)	82,1	3,3	8,5
Larix decidua (needles)	20,4	0,6	31,4
Picea abies (needles)	6,6	1,0	5,6
Pinus montana (needles)	15,5	0,5	26,5
Roots from raw humus	18,5	13,7	1,2
Raw humus ($<$ 2mm)	114,0	428,0	0,23

6. Conclusions

The low plant production capacity of the soils on serpentinite is obvious when compared to the neighbouring sites on acid silicate parent material. Different reasons have been given for this worldwide phenomenon (see summary by Proctor and Woodell 1975): high Mg/Ca ratio of serpentinite, P and K deficiency, or high heavy metal content. From our results it must be concluded that chromium at least is out of the question. But together with the other growth-limiting factors the high nickel uptake by some species may indeed be a reason for the scant fertility, which may furthermore be reduced by the unfavourable physical stability of the soil matrix enhancing the risk of erosion by water and also wind.

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SOILS ABOVE THE TIMBERLINE IN THE UPPER ENGADIN (Station CH-6, Profiles MUOTTAS 1 and 2)

by

M. Müller*

1 Introduction

1.1 Geographical location

Both profiles lie on the ridge of Muottas Muragl (Township Samedan, Upper Engadin, canton of the Grisons, Switzerland). The distance between them is about 300m.

Profile MUOTTAS 1: Coord. 789.660/155.260; 2520m above sea level

Profile MUOTTAS 2: Coord. 789.900/155.430; 2540m above sea level

Land map of Switzerland 1:25 000, sheet 1257, St. Moritz

1.2 Geology

The ridge between Val Muragl and Val Champagna belongs to the Languard-nappe, the lower most element of the Middle Austro-Alpine. The parent material of both profiles is the sandy deposit of a coarse-grained gneiss, analysed by Schuppli (1921) as Muscovite-gneiss of Muottas Muragl (Tab. 1).

Table 1. Analysis Muscovite-gneiss of Muottas Muragl (Schuppli H, 1921: Petrographische Untersuchungen im Gebiet des Piz Languard [Oberengadin]. Dissertation University of Zurich)

SiO_2	74.02%	CaO	1.22%
TiO_2	traces	Na_2O	2.00%
Al_2O_3	13.87%	K_2O	6.09%
Fe_2O_3	0.96%	H_2O(110°)	0.10%
FeO	0.90%	H_2O(110°)	0.67%
MgO	0.23%	Total	100.06%

density 2.65

1.3 Climate and topography

The Upper Engadin is screened from rain-carrying winds by high mountain ranges. The result is a continental climate with below average precipitation and minimal cloud cover.

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The average temperature for the Muottas Muragl area is -1.5° C (elevation 2,500m above sea level). The mean precipitation is 1085mm, about a third falls during the summer (Fig. 1).

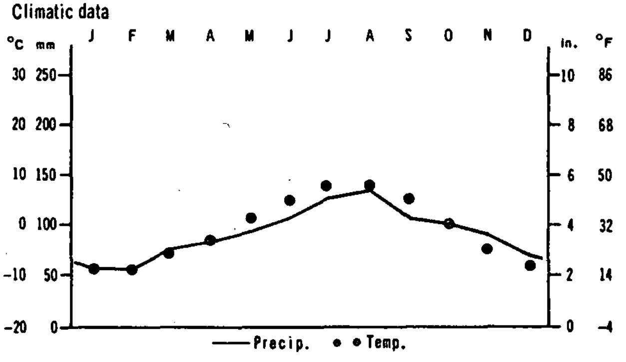


Figure 1. Temperature and precipitation at 2500m above sea level in Val Muragl. Calculated by G. Gensler.

Lacking the moderating effects of a tree or dwarf-shrub canopy, the alpine microclimate is primarily influenced by the topography. The topography and microclimates of the MUOTTAS 1 and 2 profiles are compared in Table 2. MUOTTAS 1 lies on a slope in a wind-protected, sunny trough which, due to drifts, is snow covered longer than MUOTTAS 2. MUOTTAS 2 is located on a shady, wind-exposed terrace.

Using the sucrose inversion method, the effective mean temperatures at 5cm soil depth were measured during different periods (Tab. 3).

1.4 Vegetation, management

Both profiles lie above the timberline under alpine grass habitats. Intensive pasturing, wood-felling and intentional fire-clearing to expand pasturage have pushed the timberline down to its present elevation of 2100 to 2300m above sea level. Below approx. 2450m one increasingly finds transitions from grass to dwarf-shrub associations, which are often evidence of earlier timber stands. The MUOTTAS 1 and 2 profiles, however, most probably developed under grassland, uninfluenced by trees and dwarf-shrubs.

The Val Muragl belongs to an alpine farm cooperative of the same name. The Muragl Alp was used as a dairy pasture until 1949; today it serves as summer pasturage for heifers.

The MUOTTAS 1 profile lies under a matgrass pasture while MUOTTAS 2 is covered by a Carex curvula sward (see Section 4.4).

Table 2. Comparison of topographie and microclimate for the profiles MUOTTAS 1 and 2.

	MUOTTAS 1	MUOTTAS 2
Elevation	2520 m	2540 m
Exposition	SSW	- (generally N)
Slope	30%	-
Situation	slope trough, gain-site, drift accumulative	terrace, loss-site
Duration of snow-melt infiltration following thaw	a few weeks to a month	a few days
Average soil humidity during vegetation period	moist	moist to dry
Duration of snow cover	8 months	7 - 8 months
Temperature during vegetation period	relatively warm for the elevation	relatively cool for the elevation
Soil temperature in winter	seldom under $0^{o}C$	soil frozen
Wind exposure	protected	exposed

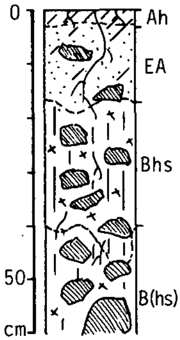
Table 3. Effective mean temperature and minimum temperature (°C) at 5cm soil depth. Standard deviations in parentheses.

Period of measurement	Muottas 1	Muottas 2
August 6 - September 3, 1980	12.55	--
September 3 - September 26, 1980	10.97(0.19)	7.79(0.59)
September 26, 1980 - July 3, 1981	2.78(0.13)	0.10(0.06)
August 1 - August 30, 1984	10.21(0.09)	--
August 30 - September 28, 1984	6.45(0.18)	--
September 28, 1984 - July 4, 1985	0.14(0.04)	--
Temperature minima		
September 30, 1980 - July 3, 1981	0.0	-13.7

2 Profile descriptions

Horizon designations according to FAO. Colors are for moist soil.

Profile MUOTTAS 1:



Ah
(USA: A1; CH: Ah)

0-3cm; brownish black (7.5YR 3/1) mull-typer moder; bleached mineral particles; little skeleton; fine crumbs, up to 2mm diameter; dense network of fine roots.

Clear smooth boundary

EA
(USA: A2; CH: (A)E)

3-17cm; grayish yellow brown (10YR5/2) loamy sand; 14% by volume skeleton, particles less than 5cm diameter, highly weathered; fine granular to fine crumb; many fine roots.

Abrupt wavy boundary

Bhs
(USA: B21hir; CH: Bhs)

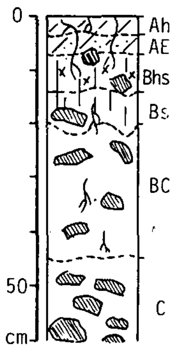
17-40cm; reddish black (5YR2/2) loamy sand; 20% by vol. skeleton, particles up to 10cm diameter, weathered; partly cemented (ortstein); few roots.

Clear irregular boundary; up to 30cm deep pockets into the B(hs) horizon.

B(hs)
(USA: B22hir; CH: B(hs))

40-70cm; brown (7.5YR4/4) sand; 56% by volume skeleton, particles often larger than 10cm diameter, slightly weathered; partly loose, partly weakly cemented; isolated roots.

Profile MUOTTAS 2:



Ah
(USA: A11; CH: Ah)

0-3cm; brownish black (5YR2/1) mull-typer moder; bleached mineral particles; little skeleton; fine crumbs up to 2mm diameter; dense network of fine roots.

Mostly clear smooth boundary

AE
(USA: A12; CH: (E)A)

3-7cm; very dark brown (7.5YR2/3) loamy sand, slightly bleached; little skeleton; fine crumb and fine granular; many fine roots.

Mostly clear smooth boundary

Bhs
(USA: B21hir; CH: Bhs)

7-14cm; reddish black (2.5YR2/1) loamy sand; 15% by volume skeleton, most particles smaller than 1cm diameter, weathered; few roots.

Clear wavy boundary

Bs
(USA: B22ir; CH: Bs)

14-20cm; dark reddish brown (5YR3/4) sand; 21% by volume skeleton, most particles smaller than 5cm, weathered; few roots.

Clear wavy boundary; pockets into the BC horizon.

BC
(USA: B3; CH: BC)

20-45cm; dull yellowish brown (10YR5/4) sand; 64% by volume skeleton, some particless larger than 10cm diameter, slightly weathered; single roots.

Clear wavy boundary

C
(USA & CH: C)

45-70cm; dull yellow (2.5Y5/3-6/3) sand; 76% by volume skeleton, some particles larger than 40cm diameter, unweathered; no roots.

3 Classification of the profiles

Profile MUOTTAS 1:	CH, GFR:	Alpiner Eisenhumuspodsol
	FAO:	Orthic Podzol
	USA:	Typic Cryorthod
	F:	Podzol humo-ferrugineux alpin

Profile MUOTTAS 2:	CH:	Alpiner Braunpodsol (with Bhs-horizon)
	GFR:	Braunerde-Podsol
	FAO:	Orthic Podzol
	USA:	Haplic Cryohumod
	F:	Sol podzolique humifère (alpin)

4 Physical, chemical, microbiological and botanical analyses

4.1 Physical soil properties

The MUOTTAS 1 profile is a highly permeable, drought-prone soil. The high permeability is explained by the large proportion of coarse pores and respectively small amounts of clay and silt (Tab. 4,5,6; Fig. 2). The available water holding capacity is small, therefore the soil tends to dry out (holding capacity for readily available water 25mm [respectively liter/m² soil], holding capacity for water with reduced availability [high soil moisture tension] 31mm; total 56mm; calculated for the upper 40cm of soil).

The low apparent density in the Ah-horizon is due to the high organic matter content, while the conspicuously large proportion of fine pores could be a result of the method used for measurement (core-sample on tension table).

Porosity and permeability were determined in the MUOTTAS 1 profile only, but the MUOTTAS 2 profile should show similar values.

Table 4. Density, porosity, pore-size distribution and permeability of the MUOTTAS 1 profile. Measurements were made on core-samples 4,2 cm high by 5,5 cm diameter.

Horizon	Depth cm	Bulk density a oven-dry g cm^{-3}	Particle density r oven-dry g cm^{-3}	Porosity E $E=1-\frac{r}{a}$	Water content in % by vol. at pF (bars) 2(0,1)	3(1)	4,2(15)	kf cmd^{-1}
Ah	0- 3	0,7	1,8	0,619	43,5	37,7	31,0	180
EA	3-17	1,25	2,44	0,488	22,6	17,2	8,9	500
Bhs	17-40	1,28	2,70	0,526	26,3	19,5	12,0	460

Table 5. Results of analysis for Profile MUOTTAS 1

No	hor.	depth cm	skel. %	texture; % of humus-free fine earth (particle diameter in mm) sand coarse 2-0,5	med. 0,5-0,2	fine 0,2-0,1	very f. 0,1-0,05	Σ	silt	clay	kf cm/d	kf cm/sec
1	2	3	4	5	6	7	7a	8	12	13	14	15
1	Ah	0-3	<1								180	$2x10^{-3}$
2	EA	3-17	14	27,4	25,5	11,9	8,9	73,8	15,6	10,7	500	$6x10^{-3}$
3	Bhs	17-40	20	28,0	25,6	12,3	10,8	76,7	15,9	7,4	460	$5x10^{-3}$
4	B(hs)	40-70	56	45,8	27,0	8,5	6,4	87,7	7,4	4,9		

No	hor.	bulk dens. g/cm^3	porosity %	water content in % at pF 2,0	3,0	4,2	pH H_2O	pH $CaCl_2$	Fe_d mg/g min. fine earth (*g/litre soil)	Fe_o	Al_d	Fe_o/Fe_d	Mn_o mg/kg (*mg/l soil)	$P_{citr.}$
1	2	16	17	19a	20a	21a	22	23	24	25		26	27	28
1	Ah	0,7	61,9	43,5	37,7	31,0	4,6	3,9	6,7	3,3	2,3	0,49	1806	160
									3,2*	1,6*	1,1*		1284*	114*
2	EA	1,25	48,8	22,5	17,2	8,9	4,3	3,8	3,1	1,2	1,0	0,41	251	23
									2,8*	1,1*	0,9*		231*	21*
3	Bhs	1,28	52,6	26,3	19,6	12,0	4,7	4,2	11,8	10,0	7,0	0,84	33	18
									8,6*	7,3*	5,0*		26*	14*
4	B(hs)	1,79					4,8	4,4	4,4	3,1	4,3	0,70	87	199
									1,7*	1,2*	1,6*		34*	77*

No	hor.	$C_{org.}$ %	$N_{tot.}$ mg/g	C/N	carbonate %	CEC pot. meq/kg	exchangeable cations in meq/kg Ca	K	Mg	Na	H	V %
1	2	29	30	31	32	33	35	36	37	38	39	41
1	Ah	14,5	11	13	-	304	58	19,2	21	2,4	204	33
2	EA	1,3	2	8	-	72	5	1,3	2	0,3	63	12
3	Bhs	2,8	2	13	-	126	3	0,9	1	0,4	121	4
4	B(hs)	1,1	1	13	-	33	2	0,4	0,3	0,2	30	9

Table 6. Results of analysis for Profile MUOTTAS 2

No	hor.	depth	skel.	texture; % of humus-free fine earth (particle diameter in mm)							kf	
				sand					silt	clay		
		cm	%	coarse 2-0,5	med. 0,5-0,2	fine 0,2-0,1	very f. 0,1-0,05	Σ			cm/d	cm/sec
1	2	3	4	5	6	7	7a	8	12	13	14	15
1	Ah	0-3	<1									
2	AE	3-7	<1	31,7	17,9	10,4	8,9	68,9	18,9	12,3		
3	Bhs	7-14	15	28,9	16,4	10,1	11,6	66,9	25,5	7,7		
4	Bs	14-20	21	32,9	17,1	9,5	10,2	69,6	21,6	8,8		
5	BC	20-45	64	18,2	15,5	10,8	12,6	57,1	30,6	12,3		
6	C	45-70	76	44,4	17,0	7,1	6,6	75,1	18,2	6,7		

No	hor.	bulk dens. g/cm^3	porosity %	water content in % at pF 2,0	3,0	4,2	pH H_2O	$CaCl_2$	Fe_d	Fe_o	Al_d	Fe_o/Fe_d	Mn_o	$P_{citr.}$
									mg/g min. fine earth (*g/litre soil)				mg/kg (*mg/l soil)	
1	2	16	17	19a	20a	21a	22	23	24	25		26	27	28
1	Ah						4,4	3,6	8,4 2,9*	2,5 0,9*	3,8 1,3*	0,29	33 21*	144 92*
2	AE						4,3	3,6	2,4 1,4*	0,8 0,5*	1,3 0,7*	0,33	2 1*	
3	Bhs						4,7	3,8	9,5 6,6*	7,9 5,5*	7,1 4,9*	0,82	9 7*	
4	Bs						5,3	4,1	4,4 3,3*	2,5 1,9*	4,7 3,5*	0,58	45 36*	
5	BC						5,5	4,3	3,5 2,5*	1,5 1,0*	1,9 1,3*	0,42	115 81*	
6	C						6,0	4,5	2,2 0,7*	0,9 0,3*	0,9 0,3*	0,43	96 29*	

No	hor.	$C_{org.}$ %	$N_{tot.}$ mg/g	C/N	carbonate %	CEC pot. meq/kg	exchangeable cations in meq/kg Ca	K	Mg	Na	H	V %
1	2	29	30	31	32	33	35	36	37	38	39	41
1	Ah	26,3	13	20	-	344	61	9,4	16,8	0,9	256	26
2	AE	4,3	3	15	-	176	13	1,2	4,1	0,5	157	11
3	Bhs	5,3	3	18	-	219	5	0,4	1,1	0,5	212	3
4	Bs	2,3	1	19	-	97	1	0,4	0,3	1,0	94	3
5	BC	0,6	0,5	13	-	38	1	0,4	0,3	1,1	35	7
6	C	0,2	0,3	8	-	16	1	0,5	0,2	0,8	14	14

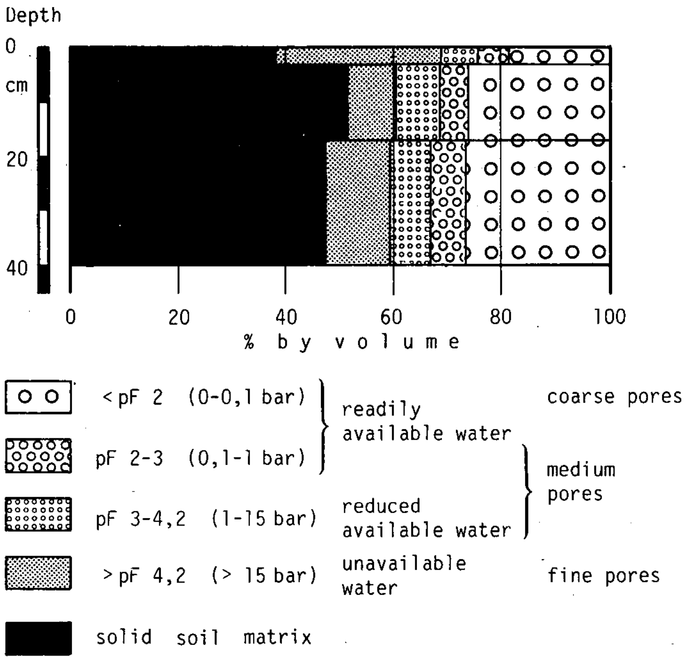


Figure 2. MUOTTAS 1 profile: Pore-size distribution as defined by the corresponding soil moisture tensions.

4.2 Chemical soil properties

Both soils are very acid and exhibit distinct features of podzolisation (Tab. 5, 6, 7; Fig. 3).

The organic matter (ignition losses) counts for 41% and 46%, respectively, of the Ah-horizon in the MUOTTAS 1 and 2 profiles. The extractable proportion of organic carbon increases with depth and is over 90% in the illuvial horizons.

As a result of the low clay content, the cation-exchange capacity depends mostly on the organic matter. In the MUOTTAS 1 profile 39% and in the MUOTTAS 2 profile 53% of the exchangeable bases are located in the upper 3cm of soil, where most of roots are also found.

In both profiles major translocations of sesquioxides and organic matter were observed (Tab. 7; Fig. 3). The highest iron and aluminium contents lie not in the Bs-, but in the dark Bhs-horizons. Also the highest Fe_o/Fe_d ratios were found here.

In Fig. 4 the humus and iron contents per m² of the profiles MUOTTAS 1 and 2 are compared. The morphologically better differentiated, further developed MUOTTAS 1 profile clearly has more free iron. On the other hand, the organic matter contents differ little.

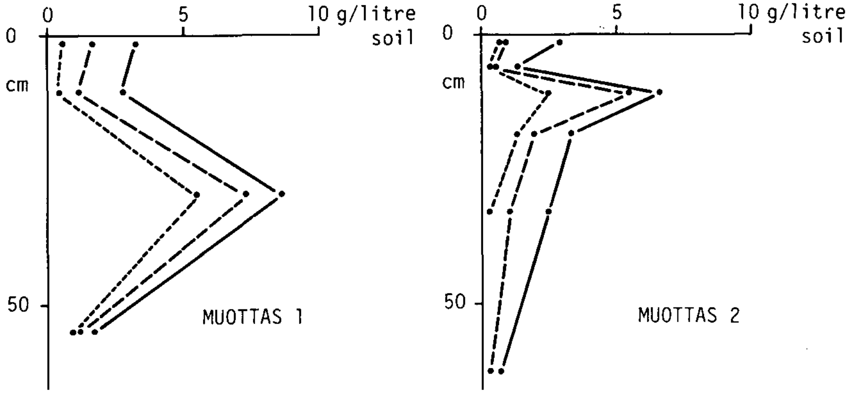


Figure 3. Distribution of Fe_d, Fe_o, Fe_{py} in profiles MUOTTAS 1 and 2.

——— Fe_d (dithionite-citrate extractable iron)
— — Fe_o (oxalate extractable iron)
------ Fe_{py} (pyrophosphate extractable iron)

Table 7. Chemical characteristics of the organic matter found in the MUOTTAS 1 and 2 profiles
C_{py}: Pyrophosphate extractable C

Horizon	Depth cm	Ignition loss %	Organic C (C) %	Fulvic acids (FA) %	Humic acids (HA) %	C_{extr} (FA+HA) %	C_{extr}/C	C_{py} %	C_{py}/C	N %	C/N
Profile MUOTTAS 1											
Ah	0- 3	32,2	14,5	3,8	2,4	6,2	0,43	2,3	0,16	1,1	13
EA	3-17	7,1	1,3	0,9	0,2	1,1	0,90	0,6	0,47	0,2	8
Bhs	17-40	11,8	2,8	1,9	0,7	2,6	0,95	2,8	1	0,2	13
B(hs)	40-70	6,1	1,1	1,1	0,2	1,3	1	1,2	1	0,1	13
Profile MUOTTAS 2											
Ah	0- 3	46,2	26,3	3,7	3,0	6,6	0,25	3,2	0,12	1,3	20
AE	3- 7	11,4	4,3	2,2	1,1	3,4	0,79	1,1	0,25	0,3	15
Bhs	7-14	11,9	5,3	3,0	1,9	4,8	0,91	3,1	0,58	0,3	18
Bs	14-20	5,4	2,3	2,1	0,6	2,6	1	1,4	0,64	0,1	19
BC	20-45	1,7	0,6							0,05	13
C	45-70	0,5	0,2							0,03	8

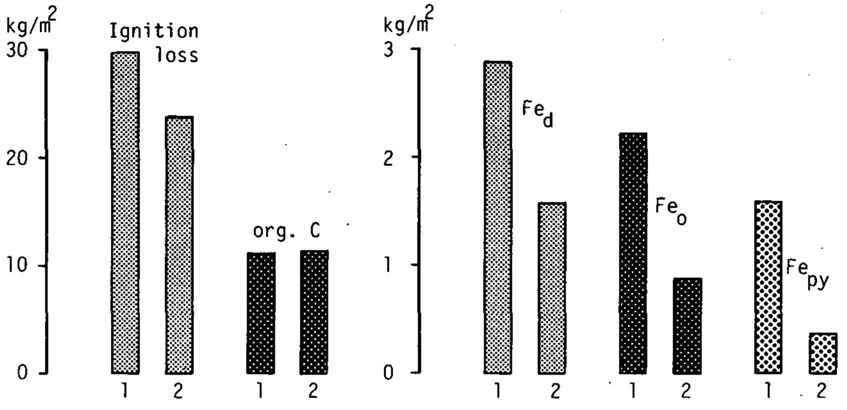


Figure 4. Organic matter and iron contents per m^2 in the MUOTTAS 1 (1) and MUOTTAS 2 (2) profiles.

4.3 Soil biological properties and analyses **(by W. Jäggi*)**

The presence of various groups of soil microorganisms and the potential for microbial decomposition of organic material were determined by the same methods used for the KLOSTERS profile (Station CH-4).

The majority of microorganism groups appears less frequently in the MUOTTAS 1 profile than in the reference profile RECKENHOLZ (Fig. 5).

In MUOTTAS 1 the size of the bacteria populations grown on peptone or mineral agar media was the same. This indicates that all bacteria present can multiply on a mineral-glucose medium without any other source of energy or carbon.

With the exception of the fungi, nitrite oxidizers and cellulose decomposers, soil microorganisms are less abundant in the Bhs-horizon than in the other horizons. The reasons for these exceptions may be that most of the cellulytes are fungi which still find a relatively suitable environment in this horizon and that the low pH-values adversly affect the nitrite oxidizers.

In the laboratory analysis, the cellulose degradation in the Ah-horizon of the MUOTTAS 1 profile is higher than in the Ap-horizon of the reference profile RECKENHOLZ (Fig. 6.a), even though the cellulytes' densities are the inverse (Fig. 5). The incubation period for determining the potential cellulose degradation of 4 or more weeks is relatively long. During this time, a specific population capable of degrading this substrate develops. Therefore, the developmental conditions in the laboratory for the cellulytes in the Ah-horizon of the MUOTTAS 1 profile are more favourable than for the other horizons analysed. In the field, on the other hand, the conditions for cellulose degradation are poor in the entire MUOTTAS 1 profile. Low temperatures, and dryness as well, could account for this.

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The protease activity, indicating the potential for microbial protein decomposition, is very high in the Ah-horizon of the MUOTTAS 1 profile (Fig 6.b). Under laboratory conditions, the nitrogen mineralization in this horizon is also high. Lacking the clover-meal supplement, N-mineralization in the Bhs-horizon is low. The reason for these differing N-mineralization rates could be that there is more available nitrogen, necessary for the development of a microorganism population, in the Ah-horizon than in the Bhs-horizon. This hypothesis is supported by the fact that the addition of clover-meal gives almost equally strong increases in N-mineralization rates in both horizons.

In the laboratory, the MOUTTAS 1 profile's Ah-horizon showed a very high activity, even though in the field the microorganism population and cellulose degradation are not correspondingly high. From this it can be concluded that the environmental conditions hinder a high microbial activity, even though the requisite adequate organic material would be present. This activity is only made possible in the higher temperatures and moisture available under laboratory conditions. In addition, in the Bhs-horizon, a lack of sufficient available nitrogen is also a limiting factor for the increase of microorganisms.

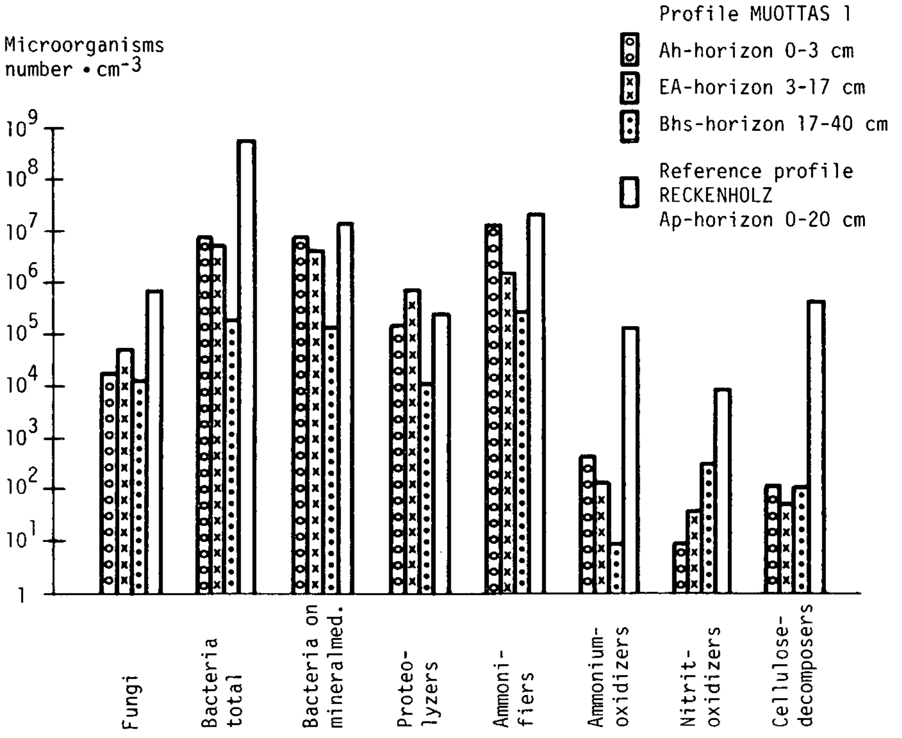


Figure 5. Prensence of different groups of microorganisms in the MUOTTAS 1 profile and the reference profile RECKENHOLZ

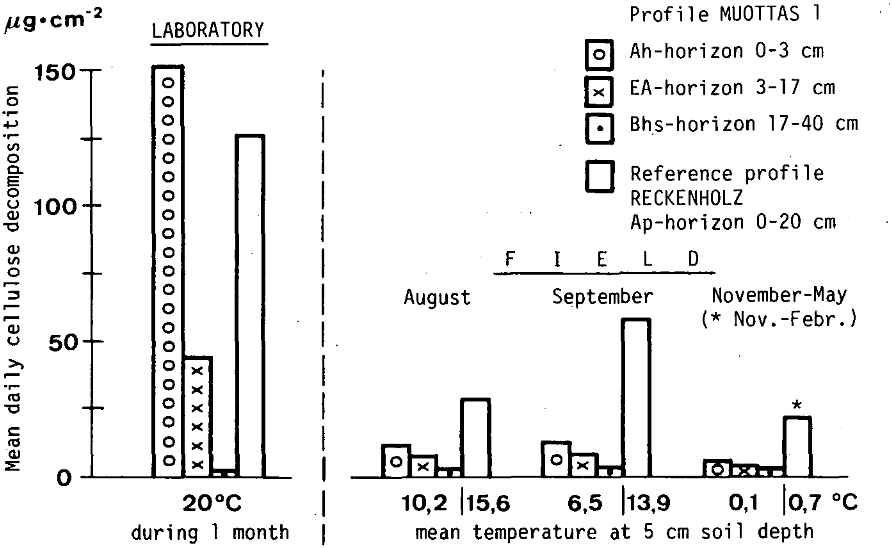


Figure 6.a) Cellulose degradation in Profile MUOTTAS 1 and reference profile RECKENHOLZ in the laboratory and field during various time periods

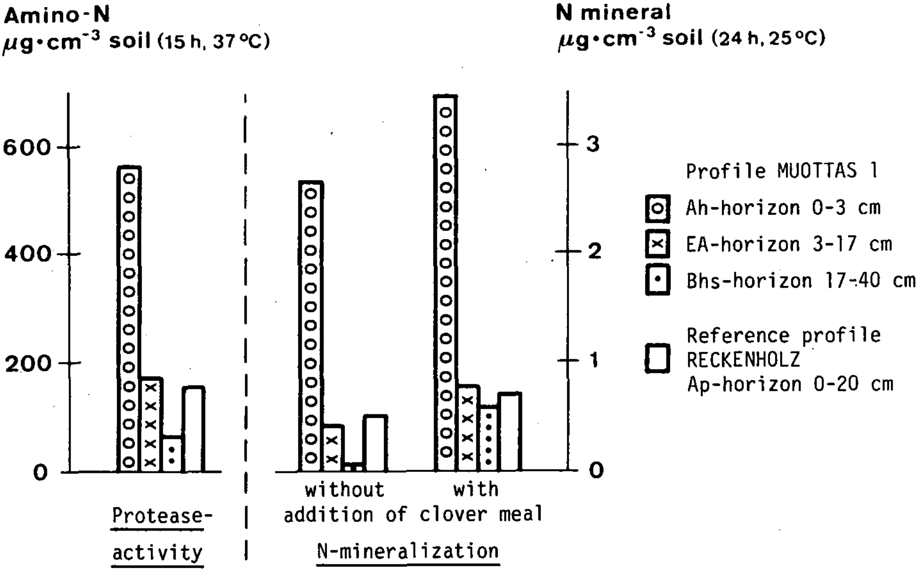
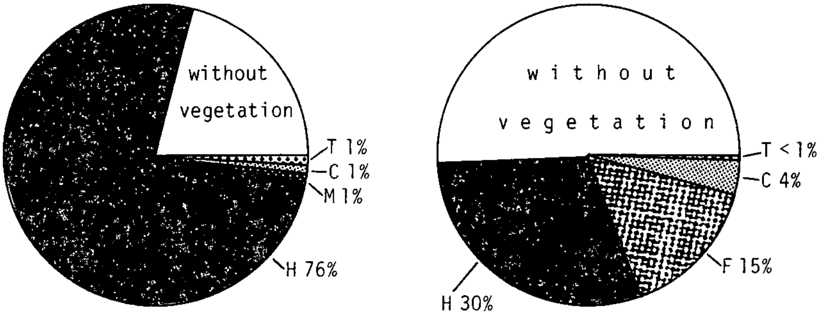


Figure 6.b) Protease-activity and nitrogen-mineralization in the laboratory analyses of Profile MUOTTAS 1 and reference profile RECKENHOLZ

4.4 Botanical description

A phytosociological survey using the Braun-Blanquet method was made on both profiles. Figure 7 gives the surface area ratios of the various types of growth found in the two surveys. The hemicryptophytes dominate in both cases. The MUOTTAS 2 location is wind-exposed and in winter often free of snow. This expresses itself in the sparse vegetative cover and the high proportion of cold- and drought-resistent lichens. Lichens are missing in MUOTTAS 1; instead there are numerous thermophylic plants as well as species which winter under a deep snow cover.



MUOTTAS 1. Matgrass pasture (Nardetum alpigenum caricetosum sempervirentis Br.-Bl.)

MUOTTAS 2. Carex curvula sward (Caricetum curvulae Brockm.-Jer.)

Figure 7. Surface-area ratios of the various types of growth found in the phytosociological surveys of MUOTTAS 1 and 2.

H: Hemicryptophytes (Perennials which winter with buds at or just under the soil surface)

C: Chamaephytes (Perennials which winter with buds above the soil surface)

T: Therophytes (Annuals)

F: Lichens

M: Mosses

5 Discussion and Summary

The MUOTTAS 1 and 2 profiles are located above the timber-line between 2500 and 2600m above sea level in the alpine grassland area. Deposits of a coarse-grained gneiss are the parent material of these soils. The average annual air temperature is -1.5° C; the annual precipitation of about 1100mm is, for the elevation, relatively low.

Low temperatures, short vegetation periods and occasional drought in summer slow soil development. From the coarse-grained parent material sandy, highly skeletal, shallow, permeable soils are formed. Long wet, cold phases and low pH-values hinder the decomposition of the organic materials and favor the formation of low molecular humic substances which can mobilise the sesquioxides as organo-mineral complexes. The majority of soils in this area, therefore, show distinct features of podzolisation.

Since no earthworms are present, soil mixing is poor and the greater part of the organic material remains in the upper 3cm of soil. Under the alpine grassland associations, consisting mainly of readily degradable herbs and grasses, no raw humus layers develop.

Lacking the moderating effects of a tree or dwarf-shrub canopy, the principle influence on microclimate and, therefore, soil development is topography. The most pronounced podzolisation (MUOTTAS 1, for example) is observed in wind-protected gain-sites where the snow melt infiltration is highest. In dry, often wind-exposed loss-sites shallow, less distinctly podzolised soils develop (example: MUOTTAS 2 profile). Soils become shallower and less and less podzolised with increasing elevation until the cold and snow completely prevent soil development.

Part II AUSTRIA

Austria

25. - 29.8.86 Austrian Society of Soil Science

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 48, 123, 1986

SUBJECT OF THE FIELD-TRIP C IN AUSTRIA

by O. Nestroy

During this part of the excursion C it is intended to show the influence of climate, topography and height above sea level on soil genesis on different geological substrates of the Eastern Austrian Alps.

The excursion starts in the relatively dry and warm inner alpine valley of the Inn river (profiles A1 - A3) and moves through the Northern part of the Alps (A4) to the dry and warm Southern ramp of the central alpine ridge, starting from low valley position (A5) and climbing up northward (A6), passing over the top of the mountain ridge (A7a / 7b and A8) and climbing down the wet and cold Northern ramp (A9) to lower alpine regions (A10).

Programme (25/26 - 29.8.1986)

(Austria)

Monday 25.8.86	17.00	Arrival in Austria and night at Imst
Tuesday 26.8.86	08.00	Departure from Imst to Haiming (Profiles A1 - A3)
	12.00	Lunch in Zirl
		Sightseeing-tour in Innsbruck, hotel registration, dinner, night at Innsbruck
Wednesday 27.8.86	08.00	Departure from Innsbruck
		Oberndorf (Profile A4)
		Döllach (Profile A5)
		Senfteben (Profile A6)
	18.00	Arrival at Franz-Josefs-Höhe (Großglockner) (hotel registration, dinner, overnight)
Thursday 28.8.86	08.00	Departure from Franz-Josefs-Höhe
		Fallbichl (Profile A7)
		Hochtor (Profile A8)
		Edelweißspitze (Panorama-View)
	18.00	Arrival at Fusch an der Glocknerstraße (hotel registration, dinner, overnight)
Friday 29.8.86	08.00	Departure from Fusch
		Roßboden (Profile A9)
		Maishofen (Profile A10)
	12.30	Lunch in Maishofen
		Sightseeing-tour in Salzburg, hotel registration, dinner, night at Salzburg

Mitteilgn. Dtsch. Bodenkundl. Gesellsch., 48, 125-141, 1986

GENERAL INFORMATIONS ABOUT AUSTRIA - WITH SPECIAL CONSIDERATION TO ISSS-EXCURSION AREA 1986

by Nestroy, O.

The historical development of the Republic of Austria, which now occupies an area of 83,855 km^2, is very eventful. It began with the first naming of "Ostarrichi" in 996 for an area between Amstetten - Krems - St. Pölten in Lower Austria, extended over an empire of Karl VI, which reached from Spain to Balkan, in which the sun did not set, and appears now, in the whole, in that area, which remained as the rest of the Donau Monarchy according to the peace treaty of St. Germain (1919).

So eventful the history of this land is, so diverse is also the geological formation, the physical geographical set-up and the small rooming of the landscape, as well.

Austria is a mountainous country, which is assumed to about 10% of the area of the varistic mountains - now a middle mountain area, with moderate to strong relief, at an altitude of 400 to 900 m, maximally 1,387 m. It consists of mainly granite in the west, partly in contrast to it in the east of gneiss of Bohemian Massif and - of several disregarded exceptions - the Danube in the south and the Manhartsberg in the east make its boundary.

Dominant are the Alps, which occupy about 64% of the area and which can be divided as the flysch zone (about 5%), the northern lime stone Alps and the gray wacke zone (about 22%), the central Alps (33%) and finally, the southern Alps (4%).

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

The Eastern Alps, which are lower and wider in contrast to the Western Alps, consist - also, again in contrast to the western Alps - not of autochtonous massifs, rather let recognise a very complicated folding and mantle character.

The Central Alps are separated from the flysch Alps and the lime stone Alps, as well as the gray wacke zone by the northern longitudinal valley furrow (Klostertal, Arlberg, Inntal, Gerlospass, Salzachtal, Ennstal, Schobersattel, Murtal, Semmering, Schwarztal) on the one side, and on the other side from the Drau flow by the southern longitudinal valley furrow (Pustertal, Drautal, Klagenfurter Basin, Mißlingtal). The Central Alps have very abrupt forms and elevations (or upliftments) up to 3,797 m over NN (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 gray wacke zone, very important due to mines (Magnesite, Copper ore, Iron ore). They are adjacent to the northern lime stone high Alps and the Prealps with plateau-character in the east and the range type in the east at an altitude upto 3,038 m Passeierspitze).

In the south of the periadriatic juncture, there are the partly wildly fissured southern Alps, which are formed partly of lime stones and dolomites, partly of schists, and - analogous to the northern lime stone Alps - show also plateau-character.

Thus, in Austria, the alpine body has a length of about 525 km and a width of 265 km in 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 transition of Radstädter Tauernpaß and Katschbergpaß up to Brennerfurche. So, it is nothing to be surprised, that only about 30% 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 (vide map).

The highest point of Austria is the summit of Großglockner (3,797 m), the highest permanent rural settlement is the Rofenhöfe in the Tyrolian Ötztal (2,014 m), the highest road connection over the Alps is the Hochtor (2,505 m), the lowest residences/communes are Illmitz and Wallern in Seewinkel (117 m) in Burgenland and the lowest area is Neusiedler See (115 m).

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-contrasts in the summer and winter and at the same time by the decrease of the mean annual precipitation towards the east (vide map). These climatic zones are more or less modified due to the altitude and the relief, so that they can be differenciated into atlantic, continental and alpine typed climate areas.

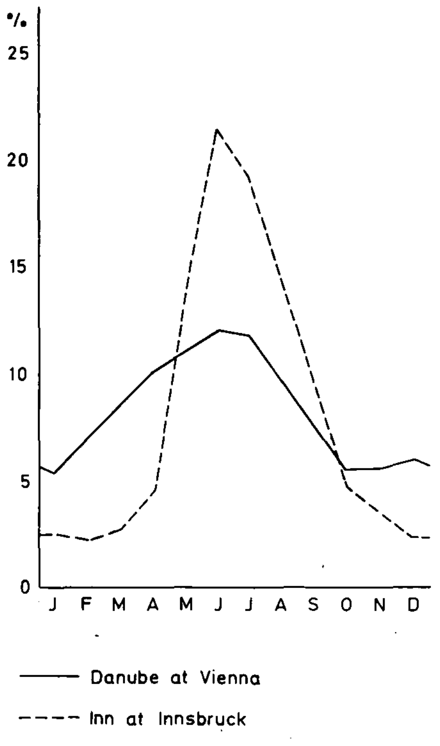
The atlantic (oceanic) coined climate areas are characterized by the lower annual amplitude of temperature, moderately warm summer, absence of a drought with an annual sum of precipitation, mostly above 1,000 mm. By the impact of rain-carrying N and NW winds, there are frequently abundant ascent-rains on the alpine north-side, which lead to an annual precipitation of 2,000 mm in Bregenzer Wald and in Salzkammergut. The continentally (pannonic) climate areas present, with a large amplitude, an annual sum of precipitation of only 600 to 700 mm, where a draught in the summer and rigidity in the winter with bare frost are further symptoms. Weinviertel, the eastern alpine footland, Wiener Basin and North Burgenland are considered to be in the pannonic climate province. The pannonic-type highland climate is characteristic for Waldviertel. The illyric-type climate province with a high thermic continentality as submediterranean symptom is characteri ed by a second maximum precipitation in the late summer or in the autumn, with absence of droughtiness. This climate province covers the south-eastern alpine footland, Lavanttal and Klagenfurter Basin.

Within the alpine climate province, a strong dependance 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 valleys (Wipptal, Zillertal, Salzachtal, Gasteinertal) and the winter inversions (Lungau, Klagenfurter Basin, Mürztal, lower Mitterennstal). Further, the inner alpine dry valleys are to be mentioned (Upper Inntal, Kaunertal, Pitztal, Ötztal, Lower Wipptal, Upper Mölltal, Upper Iseltal, and others), where the precipitations are about 800 mm, often only 650 mm (Upper Inntal). The position in the windshadow (downwind) is to be taken as the cause. Especially, in the northern lime stone Alps and also in the Southern 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 vegetation, distinct differences can be drawn between the western and the eastern parts, further between the inner alpine positions and the peripheries. So, the upper limit for the forestry in the Western Central Alps lies between the height of 2,000 to 2,200 m, whereas; on the contrary, it is between 1,700 and 1,800 m in the alpine north and east periphery; the snow-limit ends, on the contrary, at 3,000 and 2,500 m height respectively.

The austrian national territory is drained upto 96% to the Danube, upto 3% to the Rhine and upto 1% to the Moldau; the longest river is the Danube (the Austrian portion is 350 km), followed by the Mur (348 km), the Inn (280 km), the Salzach (225 km) and the Enns (254 km) (see fig. 1 and map).

The seasonal distribution of the water-bearing from Danube and Inn



Source: A. Leidlmair, Landeskunde Österreich. Harms Handbuch der Geographie, List Verlag, München, 1983.

As can be deduced from the figure, there are considerable differences in the extent of the seasonal fluctuations of the volume of water carried by the Austrian rivers. The rivers Inn and Danube can be taken as examples. Whereas there is a difference of 500 % between the month of minimum and that of maximum discharge with the Inn (Kufstein), there is one of only just over 100 % with the Danube (Vienna). Moreover it is characteristic for the Inn that 55% of the total discharge are shared by June, Juli and August, and only 7,5% by December, January and February.

Moreover, Austria occupies about 5,200 natural lakes, such as Lake Constance, with a total area of 538.5 km^2, Neusiedler See (132 km^2), Attersee (45.9 km^2), Traunsee (24.5 km^2), Wörther See (18.8 km^2), Mondsee (14.2 km^2), Millstätter See (13.3 km^2), Wolfgangsee (13.0 km^2) and Ossiacher See (10.6 km^2),

Agriculture and forestry, which went through a radical structural change after the World War II, supply 8o% of the food stuffs out of the domestic production, with 7,3% of whole population (1983) and 9,6% of the employed persons; whilst only 3,8% constitues the portion of the agriculture and forestry at the gross domestic products.

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 continous decrease of lands for agriculture and forestry, a portion of the domestic production at food-products of 102% could be reached by the increase in productivity in all sectors of agriculture and forestry.

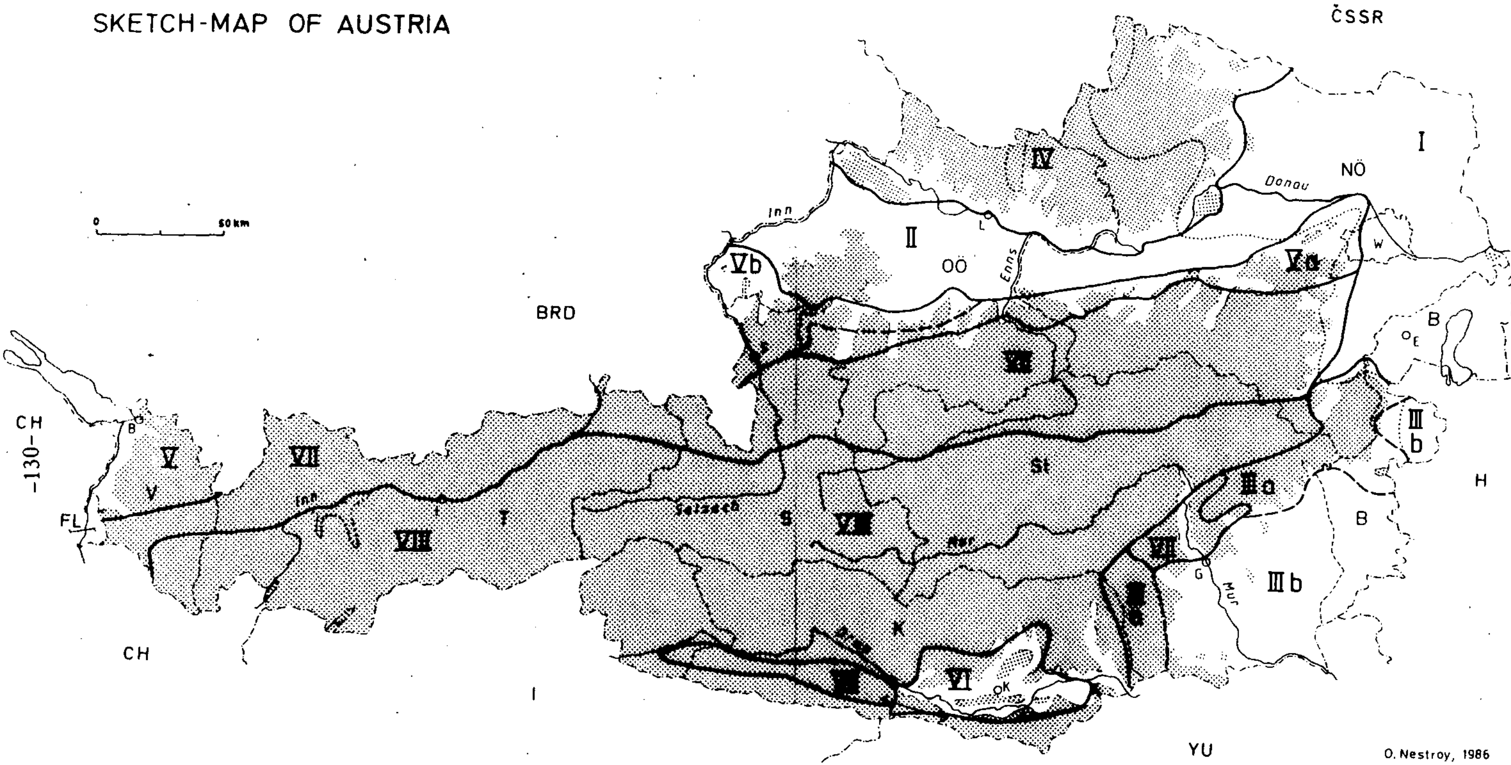
Concerning the regional structure of Austrian industries, it must be mentioned at the beginning, that in 1983, about 41% of the gross national product as produced by the processing and trade. And, as usual, the industrial centre lies in the eastern part of the country.

Here, the area including Vienna and Vienna Basin is to be mentioned. It has a very widely scattered trade and lacks large enterprises.

A second centre is the upper styrian industrial area in the zone of Mur - Mürz - Furche with steel works and metal industries; and somewhat aloof from it is the area around the provincial capital Graz, with metal works and automobile industries. The third industrial area to 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 Salzburg, in Lower Inntal and in Vorarlberger Rheinebene, 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, is characterized by a further increase of over-night accomodations in the winter season and by the high number of private quarters (about 1/3).

In 1983, there were in total 115,793,545 over-night stays, of which 76% were by the foreigners. 69,257,135 were in the commercial concerns, 24,735,585


SKETCH-MAP OF AUSTRIA
0
50 km
ČSSR
I
NÖ
Donau
IV
Inn
L
II
OÖ
Enns
Vb
Va
W
B
E
BRD
VII
VIII
CH
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VII
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Inn
FL
VIII
T
Salzach
S
VIII
St
Mur
IIIa
III
b
H
B
VII
G
Mur
IIIb
K
VI
K
CH
I
YU
O. Nestroy, 1986

Sketch Map of Austria

Explanations

B	Bregenz
E	Eisenstadt
G	Graz
I	Innsbruck
K	Klagenfurt
L	Linz
S	Salzburg
W	Vienna

B	Burgenland
K	Carinthia
NÖ	Lower Austria
OÖ	Upper Austria
S	Salzburg
St	Styria
T	Tyrol
V	Vorarlberg
W	Vienna

(stippled box)	above 500 m
....	600 -mm - Isohyet
- - - - -	Boundaries of provinces (Bundesländer)
—·—·—	National border

Soil areas:

I	Dry area
II	Foreland without moraine areas
III	SE-flank of Alps (a) and foreland (b)
IV	Bohemian Massif
V	Flysch-Zone (a) and moraine-foreland (b)
VI	Klagenfurt Basin
VII	Calcareous Alps
VIII	Central Alps

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Österreich-Atlas, Wien.

in private quarters and the rest in homes, inns, huts, vacation houses sanatoriums, nursing homes and camping sites.

Austria has exellent traffic-communications and transportations.
542,990 persons travelled and 8,094,000 ton goods were transported by inland ships within the Austrian portion of the Danube in 1984. An increase is expected after the desired opening of the Main - Danube - Canal as the national water way in 1992.

In the same year, the Austrian federal railways carried about 160,045,000 persons and about 55,775,000 ton goods through its 5,797 km long railway, of which 3,121 km is electrified. There are now 1.225 km high ways, 325 km motor ways, about 10,000 km federal roads, 25.000 km provincial roads and 60,000 km commune roads available for 3,725,963 automobiles (of which 2,468,452 Pkw and station wagon).

A number of well constructed airports are at the service of the civil aviation system. Vienna-Airport in Schwechat, which has two runways, has got about 84% of total density of the traffic in Austria in 1984, with 2,732,438 passengers in 28,477 regular flights. The other airports are in the provincial capitals: Salzburg, Linz, Innsbruck, Graz and Klagenfurt (arranged according to the density of traffic).

So, Austria of today presents 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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SPECIAL INFORMATIONS ABOUT CITIES AND LANDSCAPES

Imst

situated at the junction of the Fernpaßstraße at 828 m altitude over NN, has 6,677 (1981) inhabitants and is well known for large, old houses as well as a textile industry (tracing back to cotton industry founded in the middle of 18^{th} century).

Sources:

Landeskunde Österreichs. Hrsgg. von A. Leidlmair. Harms Handbuch der Geographie. P. List Verl., München, 1983.

Österreich - Land, Volk, Wirtschaft in Stichworten. Hrsgg. von L. Scheidl u. H. Lechleitner. Verl. F. Hirt, Wien, 1972.

Statistisches Handbuch für die Republik Österreich. Hrsgg. vom Österr. Stat. Zentralamt, XXXV. Jg., Wien, 1984.

Landscape area Upper Inntal

The portion from Landeck to Telfs, consequently Inntal itself and the bordering mountain ranges, is accounted to this area. In the north, they have predominant lime stones of the northern lime stone 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 Ötztaler Mass.

The agricultural lands in the main valley lie at about 630 m altitude over NN, and reach 1,800 m altitude into the alpine pasture. The inner alpine warm region, which reaches in the west up to 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, through which still the climatic stage "a" occurs in this area in isolated cases, otherwise mostly the stages "b" and "c" dominate.

The suitable conditions for production force the grassland farming (about 60% of all farms), where around 1/3 of the farms show high portion of forest. Specially, the optimal conditions of production on the terraces allow the existence of some plough-land- grassland farming.

Sources:

Schwackhöfer, W.: Die landwirtschaftlichen Kleinproduktionsgebiete Österreichs. Der Förderungsdienst, Sondernummer, 14. Jg., Wien, 1966.
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Tirol-Atlas: C 3 Tektonik, Entw.: R. Brandner, 1:600.000, Innsbruck, 1980.

Innsbruck

Provincial capital of Tyrol, situated at 574 m altitude over NN on a level alluvial cone of the river Sill, is protruded from the northern range. In 1981, 117 187 inhabitants. The development of this city into a unique inner alpine city is conditioned, primarily, by the position at the pass-foot at the interlace of Brennerlinie into the furrow of the northern longitudinal valley. At the place of Roman rest-station Veldidena, already 870 the Stift Wilten was mentioned. Innsbruck had a status of a city as early as in 1239 and could leave behind the then major Hall for the first time in the 15th century, when the Tyrolean line of the Habsburgs had shifted their residence here. As the favorite residence of Kaiser Maximilian I, this place reached its height, which was reinforced (intensified) by the settlement of landed gentry, religious orders and similar others. The present-day governmental sector originates from this period. In 1677, Innsbruck got a university; transport business and public service were further pillars of the urban-economy. The development of Brennerstraße, the railroads (towards Brenner, Kufstein, Arlberg and Mittenwald), as well as the motor ways intensified the natural transport suitability. Several cableways (Hafelekar, Patscherkofel, Absamer Lizum) make the surrounding mountains accessible, so that even the tourism particularly through the Olympic Winter Sport in 1964, with a 1,64 Mio. over-night accomodations, rose to the second position after Vienna.

Out of the sights of the old city, only the gothic Prunkerker "Goldenes Dachl", the Hofburg (Imperial Palace), the court church (so called "Schwarzmanderkirche" with grave of Maximilian) and the Laubengassen should be mentioned.

Sources:

Landeskunde Österreichs. Hrsgg. von A. Leidlmair. Harms Handbuch der Geographie, P. List Verl. München, 1983.
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Landscape area Kitzbühel

The scenically very alternating area presents the transition from the high alpine to the greywacke zone, showing hilly character, which, predominating by greywacke slates, is built up from intersperred porphyroid and porphyroidtuffs. So, the contrast between the precipitous, chalky formation of the Kaisergebirge and the Loferer Steinberge to large pastures on the mildly rounded "Grasberge" is specially noticeable.

The agricultural lands lie between 550 m over NN (Valley area) and around 1,900 m altitude. The climatic stage "c" results from a mean sum of annual precipitation between 1,200 and 2,000 mm with a mean annual temperature of 7,5^{o}C the strikes of inversion and lack of foehn.

Therefore, nearly 2/3 of the agricultural form estates are grassland-farming, the rest are grassland-forestry and forestry.

Sources:

Schwackhöfer, W.: Die landwirtschaftlichen Kleinproduktionsgebiete Österreichs. Der Förderungsdienst, Sondernummer, 14. Jg., Wien, 1966.
Tirol-Atlas: C 2 Geologie, Entw.: R. Brandner, 1:300.000, Innsbruck, 1980.
Tirol-Atlas: C 3 Tektonik, Entw.: R. Brandner, 1:600.000, Innsbruck, 1980.

Landscape area Upper Mölltal

This area lies at the border of the penninic central gneiss in the east and Bündner Schiefer of Glockner Decke in the west, in the region of the southern slope of the Hohe Tauern. So, the climatic situation is evident by a medium sum of annual precipitation between 800 and 1,700 mm with a mean annual temperature between 7.6 to 0.6. This generally wet-cool mountain climate is very strongly modified by the exposition: When the settlement on the sun-facing side reaches up to around 1,400 m over NN, the alpine pasture housing up to around 1,900 m, the alpine pasture zone up to 2,400 m, the limits on the shadowed sides are quite lower. In the valley area with only a level relief, which has the climatic stages "b" and "c", are about 2/3 of all farms grassland-farming. The rest can be accounted as grassland-forestry and forestry.

Sources:

Schwackhöfer, W.: Die landwirtschaftlichen Kleinproduktionsgebiete Österreichs. Der Förderungsdienst, Sondernummer, 14. Jg., Wien, 1966.

Tirol-Atlas: C 2 Geologie. Entw.: R. Brandner, 1:300.000, Innsbruck, 1980.

Tirol-Atlas: C 3 Tektonik. Entw.: R. Brandner, 1:600.000, Innsbruck, 1980.

Großglockner - Hochalpenstraße

This road presents an engineering accomplishment of Hofrat Dipl.-Ing. F. Wallack, which was constructed in order to cross the alpine main crest between the then existing crossings Brenner and Radstädter Tauern (distance 156 km).

The forerunner of this road was already a Roman way, later the old Glocknerstraße, which was built in 1900 to 1908 and overcame an altitudinal difference of 1700 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, 3200 people, who were engaged at different construction locations between 1500 and 2500 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 earth was removed, 410,000 m^3 rocks was blown, 67 bridges with spans between 2 and 32 m were built, as well as 2 tunnels (Hochtor with 311 m at 2,506 m over NN, at the same time the highest point of the road and Mittertörl with 117 m length) were constructed.

With a length of 47.8 km (Bruck - Heiligenblut) and the Gletscherstraße from Guttal (8.7 km), the road has a maximum gradient of 11%. The construction costs amounted to 25.8 million AS, which corresponds to the amount of 700 million AS at present.

Including 1984, till then, 35 million users in 9.2 million automobiles could be counted.

Sources:

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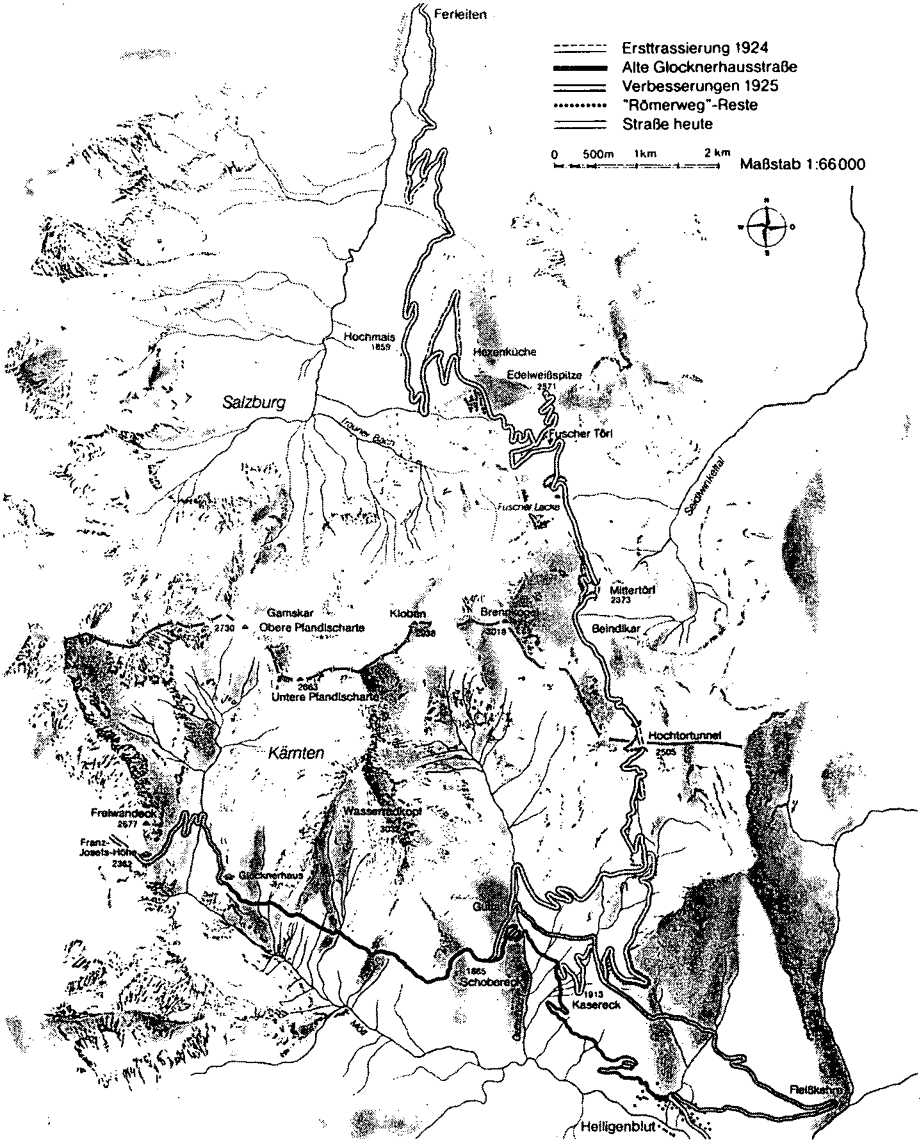
Ferleiten
Ersttrassierung 1924
Alte Glocknerhausstraße
Verbesserungen 1925
"Römerweg"-Reste
Straße heute
0 500m 1km 2 km
Maßstab 1:66000
Hochmais
1859
Hexenküche
Edelweißspitze
2571
Salzburg
Trauner Bach
Fuscher Törl
Fuscher Lacke
Seidlwinkltal
Mittertörl
2373
Beindlkar
Gamskar
Obere Pfandlscharte
2730
Kloben
Brennkogel
3018
2663
Untere Pfandlscharte
Hochtortunnel
2505
Kärnten
Freiwandeck
2677
Franz-Josefs-Höhe
2362
Wasserradkopf
Glocknerhaus
Guttal
1865
Schobereck
1913
Kasereck
Möll
Heiligenblut
Fleißkehre

Landscape area Fuscher Aache

This is in the zone of the cross valleys of Tauern in the rain-stagnant area of the alpine main crest. Therefore, this area gets its character through a mean annual precipitation about 1200 mm with a mean annual temperature upto 6.2^{o}C; the climatic level "d" characterizes this cold-wet climate.

The farming-areas of this zone, predominantly built up from Bündner Schiefer, lie between 800 m and 1,300 m over NN, high alpine pastures and mountain mowers upto 2,200 m. So, about 75% of the farms are to be denoted at grassland-farming, moreover, grassland-forestry farms are also of importance.

Sources:

Schwackhöfer, W.: Die landwirtschaftlichen Kleinproduktionsgebiete Österreichs. Der Förderungsdienst, Sondernummer, 14. Jg., Wien, 1966.
Tirol-Atlas: C 2 Geologie. Entw.: R. Brandner, 1:300.000, Innsbruck, 1980.
Tirol-Atlas: C 3 Tektonik. Entw.: R. Brandner, 1:600.000, Innsbruck, 1980.

Landscape area Mitterpinzgau

This area is the catchment area of Saalach and extends from Zell am See in the south upto Steinpaß; in the centre is the Saalfeldner Basin at 530 to 600 m over NN. This area lies within graywacke zone; graywacke schist is the dominant rock.

Climatically, this area is characterized with climatic level "c" and "d", with a mean annual sum of precipitation between 1000 and 2000 m and a mean annual temperature below 7^{o}C.

In consequence of the position of the basin and alpine pasture land, reaching upto 2000 m and covering about 1/4 area of the cultivable lands, the grassland is dominant (about 63%), besides, about 30% farms with a large amount of forests and forestry.

Sources:

Schwackhöfer, W.: Die landwirtschaftlichen Kleinproduktionsgebiete Österreichs. Der Förderungsdienst, Sondernummer, 14. Jg., Wien, 1966.
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Salzburg

is the provincial capital of the similarly named province with 139,426 (1981) inhabitants, situated at 427 m over NN in marvellous protective position of Mönchsberg, Festungsberg and Kapuzinerberg. In 700 AC, the convents St. Peter and Nonnberg were founded at the location of the Roman Juvavum. Since 798 AC, Salzburg has an Archbishops residence. The enjoyment of the Archbishops Markus Sittikus and Paris Lodron in the architectural works is reflected not only in Fortress Hohensalzburg, the greatest in Austria and dating back to the 11th century, reconstructed in the 15th century, but also in the excellent municipal architectural accomplishment: The main part of the prince's city contains New Residence and New Building, further numerous baroque castles in the city-area: Mirabell, Hellbrunn, Leopoldskron, Klesheim.

The loss of the residence function, government authorities and university (founded in 1620) brought a temporal decline to the city through the secularising in 1803, which, however, could be more than overcome made up by an uprise in the middle of the 19th century. Hence, Salzburg flourished with road construction, increasing trade, above all with the introduction of Salzburg Festival (1920) and with other cultural institutions ("Mozarteum", "Haus der Natur" and the expansion to a full-fledged university in 1963). The reputation of the city, that it is one of the most beautiful cities of the continent, is also proved by the number of overnight-stays of its visitors (1980: 1,52 million).

Sources:

Lexikon der Geographie. G. Westermann Verl., Braunschweig, 1969.

Österreich - Land, Volk, Wirtschaft in Stichworten. Hrsgg. von L. Scheidl u. H. Lechleitner, Verl. F. Hirt, Wien, 1972.

Statistisches Handbuch für die Republik Österreich. Hrsgg. vom Österr. Stat. Zentralamt, XXXV. Jg., Wien, 1984.

Tabelle 1: Cultivated plants in ha per province, 1983

	Tyrol	Carinthia	Salzburg	Austria
Arableland	22.628	75.890	13.012	1,421.950
Vineyards	1	2		57.760
Permanent meadows, cultivated	85.313	93.573	90.118	994.019
pasture, enclosed pastures, mountain pasture, mountain meadows, litter meadows	331.069	178.893	201.948	991.571
Woods	426.323	432.815	250.322	3,221.101
Flowing and standing water marshy areas	2.258	6.062	7.232	47.928
Buildings and courtyards	328.268	69.614	106.451	770.424
Self-managed total area	1,206.154	863.607	677.134	7,579.479

Source: Statistisches Handbuch für die Republik Österreich, 1984.

On area and population for provinces in 1984 informs Tab. 2.

Tabelle 2: Area (km^2) and population of the provinces and capitals of the provinces

Province	Area	Population	Provincial capital
Burgenland	3.965,4	268.080	(Eisenstadt: 10.102)
Carinthia	9.533,8	538.918	(Klagenfurt: 87.321)
Lower Austria	19.172,1	1,422.034	-
Upper Austria	11.979,6	1,280.037	(Linz: 199.910)
Salzburg	7.154,0	452.704	(Salzburg: 139.426)
Styria	16.387,1	1,183.280	(Graz: 243.166)
Tyrol	12.647,1	597.928	(Innsbruck: 117.287)
Vorarlberg	2.601,3	307.853	(Bregenz: 105.345)
Vienna	414,9	1,501.717	(Capital of Austria)
Austria	83.855,3	7,552.551	

The annual increment (from 1975 through 1982) amounts 0,1%, the density of population about 90 persons per km^2. About 84% of the population are Roman Catholics, 6% are Lutheran (AB and HB).

Source: Statistisches Handbuch für die Republik Österreich, 1985.

Table 3 gives the distribution of employees on severel section of economy (1981).

Tabelle 3: Employees and economic sections, 1981

		%
Total employed persons	3,411.521	100,0
Agriculture and forestry	290.490	8,5
Power and Water supply	40.970	1,2
Mining Industry	25.912	0,8
Processing trade, Industry	1,038.711	30,4
Construction	292.955	8,6
Trade, Storage	454.084	13,3
Accomodation and Hotels	174.450	5,1
Transport, News, Information, Transmission	218.138	6,4
Finance and credit systems, Private Insurance	190.735	5,6
Personal, social and public services	685.076	20,1

Source: Beiträge zur österreichischen Statistik, 630/21.

This table is at the same time, the transition to the next chapter, namely the mining industry and the industry.

Austria is an old country with mining industry. Of course, there are only a few mine-industries in operating now. Thus, the old saying becomes true, that "Austria is rich in poor mine-deposits". In 1984, in total about 15 million tons mineral raw material was produced, its distribution is shown in the following chart:

Tabelle 4: Production of minerals

Rawmaterial	Production in 1.000 t	Minerale	Production in 1.000 t	Rawmaterial	Production in 1.000 t
Iron-ore	3,600,0	Talc	134,0	Quartz	223,0
Iron mica-ore	11,1	Porcelain-clay	455,6	Feldspar	2,5
Lead zinc-ore	836,6	Pyroschist	0,9	Trass	9,6
Antimony-ore	26,6	Magnesite	1,183,4	Salt-brine (m^3)	2,191,8
Tungsten	531,5	Dolomite	981,0	Rock-salt	1,1
Gypsum	600,0	Clay	18,0	Coal	2,901,4
Anhydrite	140,0	Illite	285,5	Mineraloil	1,205,4
Graphite	43,7	Quartzsand	781,9	Natural gas (in 1.000 m^3n)	1,272,3

Source: Österreichisches Montan-Handbuch, 1985.

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TO THE GEOLOGY OF THE CENTRAL ALPS (compare Profiles 5 to 10)

The excursion route crosses twice the deepest tectonic unit of the whole structure of Eastern Alps, the "Tauern Window" firstly, on the way Mittersill - Felbertauerntunnel - Matrei in East Tyrol, later 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 gneis (premesozoic Granitoids) and their accompanying pre-permian 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 Perms-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 1 to 3 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") (Profiles 7 and 8 and Edelweißspitze).

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 H.P. CORNELIUS and E. CLAR, 1939). They form, for example, the bedrock in profile 5, in particular, the Großglockner itself and some others of the summits in the surrounding (see panoramic view Edelweißspitze).

C) The "Fusch Facies" is similar to the phyllite rich Brennkogel Facies. It comprises again the stratigraphic succession 1 to 4 and might correspond to the southern border of the Penninic Ocean (Profile 9).

On the alpidic Metamorphism:

a) an early alpidic high-pressure metamorphism, originated by a quick subduction, is still recognizable especially in the eclogitic prasinites (Profile 8).

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.

EDELWEIßSPITZE - PANORAMA VIEW

(compare: Geol. Panorama mit Erläuterungen in: G. Frasl und W. Frank, Jahrbuch des Deutschen Alpenv. für 1969)

1. 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, 3400 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 an Lower Palaeozoic Area of the Upper Austro Alpine Unit. To the same unit also belong the Northern concareous 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 Hochtorpass. 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 an 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").

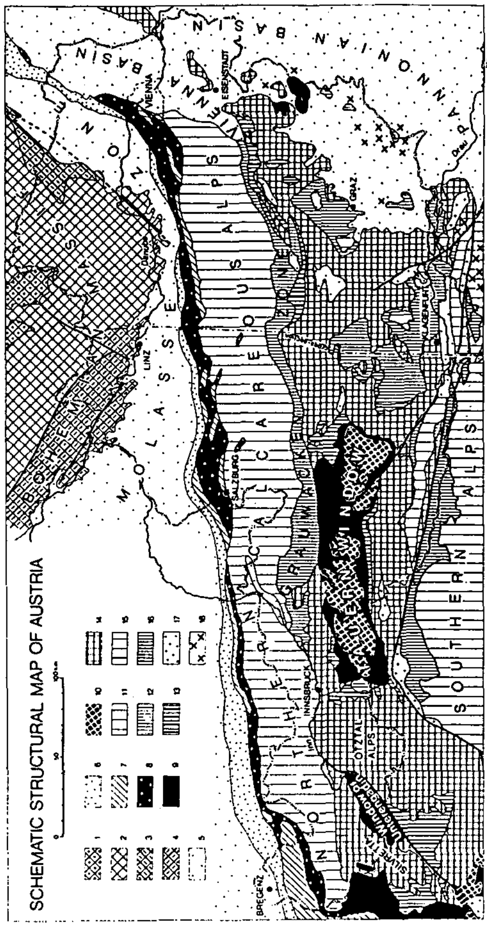
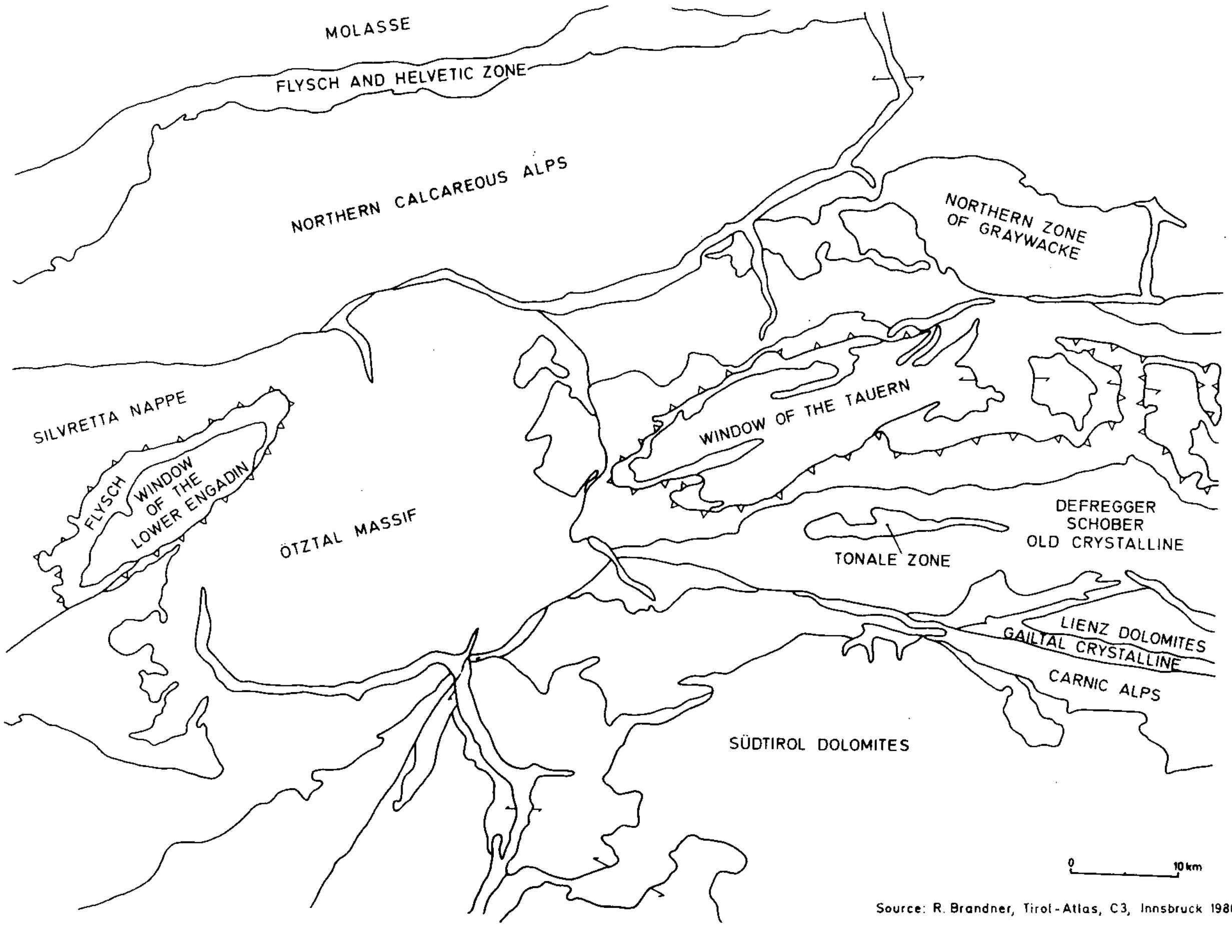


Fig. 1: Schematic structural map of Austria (after P. BECK-MANNAGETTA & A. MATURA, 1980). 1—4 = Bohemian Massif: 1 = Post-Variscan sedimentary cover; 2 = Moldanubian Zone; 3 = Moravian Zone; 4 = Bavarian Zone; 5 = Tertiary basins; 6 = Subalpine Molasse; 7 = Helvetic and Klippen Zone; 8 = Flysch Zone; 9 = Metasedimentary rocks of the Penninic Zone; 10 = Crystalline basement of the Penninic Zone; 11—14 = Austro-Alpine Unit; 11 = Permomesozoic in North-Alpine facies; 12 = Palaeozoic; 13 = Permomesozoic in Central Alpine facies; 14 = Crystalline basement ("Altkristallin"); 15 = Permomesozoic of the Southern Alps; 16 = Palaeozoic of the Southern Alps; 17 = Periadriatic intrusive masses; 18 = Neogene andesites and basalts. Cross-section see fig. 2.

(Abhandlungen d. Jhb.d. Geolog. Bundesanstalt 34, Wien, 1980)

TECTONICS (schematic)



Source: R. Brandner, Tirol-Atlas, C3, Innsbruck 1980.

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ECOCLIMATIC ASPECTS OF INNTAL UP TO THE HOHE TAUERN

by Harlfinger, O.

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 mesoskalig climatic influences, several places underlie microclima-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 differenciations of heat and water balance of the excursion area.

Inntal:

The climate of the Inn-valley is determined to a great extent by the downwind 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 (F. 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 (F. 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 dinstinct merits in connection with temperature-relations and radiation-influences (F. Lauscher). These conditions are confirmed by the small cooling quantity in the winter (Fig. 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, values of 800 W/m^2, as calculated for Imst, show these special conditions, which are often found also in the protected high valleys of the Alps (W. Mörikofer).

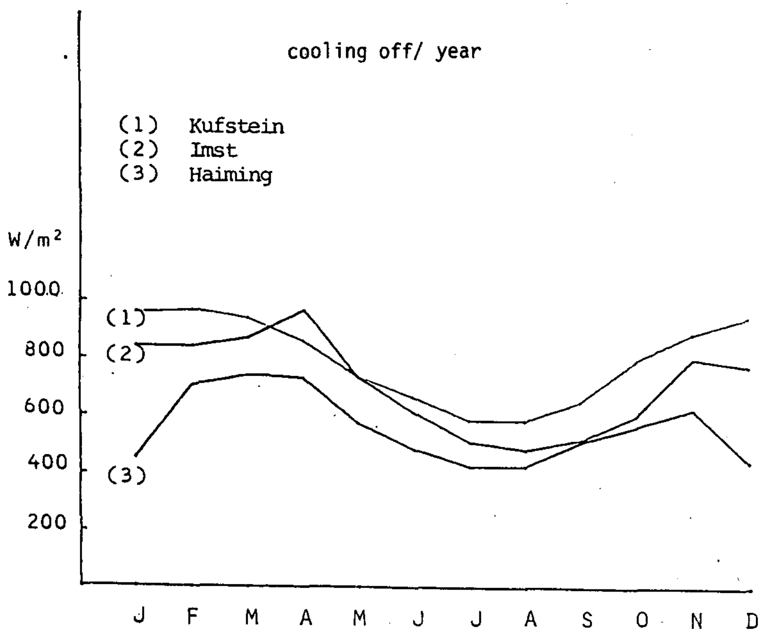

Fig. 1

In the late spring and, above all, in the summer Tyrol entirely comes under the influence of the west-storm strengthered 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 occurence of anticyclonal 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 Pitztal 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 (Tab. 1).

Percent of monthly precipitation, recorded in the period of 1951 - 1980:

Altitude		precipi-tation	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

Tab. 1

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 above msl), but also due to the fact that the quantity of winter precipitation rises to 20%. Hence, here, at 1000 m above msl, 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 differenciating portion of upwind and downwind effects within Inn-valley in Tyrol determines not only the precipitation regime, but also characterises the temperature relationships upto 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 (Fig. 2).

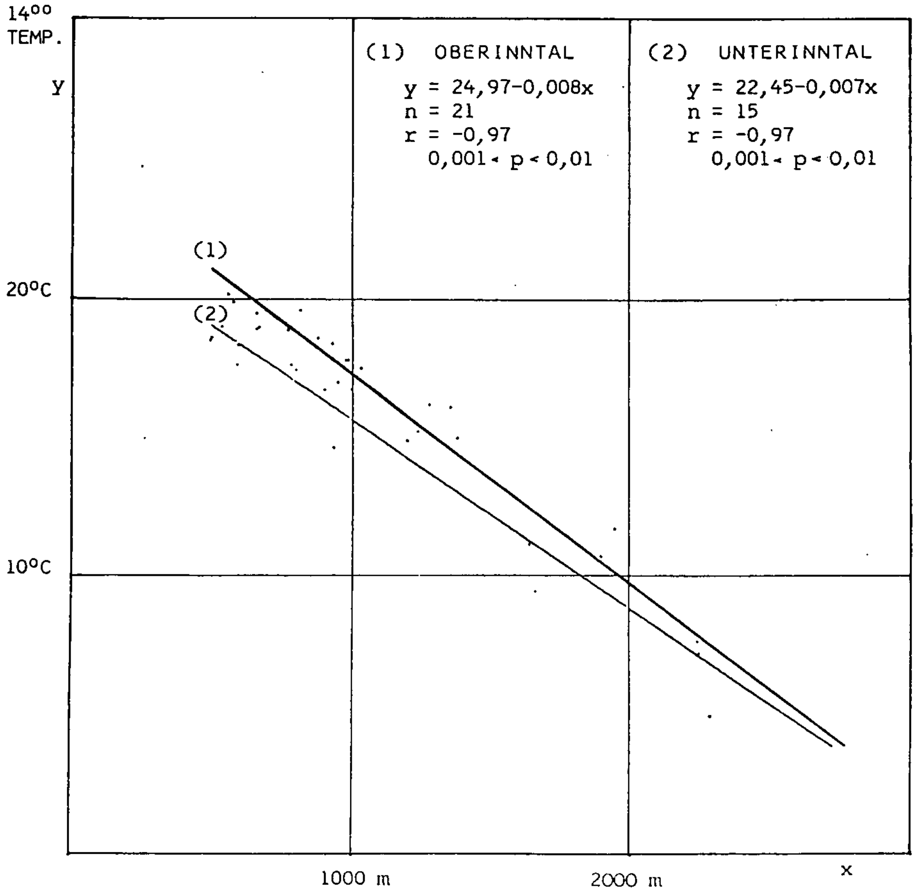

Fig. 2

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 dependance 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:

Hohe Tauern as part of the Eastern Alps represent in a pronounced way a weather and climatic border-line. 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 upto a typical high mountain-climate is found beside the continentally coined valley climate (F. Stelzer, 1981).

The contrast between the alpine north side and the alpine south side can be proved by almost all meterological parameters. The degree of cloudiness on the alpine north periphery amounts to 65%, while, on the southern side, it is 50% (O. Harlfinger, 1985, Schüepp, M. and Schirmer, H. 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 (W. 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 (Fig. 3) between Hofgastein (860 m) and Obervellach (780 m) (M. Bruck et al., 1985).

The portion of the sky radiation moves at this altitude by 40% in the summer and by 50 - 60% in the winter (R. 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 anthropogenetic air mixing. The increased energy supply on the alpine south side results expectedly in a higher temperature level. So, the isotherms of 5^0 and 10^0 range lie in the south of the alpine main crest about 150 m above that of the alpine northern side (H. 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 (F. Jeanneret and Ph. Vautier, 1977). The favorable conditions of the southern side can be more

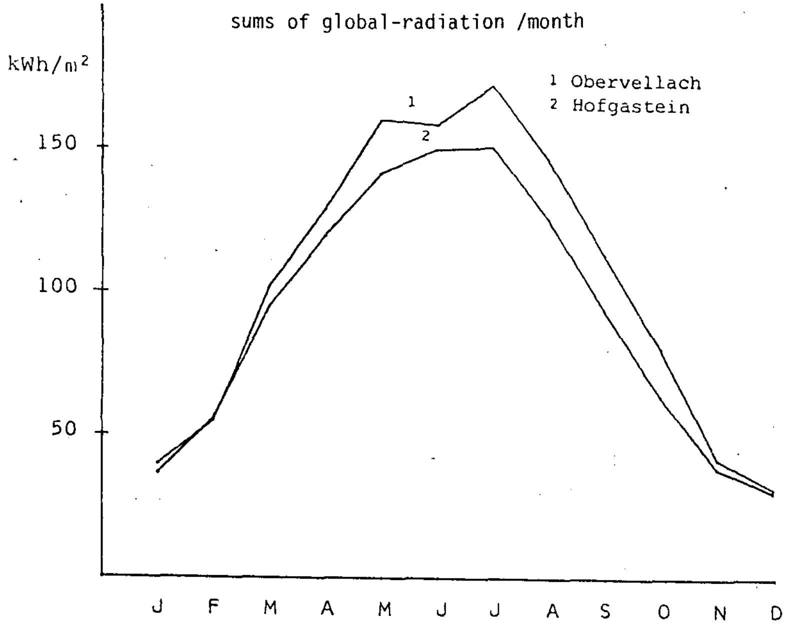

Fig. 3

evidently proved by calculating the sum of the temperature during the vegetation period (F. Fliri, 1960). From Tab. 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.

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 (H. 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 (H. Wilfinger, 1981, F. Lauscher and M. Roller, 1956). On the other side, the seasonal differences become obscured with the increase of the altitude; Consequently, besides the summer maximum, a winter maximum, or in the south

altitude (m)	temperature summation		
	expos. north	expos. 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

Tab. 2

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 dependance 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 characteristical for the mediterranean influence on the southern side of the Alps. According to Tab. 1, 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 upto 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 to 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 (F. Steinhauser).

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SOIL AND LOCATIONS IN THE EAST ALPINE ZONALITY

by Solar, F.

Development of zonal typical forms and zonal transitional forms in modification, conditioned by substrate and relief.

Contrasting typical forms: Mountain black soil (profiles 1, 2, 5) of inner alpine downwind and alpine Pseudogley (profiles 7b, 9) of alpine upwind (high zonally modified, substrate dependent).

Transitional forms: Brown soil (profile 6); also relief or regradation forms in downwind; regradation leads up to A/C-soil (profiles 2, 5b).

Substratogene, high zonal contrast forms: Podzol. The deposits of inner alpine downwind (profile 3) are extrazonal-regrading.

Zonal phenomena in the limestone Alps: transitional forms of relict-soils (Nivigenhydromorphism), Humus forms (Pechmoder, Torfmoder).

Soil forming and Location factors in the specific east alpine interactional system; climate as impulse generating zoning factor (tab. 1, 2).

Climate formed as the east alpine double zonality

- Upwind/downwind -zonality. Determinative is the opening or the shielding against the mediterranean weather front (VB) and the atlantic W and NW front. The S and N alpine are upwind zones, central alpine according to orientation and altitude partly upwind and partly downwind. High altitudinal constant upwind/downwind- change results from decreasing altitude of the shielding mountains (e.g. Inn-valley, decline below 2000 m E Achenseefurche, vide fig. 2). Form identic change also high zonally possible (vide fig. 1, compare profiles sequence 5 - 8).

- High zonality. Hygrometric form-change. Upwind character increasing with altitude. High zonal change in upwind of quantitative nature (compare profiles sequence 10 - 9 - 7b); high zonal change in downwind of qualitative nature (compare profiles sequence 5 - 8) and relief dependant, relief equalizing only in high zonal upwind from about 2100 m.

Lithographic, geomorphologic and development -historical factors modify the zonal characteristics through:

- Infiltration and percolation nature on clasticity and fine clastic pre-process (solum begins) and on particle shape (silty/platy: sandy/granular)

- Preweathering. Prominent in the view of regradation

- Stabilization of state through incorporation of new material (also aeolian).

- relief and relief-conditioned modification.

Table 1. Upwind/Downwind-characteristics

Criteria	Downwind	Upwind
RANGE or EXTENT	Planare to hochmontane levels of central inner Alps North alpine downwind W of Achensee-/ Brennerfurche South alpine/ central alpine downwind: Vintschgau, Pustertal, southern Tauern valleys (transitional forms eastward up to Langau	Alpine periphery; central alpine in strongly modified form Central upwind N of alpine main crest: Bregenzer Wald, N-lime stone Alps, Kitzbüheler Alps, Hohe Tauern
FORMS	Warm climatic ranges a - d (vide Land evaluation in Austria) Summer moist/temperate, meadow of talloat grass Summer dry/intensive radiation, feather grass meadow (optimum due to shadow position)	Warm climatic ranges (b)-e (vide Land evaluation in Austria) Snowy upwind, snow cover 110/120, 140 days respectively graduated hydromorphism due to snow. Soil in normal winter open or frozen. Relief conditioning, relief equalization
SOILS	Mountain black soils (summer moist downwind) dry Braunerde (summer dry downwind), Braunerde (shadow and transitional positions, partly regraded). Pseudogleys on impermeable till or basin days.	Terra fusca, Braunlehm (Brown soils) Rotlehm and their regradational forms (muck A/C, Pseudorendsina and Mg-oversaturated redeposited forms), Rendsinas, Alpine Pseudogleys and surface pseudogleying; Pseudogley (like in downwind); Braunerde; Podzol (substrate sandy/granular).

Table 2. Characteristics of typical forms

Criteria		
RANGE	Summer moist downwind, 500 - 1500 m altitude, a-d climatic ranges	Upwind from hochmontane according to percolation deposition Typical location: central downwind, initial position in valley soil zone
CLIMATE	Maximum precipitation in summer, Transition to Braunerde in illyrian typed double maximum (autumns, summer)	Snowy upwind (snow cover , 140 days, initial forms, i.e. surface pseudogleyzation from 110/120 days), influenced by snow
SUBSTRATE	fine sediment cover (condition of solum-depth) on gravel, torrential wash, till or basin clay in absence of deep solum: Pararendsina	silty/platy weathering substrate (Phyllite, schist, foliated gneiss) on sandy/granular weathering substrate: Podzol
PREWEATHERING	Braunerde material frequent substrate acid mountain black soil (vide Profiles 2, 5) Regradation climate (continuous droughtiness), A/C-dynamics due to earthworm (regraded A/C-soils from Terra Fusca and Braunlehm mountain black soils)	In lime stone Alps from medium textured terra fusca In central Alps initial forms on Braunerde, floodplain soils, soddy brown soils and soddy red soils (Initial surface pseudogleyzation)
POSITION RELIEF	Alpine plain sites: Terraces, floodplain, rammnants of planation (Relief-favoured, relief-conditioned solum-depth). in sloping sites Pararendsina	In full upwind on all forms, without condition of relief In high zonal transitional upwind/downwind zone, limited only to concave forms

DYNAMICS	Water regime balanced/ surface dry - soil warm (modified due to high altitude); in high zonal boundary sites on basin clays moderately intermittently moist. Substance enrichment dynamics and precipitation dynamics (AC_{ca} C_{ca} from 50 cm depth) In boundary sites selective Ca-leaching and Na/Mg-enrichment) earthworm-crust humus cover. Basic substance incorporation in acidic forms, NH_4 NO_3 (characteristic difference to chernozem)	Moist, due to stagnancy, intermittently moist (mostly from the bottom), adjusted (moderate) soil cold. Initial forms moderately intermittently moist surface continuous substance transformation in open, snow-covered soil with reduced aeration and ground-air expulsion Reduction in humus-rich surface soil + hydromorphism due to snow acid, selective Al/Fe-leaching, N-retarding! acid nitrate soils
LAND USE YIELD	arable land, arable land/grassland, in boundary sites "Egart" qualitatively and quantitatively high yield sites	Grassland, alpine pasture, on initial forms fodder cultivation. 120 - 60 grazing-days. Yield medium - low due to altitude
PROFILE	Profiles, sedimentologically of same deposit, pedogenetically or uniformly typed (or characterised) A/AC/C,$A/AC_{Ca}/C_{Ca}/C$-- profiles Transition to groundwater hydromorphism: A/AC/Cg Transition to pseudogleys: A/AC/AP/CS	Full forms with "hanging" stagnation zone: AP/P/Bv/--- AP/P/Cv/Cg/--- Initials forms (surface pseudogleyzation): AP/Bv/Cv--- AP/Bv/Cg---

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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)

by Nestroy, O.

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, specially 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 over NN 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 (O. Harlfinger, in this booklet).

As a further example, the varying radiation value should also be cited. A level surface (49^{0}N Latitude) receives 151,000 ly (=cal/cm^{2})/ year, at the south position (35^{0}), however, 183,000 ly, i.e. about 22% more. With a slope of 30^{0}, 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 (H. Klug and R. Lang, 1983).

The higher sum of precipitation, already mentioned, causes, mainly on the convex positions and positions with longer frostation, 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 taxonomic grouping difficult.

In connection to the temperature, it should be mentioned, that the isotherm of 5^{0} and 10^{0} 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 (O. 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 defind by W. Graf is to be rejected (H. Zöttl, 1965).

Further, the factor relief is of special importance, because, between this and the natural or human exerted massmovements, a close 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 frostation as well as weathering form of parent material, so that it requires only a small impulse to initiate a development of Laike, 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. K. Schnetzinger (1972) has already pointed out about the pseudogleyzation of surface soil by cattle-steps at Zell am See (770 m over NN). 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), treading-down of their edges and often the initiation of "Plaiken" occur (H. 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 cursoryly by described.

Along with the fundamental significance of rock chemistry (calcareous, noncalcareous, 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 peak. This fact is, in no way, an individual case in the Alps (O. 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) upto 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 detrital fan and rock fan, so that no strong biological obstruction can take place.

This brief description of effect of soil forming factors in the mountains may serve as an informative contribution to the idea of soil formation and soil in this area.

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PLANT-SOCIOLOGICAL COMMENTS ON THE PROFILE-LOCATIONS WITH SUPPLEMENTARY LIST OF THE PLANTS

by Lichtenegger, E.

The permanent vegetation is the most definite indicator of the permanently affecting environment factors. On the basis of the knowledge of the conditions of plant-growth and their associating, it is thus possible, to make a comprehensive comment on the profile-locations. The results correspond to the diagnoses of soil science so much, as the parameters of soil science affect the plant-growth. For the following discussion, the profile-locations are arranged in accordance with the pedological description.

Location of profiles 1, 2 at the height of 660 m, 670 m NN Rolling (or hilly), red fir - winter lime tree - site, moderately winter cold, summer warm. Soil adequately moist at the bottom (higher portion to the meadow - pigweed), occasionally severely dry at the surface during the warm season (occurrence of species of dry and semi-dry grasses), however changing with longer periods of adequate moistness at the surface (still numerous occurrence of common meadow grass, showing moistness at the surface), biological activity deep-reaching, moderately fertilzed. Predominantly suitable for arable land (or crop land). For grassland, the yield depression can be compensated to a large extent by adequate fertilization early in the spring or by occassional irrigation. Higher nutrient consumption without increased danger of weed growth is possible. Location of profile 2 extensively decalcified (absence of meadow-sage).

Location of profile 3, abouth 670 m NN

To a large extent covering with location of profile 2. Similarly, adequately moist at the bottom (appearance of species of lowland forest and ravine woods), surface droughtiness is lessened by forest-shadow. Removal of bases is continued by the plant parts, falling off from the soil acidifying plants (higher portion of species of soil acidifying pine woods). Progressive acidification towards bottom is stopped by the influence of base-rich substrate (very numerous occurence of base receiving large - flowered self-heal). So, podsol is not outcome of actual soil dynamics, but rather of a relict origin. Regradation of podzol is possible through recovering of red fir woods to the winter lime - deciduous forest.

Profile location 4, about 690 m NN

Montane, bird cherry - ash tree - lowland forest - site, winter cold, moderately summer warm, Soil slightly moist at the bottom (occurrence of species of moist meadow) and moderately intermittently moist at the surface (numerous occurrence of plum tree - crowfoot), due to higher precipitation in the winter and the spring longer over-moist and under-cool in the spring. Fodder growth is, hence, suppressed (or reduced). In the warm season hardly any yield-depression due to droughtiness. Moderately fertilized, higher fertilization easily leads to weed growth. Predominantly suitable for grassland. High weed growth if used for crop production.

Location of profile 5, about 1110 m NN

Montane, isolated oak - site in small areas, moderately winter cold, moderately summer warm, has warmer effect due to intensive radiation. Soil somewhat more adequately moist than in profile sites 1 and 2 and as a result, less warming up less droughtiness in the surface (actually intensiver occurrence of wild criander), biological activity less deep-reaching and active, moderately fertilized. Suitable for crops and grassland. With corresponding higher fertilization, in accordance with the position, high grassland-yield possible in spite of occassional moderate droughtiness at the surface.

Location of profile 6, about 1930 m NN

Subalpine, larch forest - combat zone, winter cold, summer cool, water regime on the summit extensively steady, however at the border of the over-wetting (intensive occurrence of glove-flower), in the depressions (or synclinal positions) additionally moderately moist at the bottom. Biological activity and nutrient consumption suppressed (or reduced) due to soil coolness, not fertilized. By fertilization still considerable yield-increase possible, however precautions against weed growth required.

Location of profile 7 a b, about 2180 m, 2250 m NN

Alpine, alpine original (or natural) meadow evolved as the knee reed grass in the convex position and as meadows in small snow-covered valleys in the concave position, very winter cold, summer cool with intensive emission at night. Hence, also during the vegetation period predominantly soil cool. Less evaporation secures extensive steady soil moistness even in the south-exposed position (7a). In prolonged dry periods, there is less surface-dryness. In the small valleys covered by snow (7b), due to longer snow-cover and lateral water inflow, stagnant - intermittently moist and permanently moist at the bottom (dominance of the species of small snow-covered valley - association). Biological activity strongly suppressed, yield-capability very little. Yield increase through fertilization is possible only to a small extent, economically insignificant.

Location of profile 8, about 2520 m NN

Subnival, below the snow-limit, talus-vegetation, with high amount of snow-soil - association, very winter cold, summer cold, little warming up of the soil even in the summer. Evaporation little even from the shallow, fine soil layers. Hence, soil mostly moist and cold. Scanty growth of plants. Substance-production very little.

Location of profile 9, about 1280 m NN

High montane to subalpine, lower zone of the pine-dominant subalpine coniferous woods, winter cold, summer cool (high amount of species of alpine well-grown meadows). Due to high precipitation, longer snow-cover and soil coolness moist at the bottom and intermittently moist at the surface (numerous occurrence of species of vegetation of level marshy lands). Similar to snow-soil climate, hence in spite of the lower position, almost optimum conditions for development of alpine grass - pseudogley. Reduced yield-production due to shorthened vegetation period.

Location of profile 10, about 770 m NN

Montane, bird cherry - ash tree - lowland forest - site, winter cold, moderately summer warm. Soil slightly moist at the bottom and moderately intermittently moist at the surface, due to higher warming up and less precipitation more severely droughty than at the profile site 4 (absence of serpentine - knot grass), consumption of nutrients and yield-capability, hence, somewhat to be evalued higher, moderately fertilized.

A detailed description of vegetation cover for each excursion site is given in the chapter "Description of sites and soils", pages 183 - 241.

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THE LAND EVALUATION IN AUSTRIA

by Ornig, F.

The Austrian land evaluation is carried out all over the country with uniform aspects on the basis of the "Bodenschätzungsgesetz 1970". This law has the origin in the "Reichsbodenschätzungsgesetz 1934", after which the land evaluation was carried out in the then German territory (now GDR, FRG) and also in Austria since 1938. After the end of the World War II, the commenced work in Austria was proceeded, so that the "primary evaluation" of total agriculturally used lands in Austria could be finished in 1972. Consequently, for agriculturally cultivable soils of Austria, there are evaluation results, covering areas, in maps and booklets of the Finance Office and in the documents of "Österreichischen Grenzkatasters". They contain about 80,000 catastral mapping sheets with more than 3,000,000 ha. They are available for everybody to have a look. The aim of the present land evaluation works is, for the causes of legal and implementational assessment, to make a review of the primary evaluation or the previous èvaluation in every 20 years, in order to maintain the results in accordance with the actual level of science and practice.

In this connection ,it was and it is to list the natural conditions of yield of all agriculturally used lands of Austria and, indeed, to list:
the climatic conditions.
the soil and water relationships,
in relation to the morphology and the special features.

For this, different landscape areas - small production areas - typical locations - comparable areas were chosen, described, analysed and evaluated according to the advice in "Bundesschätzungsbeirat" (about 15 members from science, practice and financial administrations) on the basis of a field designation with a comparative number - value between 0 and 100. And, this was published by the Federal Ministry of Finance. In this way, the evaluation becomes effective. This network of exactly measured typical locations of about 200 "Bundesmusterstücken" and not all 300 "Landesmusterstücken", distributed over whole Austria, reflects the entire differences in the natural yield-conditions of agriculturally used lands in the federal territory.

The estimation of all the rest of the agriculturally used lands of Austria has to be made always in relation to a sample area, where on the idea of this sample area or in comparison to it, the corresponding assessment frame was developed. In relation to these, according to a field designation, a value is assessed

between 0 = unproductive and
100 = the best location in Austria.

Considering the respective specific climatical and morphological conditions, as well as special features, there is a second value, with which, when transferred on the concerned ground-piece, a yield measuring number is calculated. This recorded in the ground-piece register, is open to the public and has effect on takes and sales of an agricultural farm considerably, in relation to the respective economic yield-conditions.

As it has been already mentioned, "assessment frames" were always worked out for objectification of the comparison to be drawn in the view of the effective results of the sample area during the present evaluation of a location - " review" - in respect to the continuity of the primary evaluation.
These frames are:

a) the climatic frame

This is not only to ensure the correct registration of macro and microclimate in average of 50 years (1920 - 1970), but also to ensure the corresponding importance of these main production factor during the evaluation of the value, which has suited the respective relationships. It is calculated, that for all soil-types with a temperature of 19^{0}C at 14 o'clock during the vegetation period (April - August) and with a precipitation of 600 mm during the same period, neither yield lowering nor the yield increasing influences are considered (Zero-line). The actual data deviate in respect to these assumptions, so corresponding addition or substraction in % should be made.

b) the arable land evaluation frame

The corresponding value is evaluated from a given range of values on the basis of soil texture (sand through loam upto clay - with eight divisions) in relation to the origin (regolith, sediment soil) in terrestrial (Tertiary or Pleistocene) and alluvial zone and the classes of state (developmental state; fertile or infertile soil), as well as the local climatic conditions. It should be pointed out here, that from sand to loess loam, the values rise upto 100 for

Grünlandschätzungsrahmen

Bodenart	Zustandsstufe	Klimastufe	Wasserverhältnisse 1	2	3	4	5	Geländeneigung Grad	A	AGr / GrA	Gr
S	I	a	60—51	50—43	42—35	34—28	27—20				
		b	52—44	43—36	35—29	28—23	22—16				
		c	45—38	37—30	29—24	23—19	18—13				
	II	a	50—43	42—36	35—29	28—23	22—16				
		b	43—37	36—30	29—24	23—19	18—13	4	4	—	—
		c	37—32	31—26	25—21	20—16	15—10				
	III	a	41—34	33—28	27—23	22—18	17—12				
		b	36—30	29—24	23—19	18—15	14—10	6	6	4	—
		c	31—26	25—21	20—16	15—12	11— 7				
	IV	a	33—28	27—23	22—18	17—12	11— 7				
		b	29—24	23—19	18—15	14—10	9— 7	8	8	5	4
		c	25—21	20—16	15—12	11— 7					
lS	I	a	73—64	63—54	53—45	44—37	36—28				
		b	65—56	55—47	46—39	38—31	30—23	10	10	7	5
		c	57—49	48—41	40—34	33—27	26—19				
	II	a	62—54	53—45	44—37	36—30	29—22				
		b	55—47	46—39	38—32	31—26	25—19	12	12	9	6
		c	48—41	40—34	33—28	27—23	22—16				
	III	a	52—45	44—37	36—30	29—24	23—17				
		b	46—39	38—32	31—26	25—21	20—14	14	14	10	8
		c	40—34	33—28	27—23	22—18	17—11				
	IV	a	44—37	36—30	29—24	23—17	16—10				
		b	38—32	31—26	25—21	20—14	13— 7	16	16	13	9
		c	33—28	27—23	22—18	17—11	10— 7				
L	I	a	88—77	76—66	65—55	54—44	43—33				
		b	80—70	69—59	58—49	48—40	39—30	18	19	15	10
		c	70—61	60—52	51—43	42—35	34—25				
	II	a	75—65	64—55	54—46	45—38	37—28				
		b	68—59	58—50	49—41	40—33	32—24	20	21	17	12
		c	60—52	51—44	43—36	35—29	38—20				
	III	a	64—55	54—46	45—38	37—30	29—22				
		b	58—50	49—42	41—34	33—27	26—18	22	24	19	14
		c	51—44	43—37	36—30	29—23	22—14				
	IV	a	54—46	45—38	37—30	29—22	21—15				
		b	49—42	41—34	33—27	26—18	17—10	24	27	21	16
		c	43—37	36—30	29—23	22—14	13— 7				
T	I	a	83—72	71—62	61—52	51—41	40—31				
		b	75—66	65—55	54—45	44—37	36—26	26	30	24	18
		c	66—57	56—49	48—40	39—32	31—22				
	II	a	70—60	59—51	50—42	41—34	33—24				
		b	62—54	53—45	44—37	36—28	27—20	28	34	26	20
		c	54—46	45—39	38—31	30—23	22—16				
	III	a	57—49	48—40	39—33	32—26	25—19				
		b	51—43	42—36	35—29	28—23	22—15	30	37	29	22
		c	43—37	36—30	29—23	22—18	17—11				
	IV	a	48—40	39—33	32—26	25—19	18—11				
		b	42—36	35—29	28—23	22—15	14— 7	32	41	32	24
		c	36—30	29—23	22—18	17—11	10— 7				
Mo	I	a	50—42	41—34	33—27	26—19	18—11				
		b	48—40	39—32	31—25	24—17	16— 9	34	44	35	26
		c	45—38	37—30	29—23	22—15	14— 7				
	II	a	44—37	36—30	29—23	22—16	15— 9				
		b	42—35	34—28	27—21	20—14	13— 7	36	48	38	29
		c	39—33	32—26	25—19	18—12	11— 7				
	III	a	37—31	30—25	24—19	18—13	12— 7				
		b	34—28	27—22	21—16	15—10	9— 7	38	52	42	32
		c	30—25	24—19	18—13	12— 7					
	IV	a	30—25	24—19	18—13	12— 7					
		b	27—22	21—16	15—10	9— 7		40	56	45	35
		c	24—19	18—13	12— 7						

Klimastufe	Temp.
a	üb. 19.0 14h Temp.
a—b	19.0—18.6
b	18.5—17.6
b—c	17.5—17.1
c	17.0—16.0
c—d	15.9—15.5
d	15.4—13.0
d—e	12.9—12.1
e	unter 12.1

Klimastufe	Heutrocknung bei Jahresniederschlägen —800	800—1000	1000—1200	1200—1400	1400—1600	ü 1600
a	0	0	0	— 2	— 4	— 6
b	0	0	— 2	— 4	— 6	— 8
c	0	— 2	— 4	— 6	— 8	—10
d	— 2	— 4	— 6	— 8	—10	—12
e	— 4	— 6	— 8	—10	—12	—14

Ackerschätzungsrahmen

Bodenart	Entstehungsart	Zustandsstufe 1	2	3	4	5	6	7
S	D		41—34	33—27	26—21	20—16	15—12	11—7
	Dg			30—24	23—18	17—13	12—9	8—7
	Al		44—37	36—30	29—24	23—19	18—14	13—9
	Alg			33—27	26—21	20—16	15—12	11—7
Sl (S/lS)	D	59—52	51—43	42—35	34—28	27—22	21—17	16—11
	Dg			39—32	31—25	24—19	18—14	13—7
	Al	62—54	53—46	45—38	37—31	30—24	23—19	18—13
	Alg		50—43	42—35	34—28	27—21	20—16	15—10
	V			42—35	34—28	27—21	20—16	15—10
	Vg			39—32	31—25	24—19	18—14	13—7
lS	D	67—60	59—51	50—44	43—37	36—30	29—23	22—16
	Dg		56—48	47—41	40—34	33—27	26—20	19—13
	Lö	71—63	62—54	53—46	45—39	38—32	31—25	24—18
	Al	71—63	62—54	53—46	45—39	38—32	31—25	24—18
	Alg		59—51	50—44	43—37	36—30	29—23	22—16
	V			50—44	43—37	36—30	29—23	22—16
	Vg			47—41	40—34	33—27	26—20	19—12
SL (ls/sL)	D	75—68	67—60	59—52	51—45	44—38	37—31	30—23
	Dg		64—57	56—49	48—42	41—35	34—28	27—20
	Lö	81—73	72—64	63—55	54—47	46—40	39—33	32—25
	Al	80—72	71—63	62—55	54—47	46—40	39—33	32—25
	Alg		69—60	59—52	51—45	44—38	37—31	30—23
	V		67—60	59—52	51—44	43—37	36—30	29—22
	Vg			55—48	47—40	39—32	31—24	23—16
sL	D	84—76	75—68	67—60	59—53	52—46	45—39	38—30
	Dg	81—73	72—65	64—57	56—50	49—43	42—36	35—27
	Lö	92—83	82—74	73—65	64—56	55—48	47—41	40—32
	Al	90—81	80—72	71—64	63—56	55—48	47—41	40—32
	Alg		75—68	67—60	59—53	52—46	45—39	38—30
	V		76—68	67—59	58—51	50—44	43—36	35—27
	Vg			64—55	54—45	44—36	35—27	26—18
L	D	90—82	81—74	73—66	65—58	57—50	49—43	42—34
	Dg	87—79	78—71	70—63	62—55	54—47	46—40	39—31
	Lö	100—92	91—83	82—74	73—65	64—56	55—46	45—36
	Al	100—90	89—80	79—71	70—62	61—54	53—45	44—35
	Alg		86—77	76—68	67—59	58—49	48—42	41—32
	V		82—74	73—65	64—56	55—47	46—39	38—30
	Vg			70—61	60—51	50—41	40—30	29—19
LT	D	82—74	73—66	65—58	57—51	50—43	42—36	35—26
	Dg		70—63	62—55	54—48	47—40	39—33	32—23
	Al		77—70	69—61	60—54	53—46	45—38	37—27
	Alg		74—67	66—58	57—51	50—43	42—35	34—24
	V		73—66	65—57	56—49	48—40	39—32	31—23
	Vg			63—55	54—45	44—36	35—26	25—16
T	D		67—60	59—53	52—45	44—38	37—28	27—17
	Dg			56—50	49—42	41—35	34—25	24—14
	Al		70—62	61—55	54—47	46—39	38—29	28—17
	Alg			59—52	51—44	43—36	35—26	25—14
	V		67—59	58—51	50—42	41—34	33—24	23—13
	Vg			55—48	47—39	38—31	30—21	20—10
Mo				36—29	28—22	21—16	15—10	9—7

Hochwald guter	Hochwald geringer	Nieder- und Schälwald
Durchschnittliche Mittelhöhe in m		
22—20	14—12	8—7
Breite der Sonderfläche in m		
30	20	10

Abrechnung in % für Waldschatten:
S 24—16
O. o. W. 16—10

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the best classes of state, where as the values decline again with increase in the heaviness of the soil texture (clay soils).

c) the grassland evaluation frame

This is done in a similar way as in the case of arable land. In addition, there comes only a combination of respective two soil textures and also a large-scale designation of classes of state. In addition, the water-conditions of a location are exactly evaluated here, and these are the critical differences for arable land evaluation frame. According to the rating of the water-classes (5 in total) in relation to a direct classification of macro climate (climatic classes a - e), again, there results eventually a range of values, from which the number, corresponding to the location, is estimated in comparison to a sample area.

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SOIL ANALYTICAL METHODS

by Blum, W.E.H. [1], O. Danneberg [2] and E. Klaghofer [3]

The excursion profiles were analyzed by physical, chemical and mineralogical methods in different research laboratories, adress see below.

In the following the methods are described in the sequence of the listing of analytical results in the tables of the next chapter "Description of sites and soils".

1. Physical methods

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.

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'.

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

$$n = \left(1 - \frac{\rho d}{\rho s}\right) \times 100$$

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

2. Chemical methods

pH (H_2O, $CaCl_2$) was determined electrometrically in soil suspensions with H_2O and 0,01 M $CaCl_2$ at a soil: solution ratio 1:2,5.

Fe in Na-dithionite-citrate (Fe_d) and Fe and Mn in NH_4-Oxalate (Fe_o/Mn_o) 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 NO_2 and titration of N after destillation.

Carbonate content was analyzed volumetrically with a SCHEIBLER calcimeter, measuring CO_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.

3. Mineralogical methods

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

4. References

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DESCRIPTION OF SITES AND SOILS

by Blum, W.E.H. [1], Danneberg, O. [2], Eisenhut, M. [2], Frasl, G. [3], Klaghofer, E. [4], Lichtenegger, E. [5], Ornig, F. [6] and Solar, F. [1]

Following, for each site and soil profile the following informations are given in the sequence:

- Physio-geography, including
  - . location of the profiles and geomorphology (Eisenhut)
  - . geology (Frasl)
  - . climate (Ornig)
  - . vegetation (Lichtenegger)
- Soil characteristics, including
  - . morphology (Eisenhut, Solar)
  - . classification (Blum, Eisenhut)
  - . analytical data (Blum, Danneberg, Klaghofer)

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6) Federal Ministry of Finance, Soil Taxation, Office for Styria, A-8020 Graz.

S I T E S   A 1 - A 3

Inn valley near Haiming

1-3.1 Physio-geography

1-3.1.1 Location of the profiles, geomorphology and geology

The location of the profiles A-1, A-2 and A-3 is shown in the geomorphological scetch map.

On this map it can be seen that the Inn-valley is divided into three parts, the recent floodland 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 - more than 100 cm) layer of limefree coarse sand.

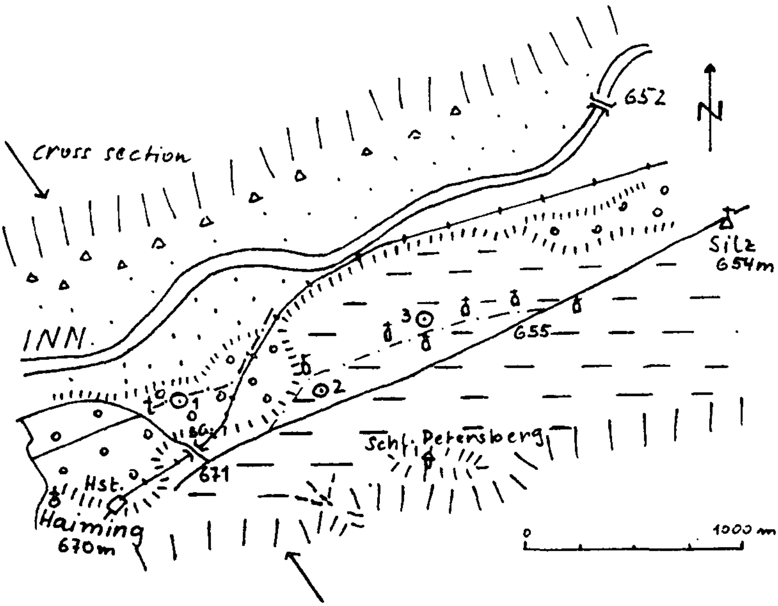
When the ice, blocking the Inn-valley melted the Inn eroded parts of the washout and built up his calcareous sediments. A lower terrace was formed, divided from the higher terrace by a steep slope of about five meters high. This new terrace is composed of calcic and crystalline gravel. The wavey surface of the gravel deposit is covered with a layer of fine loamy sand (30 - 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 floodland, 1 - 1 1/2 meters below the lower terrace. This floodland consists of a layer of silty-sandy deposits (flour sand) which cover the gravel below one meter or more.

Today the Inn is completely regulated and therefore there is no flooding. Because of the intensive agriculture the slope from the lower terrace to the floodland has been leveled off.

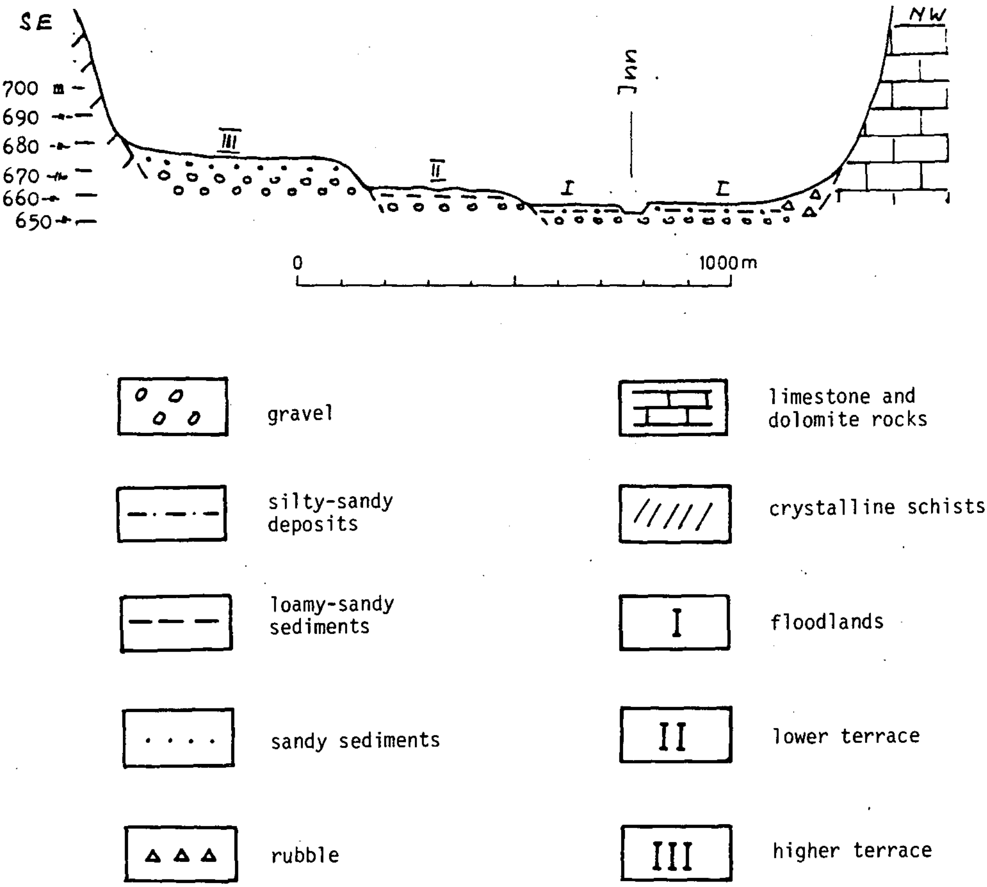
Geomorphology and geology are shown in a cross-section through the Inn valley, with 6.25 fold superelevation.

Geomorphological sketch map of the
Inn-valley near Haiming (profile A1 - A3)



- terrace slope
- valley slope
- rubble slope
- alluvial cone
- floodland of Inn (younger Holocene)
- lower terrace (latest glacial - earliest Holocene period)
- higher terrace (late glacial period)
- railway
- railwaystation
- road
- carriage way
- station of the Cross
- soil profile
- gravel pit

Cross section through the "Inn" valley
superelevation 6.25 x



1-3.1.2 Climate

Mean annual temperature:	7^{o} C
Mean temperature at 2 p.m. from April - August:	19.4^{o} C
Mean annual precipitation:	715 mm

1-3.1.3 Vegetation

The vegetation of the sites of the 3 profiles is exemplified on the pages 188 and 189.

Tabelle 1: Kolline und montane Glatthaferwiesen

Number of soil profile	1	2	5
Number of analysis	1	2	3
Date of analysis /day	8.	8.	9.
/month	6.	6.	6.
Height above sea level in 10 m	66	67	111
Inclination	0	0	14
Exposition			WSW
Surface analyzed in m^2	100	100	100
Surface covered by plants in %	85	80	90
Annual yield in dt/ha	80	85	115
Number of species	40	38	48

Dauco - Arrhenatheretum-Ass.KA:				**Kennarten der Wilde Möhren-Glatthaferwiese:**
Daucus carota	+	+		Wilde Möhre
Festuca rupicola	+	+		Furchen-Schwingel
Salvia pratensis	+		+	Wiesen-Salbei
Arrhenatherion-Arten:				**Arten der Tal-Fettwiesen:**
Arrhenatherum elatius	3	3	2	Glatthafer
Dactylis glomerat	2	2	2	Knaulgras
Knautia arvensis	1	2	+	Wiesen-Witwenblume
Galium mollugo	+	2	+	Gewöhnliches Labkraut
Crepis biennis	+	+	+	Zweijähriger Pippau
Campanula patula	+	+	+	Wiesen-Glockenblume
Bromus hordeaceus	+	+		Weiche Trespe
Cynosurion-Arten:				**Arten der Tal-Fettweiden:**
Trifolium repens		+	2	Weiß-Klee
Phleum pratense			+	Wiesen-Lieschgras
Lolium perenne	+			Deutsches Weidelgras
Polygono - Trisetion-Arten:				**Arten der Berg-Fettwiesen:**
Melandrium rubrum	+	1	+	Rotes Marienröschen
Viola tricolor ssp. tricolor		+	+	Wildes Stiefmütterchen
Arrhenatheretalia-Arten:				**Arten der Wiesen und Weiden:**
Trisetum flavescens	2	2	2	Goldhafer
Heracleum sphondylium	2	2	2	Wiesen-Bärenklau
Achillea millefolium	2	1	+	Gewöhnliche Schafgarbe
Tragopogon orientalis	1	1	1	Wiesen-Bocksbart
Agrostis tenuis	+	1	1	Rotes Straußgras
Vicia sepium	+	1	+	Zaun-Wicke
Taraxacum officinale	1	+	+	Gewöhnliche Kuhblume
Avena pubescens	+	+	+	Flaum-Hafer
Chrysanthemum leucanthemum	+	+	+	Wiesen-Wucherblume
Anthriscus sylvestris	1	+	1	Wiesen-Kerbelkraut
Pimpinella mayor	1	+	1	Große Bibernelle
Carum carvi	+		2	Wilder Kümmel
Veronica chamaedrys		+	+	Gamander-Ehrenpreis
Rhinanthus alectorolophus	+			Zottiger Klappertopf
Molinio - Arrhenatheretea-Arten:				**Arten der Grünland-Ges.:**
Poa pratensis	1	2	2	Wiesen-Rispengras
Festuca rubra	2	2	1	Rot-Schwingel
Trifolium pratense	2	1	2	Rot-Klee
Festuca pratensis	2	1	1	Wiesen-Schwingel
Leontodon hispidus	+	+	2	Rauher Löwenzahn
Vicia cracca	+	+	1	Vogel-Wicke
Rumex acetosa	+	1	+	Großer Sauerampfer
Cerastium holosteoides	+	+	+	Gewöhnliches Hornkraut
Ranunculus acris	+	1	+	Scharfer Hahnenfuß
Plantago lanceolata	+	+	+	Spitz-Wegerich
Poa trivialis	1	+	+	Gewöhnliches Rispengras
Centaurea jacea		+	+	Wiesen-Flockenblume
Lathyrus pratensis			+	Wiesen-Platterbse
Festuco - Brometea-Arten:				**Arten der Trocken-u.Halbtrockenrasen:**
Silene vulgaris	+	+	+	Aufgeblasenes Leimkraut
Centaurea scabiosa	+		+	Scabiosen-Flockenblume
Ranunculus bulbosus	+		+	Knolliger Hahnenfuß
Campanula glomerata	+	+		Büschel-Glockenblume
Plantago media			+	Mittlerer Wegerich
Seseli libanotis			+	Heilwurz

Weiters vorkommende Arten in Aufnahme 3: Euphrasis rostkoviana 1, Medicago sativa 1, Briza media +, Aegopodium podagraria +, Lotus corniculatus +, Festuca arundinaceae +.

Ort der Aufnahmen: Aufnahme 1 und 2 Haiming in Tirol, Innterrasse und Ötzterrasse, Aufnahme 3 Mitten bei Döllach im Mölltal.

+ = scarcley, not representative
1 = abundant, covering up to 1/20 of the analyzed surface
2 = very abundant, covering at least 1/20 of the analyzed surface
3 = covering 1/4 - 1/2 of the analyzed surface
4 = covering 1/2 - 3/4 of the analyzed surface
5 = covering more than 3/4 of the analyzed surface

Tabelle 2: Kolliner Rotkiefern - Lindenwald

Number of soil profile	3
Number of analysis	4
Date of analysis /day	8.
/month	6.
Height above sea level in 10 m	67
Inclination	0
Surface analyzed in m^2	100
Surface covered by plants in %	100
Number of species	49

Erico - Pinion-Arten:		**Arten der Schneeheide-Kiefernwälder:**
Pinus sylvestris	4	Rot-Kiefer
Platanthera bifolia	+	Weiße Waldhyacinthe
Vaccinio - Piceion-Arten:		**Arten der Fichtenwälder:**
Rhytidiadelphus triquetrus	3	Runzelbrudermoos
Pleurozium schreberi	3	Roststengelmoos
Hylocomium splendens	3	Hainmoos
Pyrola rotundifolia	2	Rundblättriges Wintergrün
Vaccinium vitis-idaea	2	Preiselbeere
Melampyrum sylvaticum	1	Wald-Wachtelweizen
Pyrola secunda	1	Nickendes Wintergrün
Maianthemum bifolium	1	Schattenblümchen
Deschampsia flexuosa	1	Draht-Schmiele
Picea abies	+	Fichte
Vaccinium myrtillus	+	Heidelbeere
Carpinion-Arten:		**Arten der Eichen - Hainbuchenwälder:**
Tilia cordata	2	Winter-Linde
Poa chaixii	1	Wald-Rispengras
Prunus avium	+	Vogel-Kirsche
Corylus avellana	+	Hasel
Berberidion-Arten:		**Arten der thermophilen Gebüsche:**
Juniperus communis	2	Gewöhnlicher Wacholder
Polygonatum odoratum	+	Salomonsiegel
Cornus sanguinea	+	Roter Hartriegel
Ligusticum vulgare	+	Rainweide
Berberis vulgaris	+	Berberitze
Alno - Ulmion-Arten:		**Arten der Auwälder:**
Fraxinus excelsor	+	Gewöhnliche Esche
Frangula alnus	+	Faulbaum
Tilio - Acerion-Arten:		**Arten der Schluchtwälder:**
Acer pseudoplatanus	+	Berg-Ahorn
Acer platanoides	+	Spitz-Ahorn
Querco - Fagetea-Arten:		**Arten d.europ.Fallaubwälder u.Gebüsche:**
Hieracium sylvaticum	2	Wald-Habichtskraut
Luzula pilosa	+	Behaarte Hainsimse
Melica nutans	+	Nickendes Perlgras
Brachypodium sylvaticum	+	Wald-Zwenke
Lonicera xylosteum	+	Rotes Geißblatt
Festuco - Brometea-Arten:		**Arten der Trocken-und Halbtrockenrasen:**
Prunella grandiflora	2	Großblütige Brunelle
Galium verum	+	Gelbes Labkraut
Brachypodium rupestre	+	Fieder-Zwenke

Weiters vorkommende Arten: Fragaria vesca 2, Potentilla erecta +, Vicia sepium +, Dactylis glomerata +, Athoxanthum odoratum +, Festuca rubra +, Hieracium caespitosum +, Hieracium pilosella +, Calluna vulgaris +, Achillea millefolium +, Arrhenatherum elatius +, Veronica chamaedrys +, Populus tremula +, Sorbus aucuparia +, Soidago virgaurea +.

Ort der Aufnahme: Haiming in Tirol, Ötzterrasse

1-3.2 Soil characteristics

1.2.1 Morphology of soil profile A-1

Location: Haiming (Austrian General Map 1:50.000, No. 116)

Height above sea level: 660 m

Topography: low terrace of the Inn river, plane

Parent material: Holocene river sediments with carbonate content

Land use: agric. cropping

A_p 0-20 cm: very dark brown to very dark gray (10 YR 2/2 - 3/1) sandy loam; crumb to light blocky structure; very friable, sticky and plastic, highly organic,abundant roots, few worm-holes, abrupt smooth boundary

A_h 20-35 cm: very dark brown to very dark gray (10 YR 2/2 - 3/1) sandy loam with low gravel content, fine to coarse angular-blocky structure, very friable, very plastic and sticky, medium organic matter content, many worm-holes, abundant roots, gradual boundary

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

AC_{ca} 45-60 cm: grayish brown to brown (10 YR 5/2 - 5/3) strong loamy sand with spots of humus, medium blocky-prismatic structure, very friable, plastic and non sticky, carbonate concretions and efflorescences in worm-holes, few roots, many worm-holes, gradual boundary

C_1 60-80 cm: light brownish gray to very pale brown (10 YR 6/2 - 7/3) strong loamy sand, slightly blocky to prismatic structure, very friable, plastic non sticky, some carbonate concretions, few worm-holes, few roots, gradual boundary

C_2 80-95 cm: gray to light gray (10 YR 6/1 - 2/5 Y 7/1) loamy coarse sand, very friable, non plastic, non sticky, few roots, clear boundary

D 95 + cm: bank of fine and coarse gravel of the Inn-river

1.2.2 Classification:

A: Kalkhaltige Gebirgsschwarzerde

FAO: Calcaric Phaeozem

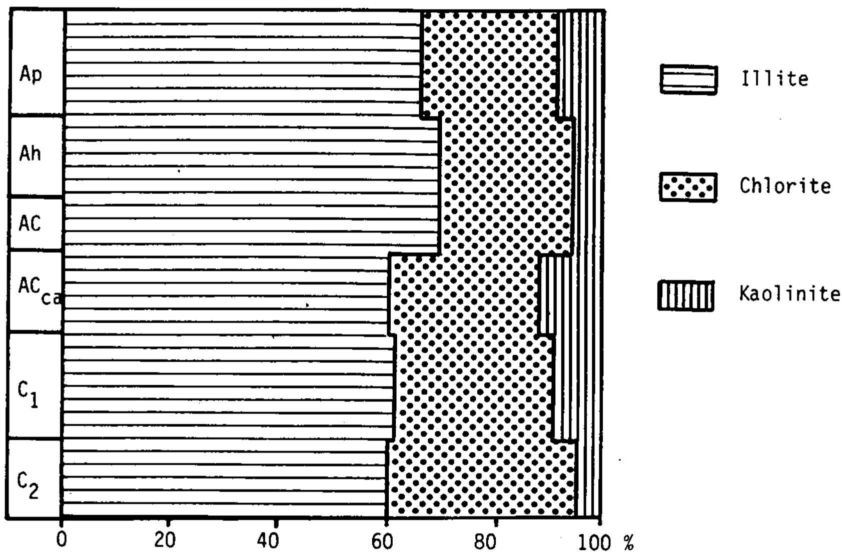
Physical and chemical characteristics of the profile A-1

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_p	0-20	-	3,5	36.6	23,3	63,4	10,2	11,4	6,7	28,3	8,3	55	±55
2	A_h	20-35	-	7,2	12,4	22,2	41,8	24,5	20,7	5,1	50,3	7,9	25	±19
3	AC	35-45	-	6,3	12,0	25,7	44,0	24,1	12,5	6,9	43,5	12,5	24	±18
4	AC_{ca}	45-60	-	1,7	13,0	29,1	43,8	26,6	12,9	6,9	46,4	9,8	-	-
5	C_1	60-80	-	1,1	15,0	34,0	50,1	25,1	12,8	5,8	43,7	6,2	-	-
6	C_2	80-95	-	0,9	39,1	28,9	68,9	16,3	9,5	3,2	29,0	2,1	-	-
7	D	95+	-	-	-	-	-	-	-	-	-	-	-	-

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fed mg/g	Feo mg/g	Feo:Fed	Mno mg/kg	Pa mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_p	1,24	53,4	52,1	42,1	34,8	11,3	7,7	7,4	6,0	4,2	0,70	410	241
2	A_h	1,51	44,4	43,4	37,0	31,1	12,1	8,2	7,5	5,2	4,5	0,87	461	165
3	AC	1,52	44,4	42,3	35,6	21,1	9,2	8,3	7,7	4,9	4,1	0,84	298	14
4	AC_{ca}	-	-	-	-	-	-	8,4	7,7	6,5	3,6	0,55	205	4
5	C_1	-	-	-	-	-	-	8,4	7,7	6,1	4,7	0,77	192	-
6	C_2	-	-	-	-	-	-	8,6	7,7	3,8	2,8	0,74	124	-
7	D	-	-	-	-	-	-	-	-	-	-	-	-	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_p	5,7	2,4	13,7	10,9	228	-	194	14	19	1	-	-	100
2	A_h	3,9	1,4	16,3	10,9	183	-	156	10	16	1	-	-	100
3	AC	1,9	0,6	18,7	13,0	137	-	118	7	11	1	-	-	100
4	AC_{ca}	1,2	<0,1	-	15,9	98	-	87	2	8	1	-	-	100
5	C_1	0,7	<0,1	-	13,0	68	-	61	1	6	1	-	-	100
6	C_2	0,7	<0,1	-	20,9	34	-	29	1	4	<1	-	-	100
7	D	-	-	-	-	-	-	-	-	-	-	-	-	-

Clay mineral distribution profile A-1



2.2.1 Morphology of soil profile A-2

Location: Haiming (Austrian General Map 1:50.000, No. 116)

Height above sea level: 670 m

Topography: late glacial terrace, plane

Parent material: sediments of the river Ötz without carbonate

Land use: pasture

Ah_1 0-10 cm: very dark grayish brown to dark brown (10 YR 3/2 - 3/3) loamy sand, fine and medium crumb structure, very friable, plastic non sticky, abundant roots, few worm-holes, gradual boundary

Ah_2 10-35 cm: very dark grayish brown to dark brown (10 YR 3/2 - 3/3) loamy coarse sand with low gravel content, fine crumb to medium blocky structure, very friable, plastic, non sticky, many roots, gradual boundary

Ah_3 35-60 cm: very dark grayish brown to dark grayish brown (10 YR 3/2 - 4/2) loamy coarse sand with low gravel content; medium blocky to medium prismatic structure, non friable, plastic, little sticky; few roots, many worm-holes; clear boundary

D_1 60-110 cm: pale brown (10 YR 6/3) coarse sand with gravels

D_2 110 + cm: grayisch brown to pale brown (10 YR 5/2 - 6/3) coarse sand and gravel

2.2.2 Classification:

A: Kalkfreie Gebirgsschwarzerde

FAO: haplic phaeozem

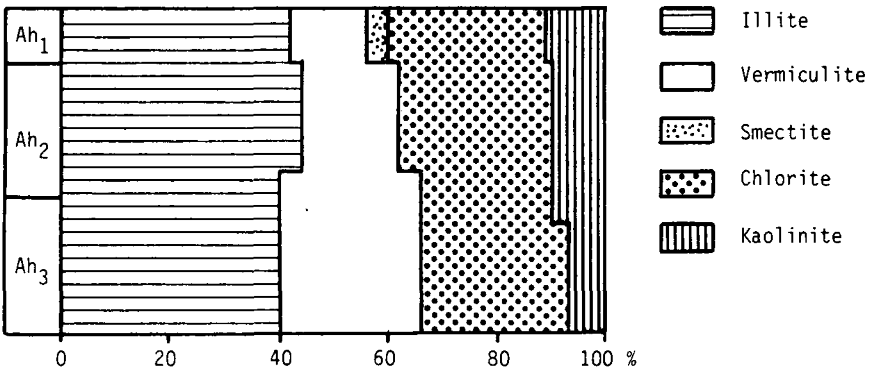
Physical and chemical characteristics of the profile A-2

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_{h1}	0-10	-	7,2	20,8	15,4	43,4	23,0	11,8	7,8	42,6	14,0	33	±29
2	A_{h2}	10-35	-	11,7	22,2	16,0	49,9	18,4	10,8	8,3	37,5	12,6	71	±35
3	A_{h3}	35-60	-	32,9	26,6	10,7	70,2	11,4	6,4	4,6	22,4	7,4	63	±43
4	D_1	60-110	-	48,7	33,9	8,9	91,5	0,8	2,9	0,7	4,4	4,1	170	±42
5	D_2	110-120	-	62,1	30,5	3,0	95,6	1,9	1,3	0,3	3,5	0,9	780	±170

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	$Fe_o:Fe_d$	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_{h1}	1,12	57,3	56,3	53,1	40,1	13,9	7,0	6,5	9,2	6,8	0,74	306	30,5
2	A_{h2}	1,15	57,0	56,0	45,7	32,8	10,7	7,2	6,8	8,5	4,7	0,55	170	16,1
3	A_{h3}	1,40	47,6	46,0	33,1	26,4	10,0	7,3	7,0	6,5	3,2	0,49	92	3,0
4	D_1	-	-	-	-	-	-	-	-	-	-	-	-	-
5	D_2	-	-	-	-	-	-	-	-	-	-	-	-	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_{h1}	7,1	4,9	8,9	0	279		214	3	40	1	-	-	93
2	A_{h2}	5,4	3,0	10,3	0	185		158	1	24	2	-	-	100
3	A_{h3}	2,5	0,7	20,4	0	88		65	1	13	1	-	-	91
4	D_1	0,6	-	-	0	30	-	23	1	4	1	-	-	97
5	D_2	0,2	-	-	0	22	-	10	1	2	1	-	-	64

Clay mineral distribution profile A-2



3.2.1 Morphology of soil profile A-3

Location: Silz (Austrian General Map 1:50.000, No. 116)

Height above sea level: 670 m

Topography: late glacial terrace, plane

Parent material: sediments of the river Ötz without carbonate

Land use: pine-forest

O_{lf} 7-0 cm: litter of trees and shrubs, partly decomposed

A_h 0-4 cm: very dark brown to very dark grayish brown (10 YR 2/2 - 3/2) loamy coarse sand, granular structure, very humic, slightly plastic, non sticky, abundant roots, clear boundary

E 4-9 cm: gray (7,5 YR 5/1 - 6/1) loamy coarse sand, loose, very weak granular structure, non plastic, non sticky, clear boundary

Bhs 9-15 cm: brown to pale brown (10 YR 4/3 - 5/3) loamy coarse sand, fine granular structure, very friable, non plastic, non sticky, few roots, gradual boundary

Bs 15-45 cm: dark yellowish brown to yellowish brown (10 YR 4/4 - 5/4) light loamy coarse sand, fine granular structure, very friable, non plastic, non sticky, very few roots, gradual boundary

BC 45-60 cm: yellowish brown to brownish yellow (10 YR 5/4 - 6/4) sand, loose granular structure, non plastic, non sticky, gradual boundary

C 60-85 cm: yellowish brown to light yellowish brown (10 YR 5/4 - 6/4) sand, clear boundary

D 85-105 + cm: grayish brown to light brownish gray (2,5 Y 5/2 - 6/2) sandy gravel

3.2.2 Classification:

A: schwach entwickelter Podsol

FAO: orthic podzol

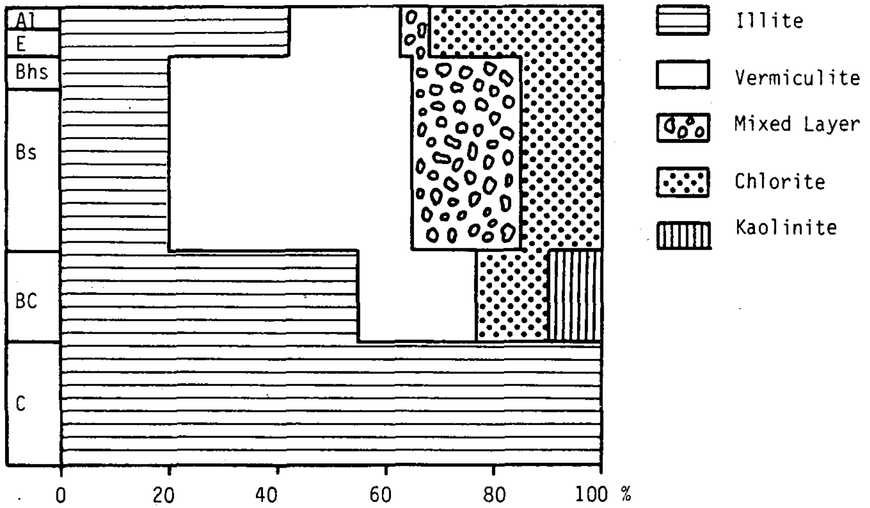
Physical and chemical characteristics of the profile A-3

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	O_{1f}	7-0	-	-	-	-	-	-	-	-	-	-	-	-
2	A_h	0-4	-	5,3	32,2	25,0	62,5	17,9	5,6	1,8	25,3	12,2	-	-
3	E	4-9	-	9,1	42,2	22,8	74,1	9,5	4,5	4,0	18,0	7,9	-	-
4	B_{hs}	9-15	-	7,5	36,8	27,8	72,1	10,9	5,7	2,7	19,3	8,6	-	-
5	B_s	15-45	-	8,0	43,0	28,5	79,5	11,2	3,0	1,0	15,2	5,3	500	±120
6	BC	45-60	-	18,3	56,7	19,3	94,3	2,5	1,5	0,4	4,4	1,3	650	±120
7	C	60-85	-	9,7	36,2	36,4	82,3	13,6	2,0	0,6	16,2	1,5	440	±310
8	D	85-105	-	48,4	43,6	3,5	95,5	0,3	0,5	0,2	1,0	3,5	>500	

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	O_{1f}	-	-	-	-	-	-	5,0	4,2	2,1	1,7	0,81	0,8	34,0
2	A_h	-	-	-	-	-	-	5,0	4,2	3,6	2,9	0,81	0,1	12,6
3	E	-	-	-	-	-	-	5,1	4,4	4,2	3,3	0,79	0,1	2,9
4	B_{hs}	-	-	-	-	-	-	5,6	4,8	4,0	3,6	0,90	0,1	1,3
5	B_s	1,27	51,7	50,6	31,9	17,5	5,2	6,1	5,2	4,3	3,8	0,88	0,1	-
6	BC	1,50	44,2	41,0	17,9	7,0	1,9	6,4	5,5	1,8	1,7	0,94	<0,1	-
7	C	1,63	39,0	33,3	16,7	4,5	0,8	6,4	5,6	1,2	1,2	-	<0,1	-
8	D	-	-	-	-	-	-	6,0	5,2	0,6	0,6	-	<0,1	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	O_{1f}	30,4	0,06	50,6	0	-	-	-	-	-	-	-	-	-
2	A_h	19,2	0,04	48,0	0	379	-	156	2	31	1	-	-	50
3	E	9,5	0,02	47,5	0	199	-	77	1	17	1	-	-	48
4	B_{hs}	1,9	-	-	0	61	-	19	-	5	1	-	-	41
5	B_s	1,0	-	-	0	35	-	9	-	4	1	-	-	40
6	BC	0,5	-	-	0	22	-	6	-	3	1	-	-	45
7	C	0,2	-	-	0	13	-	2	-	2	1	-	-	38
8	D	0,1	-	-	0	12	-	1	-	1	1	-	-	25

Clay mineral distribution profile A-3



SITE A 4

Oberndorf

4.1 Physio-geography

4.1.1 Location of the profile, geomorphology and geology

The profile is situated on the valley bottom of the "Kitzbühler Aache", see next figure. After the melting of the Würm glacier the valley, deepened by blacial exploratory excavation, was filled up. The sedimentation went on until the youngest Holocene. Today the river is forced into a concrete bed by regulation.

Below a layer of limefree loamy-sandy deposits (50 cm to 100 cm ore more) there is a gravel layer with wavey surface. The groundwater influences the soil below a depth of sixty centimeters.

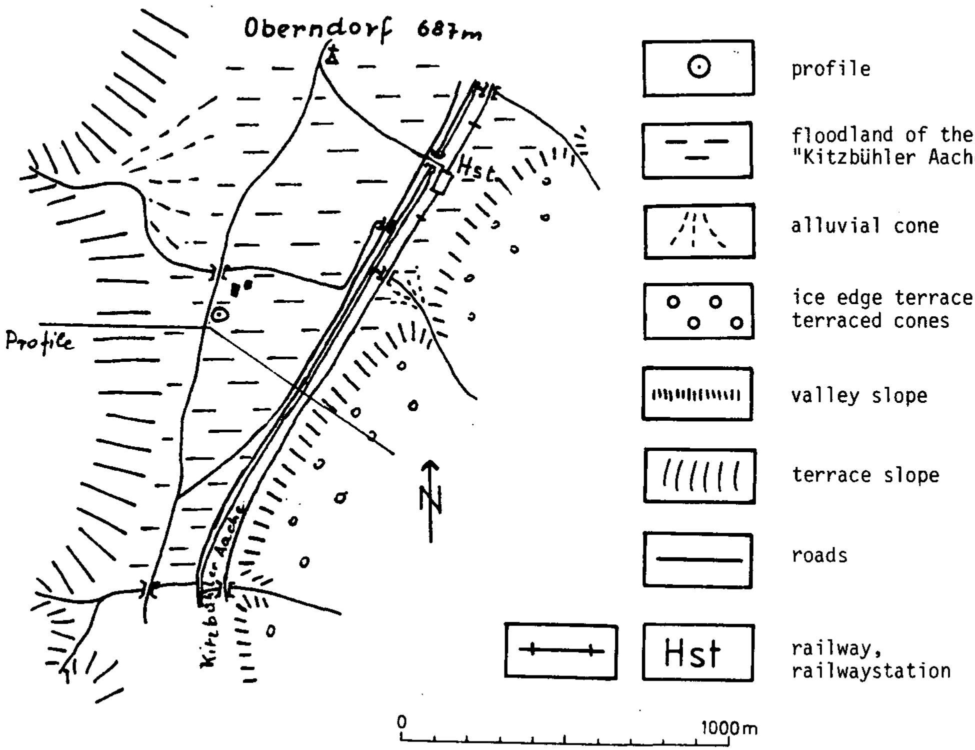
4.1.2 Climate

Mean annual temperature:	6^{o} C
Mean temperature at 2 p.m. from April - August:	$17{,}5^{o}$ C
Mean annual precipitation:	1370 mm

4.1.3 Vegetation

See page 201

Geomorphological sketch map of the area around
Oberndorf (profile A-4)



Schematic cross section through the valley of the "Kitzbühler Aache"
southern "Oberndorf" superelevation 6.25 x

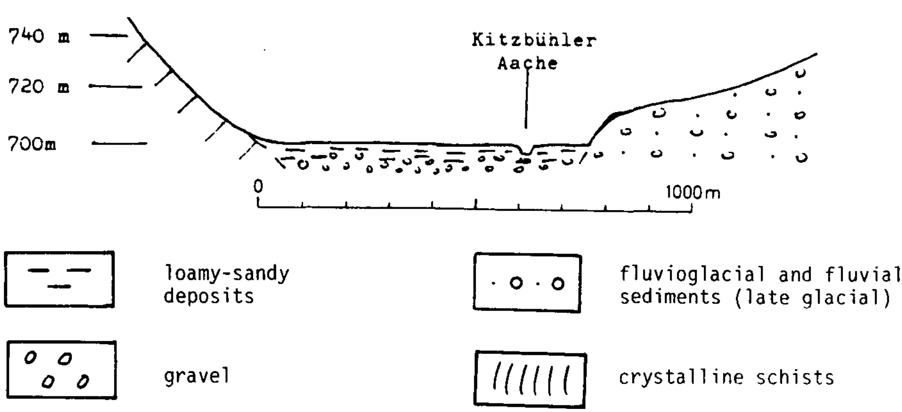


Tabelle 7: Montane Goldhaferwiesen

Number of soil profile	4	10
Number of analysis	10	11
Date of analysis /day	9.	9.
/month	6.	6.
Height above sea level in 10 m	69	77
Inclination	0	0
Surface analyzed in m^2	100	100
Surface covered by plants in '	100	100
Annual yield in dt/ha	90	98
Number of species	45	48

Polygono Trisetion-Arten:			Arten der Berg-Fettwiesen:
Melandrium rubrum	+	+	Rotes Marienröschen
Crocus albiflorus	+	+	Weißer Safran
Centaurea pseudophrygia	1	1	Perücken-Flockenblume
Chaerophyllum aureum		1	Gold-Kälberkropf
Arrhenatherion-Arten:			Arten der Tal-Fettwiesen:
Dactylis glomerata	1	1	Knaulgras
Crepis biennis	+	+	Zweijähriger Pippau
Pimpinella major	+	+	Große Bibernelle
Campanula patula		+	Wiesen-Glockenblume
Bromus hordeaceus		+	Weiche Trespe
Cynosurion-Arten:			Arten der Tal-Fettweiden:
Trifolium repens	1	2	Weiß-Klee
Phleum pratense	1	1	Wiesen-Lieschgras
Bellis perennis	1	1	Gewöhnliches Gänseblümchen
Poa annua	+	1	Einjahrs-Rispengras
Cynosurus cristatus	+		Kammgras
Leontodon autumnalis		+	Herbst-Löwenzahn
Arrhenatheretalia-Arten:			Arten der Wiesen und Weiden:
Trisetum flavescens	3	3	Goldhafer
Taraxacum officinale	1	1	Gewöhnliche Kuhblume
Alchemilla monticola	2	1	Frauenmantel
Achillea millefolium	1	1	Gewöhnliche Schafgarbe
Anthriscus sylvestris	+	1	Wiesen-Kerbelkraut
Carum carvi	+	+	Wilder Kümmel
Vicia sepium	+	+	Zaun-Wicke
Agrostis tenuis	+	1	Rotes Straußgras
Heracleum sphondylium	1	+	Wiesen-Bärenklau
Veronica chamaedrys	+	+	Gamander-Ehrenpreis
Chrysanthemum leucanthemum	+	+	Wiesen-Wucherblume
Molinietalia-Arten:			Arten der Naß- und Feuchtwiesen:
Lychnis flos-cuculi	+	+	Kuckucks-Lichtnelke
Angelica sylvestris	+	+	Wald-Engelwurz
Polygonum bistorta	+		Schlangen-Knöterich
Molinio - Arrhenatheretea-Arten:			Arten der Grünland-Gesellschaften:
Poa trivialis	2	2	Gewöhnliches Rispengras
Trifolium pratense	2	2	Rot-Klee
Poa pratensis	+	1	Wiesen-Rispengras
Festuca pratensis	1	1	Wiesen-Schwingel
Rumex acetosa	2	1	Wiesen-Sauerampfer
Ranunculus acris	1	1	Scharfer Hahnenfuß
Cerastium holosteoides	+	1	Gewöhnliches Hornkraut
Leontodon hispidus	+	+	Rauher Löwenzahn
Festuca rubra	+	+	Rot-Schwingel
Vicia cracca	+	+	Vogel-Wicke
Plantago lanceolata	+	1	Spitz-Wegerich
Prunella vulgaris	+	+	Kleine Brunelle
Lathyrus pratensis		+	Wiesen-Platterbse

Weiters vorkommende Arten in beiden Aufnahmen: Ranunculus repens 1, Anthoxanthum odoratum +, Rumex obtusifolius +, Plantago major +, Chaerophyllum hirsutum +, Agropyron repens +, Aegopodium podagraria +, Hypericum maculatum +.

Ort der Aufnahmen: Aufnahme 10 Oberndorf in Tirol, Aufnahme 11 Maishofen in Salzburg.

4.2 Soil characteristics

4.2.1 Morphology of soil profile A-4

Location: Oberndorf (Austrian General Map 1:50.000, No. 122)

Height above sea level: 690 m

Topography: bottom of the valley of the river Kitzbühler Aache, plane

Parent material: holocene river sediments

Land use: pasture

Ah	0-8 cm: dark brown to dark grayish brown (10 YR 3/3 - 4/2) sandy silt loam; medium crumb to weak fine plate structure, high porosity, very friable, many worm-holes, gradual boundary
AP_1	8-25 cm: olive brown (2,5 Y 4/4) sandy silt loam; many light grayish mottles and brown stains, coarse plate structure break to strong medium angular blocks, low porosity, many worm-holes, non to slightly friable, gradual boundary
AP_2	25-45 cm: olive brown (2,5 Y 4/4) sandy loam with some gravels; moderate to strong medium prisms, partly medium plates, many light grayish mottles and brownish stains, many worm-holes, gradual boundary
B	45-60 cm: olive brown (2,5 Y 4/4) sandy loam with some gravels; fine to medium prisms break to coarse angular blocks, partly plates, gradual boundary
B_g	60-80 cm: olive brown (2,5 Y 4/4) sandy loam, some gravels; fine granular structure, some light grayish and brownish stains, low porosity, few roots, many worm-holes, clear boundary
D	80-110 + cm: grayish brown to light brownish gray (2,5 Y 5/2 - 6/2) sandy gravel

4.2.2 Classification:

A: krumenpseudovergleyter Auboden

FAO: Eutric Fluvisol

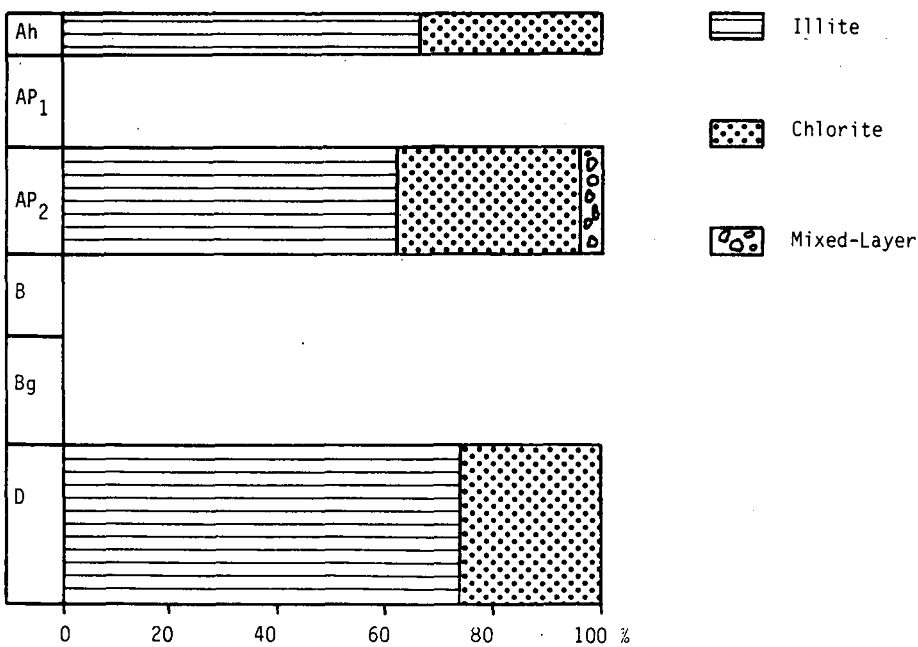
Physical and chemical characteristics of the profile A-4

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_h	0-8	-	4,6	9,5	17,6	31,7	21,0	15,3	11,5	47,8	20,5	27	±35
2	AP_1	8-25	-	3,0	9,5	19,4	31,9	26,7	11,9	11,2	49,8	18,3	5	±8
3	AP_2	25-45	-	5,4	10,5	18,8	34,7	29,9	11,2	8,1	49,2	16,1	72	±102
4	B	45-60	-	6,6	14,2	20,3	41,1	20,3	13,2	10,4	43,9	15,0	-	-
5	B_g	60-80	-	3,4	12,2	19,6	35,2	24,1	14,1	9,5	47,7	17,1	63	±32
6	D	80-110	-	7,8	60,1	20,7	88,6	1,1	1,6	9,7	5,4	6,0	>900	

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o : Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_h	1,28	52,7	51,9	49,6	45,0	13,1	5,5	4,7	13,8	9,2	0,67	880	3,9
2	AP_1	1,31	52,0	51,3	47,9	42,9	14,4	5,4	4,6	13,4	9,4	0,70	880	1,3
3	AP_2	1,26	54,4	48,7	41,9	37,3	10,8	5,7	4,8	15,3	10,1	0,66	1142	0,4
4	B	-	-	-	-	-	-	5,9	5,0	13,8	10,3	0,75	1197	0,4
5	B_g	1,37	50,6	45,8	39,6	36,2	10,9	6,1	5,1	12,1	5,8	0,48	694	-
6	D	-	-	-	-	-	-	6,2	5,6	9,2	4,6	0,50	484	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_h	3,9	0,03	13	0	128	-	42	2	14	1	-	-	46
2	AP_1	2,6	0,02	13	0	115	-	31	1	10	1	-	-	37
3	AP_2	1,3	0,01	13	0	83	-	30	1	8	1	-	-	48
4	B	1,0	0,01	-	0	70	-	27	1	8	1	-	-	53
5	B_g	1,0	0,01	-	0	66	-	30	1	9	1	-	-	62
6	D	0,3	-	-	0	30	-	14	1	5	1	-	-	70

Clay mineral distribution profile A-4



S I T E A 5

Döllach

5.1 Physio-geography

5.1.1 Location of the profile, geomorphology and geology

This profile is situated on a strongly superimposed erosion surface, the ramains of a preglacial valley bottom of the Möll. On the top of the rock bed there is a dense gray ground morain. In the depressions of the slopes solifluction material or colluvium covers the morain. On exposed positions one will find glacial polished rocks.

The microrelief is important for the soil catena. In the depressions the soil is deep and usually influenced by slope water. On konvex parts the soil is shallow.

Solifluidal redeposited morainic material and talus. Locally, also glacio-fluviatile sediments (may appear). The rounded cobbles derive mainly from lime-free to lime-rich schists and quartzites of the Bündner Schiefer series, combined with prasinites and serpentinites. Also the fine material corresponds to the desintegration of the Bündner Schiefer series. Upslope the limy micaschists (Bündner Schiefer in Glockner facies) are exposed.

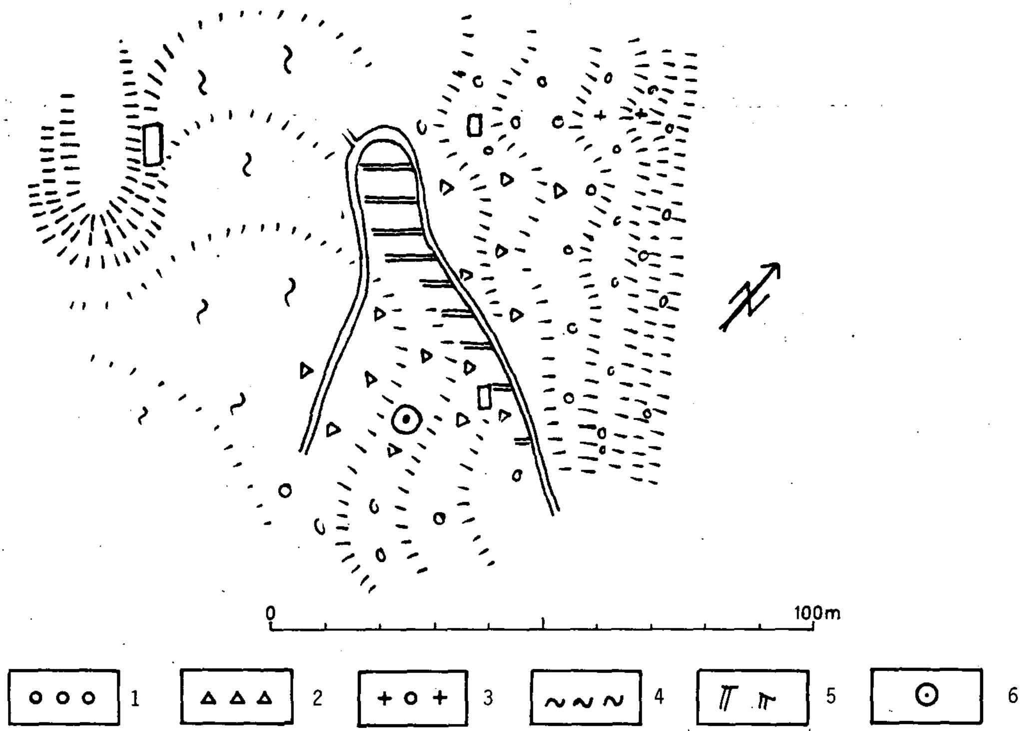
5.1.2 Climate

Mean annual temperature:	6^{o} C
Mean temperature at 2 p.m. from April - August:	$16{,}5^{o}$ C
Mean annual precipitation:	840 mm

5.1.3 Vegetation

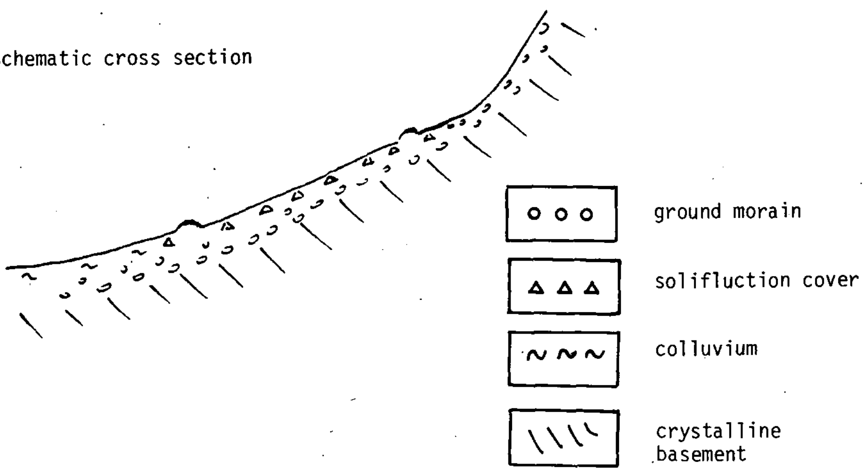
See page 188

Geomorphological sketch map or the area around
the profile A-5 ("Döllach")



1 ground morain
2 solifluction cover
3 ground morain with glacial boss
4 ground morain below colluvium
5 road slope
6 profile

Schematic cross section



5.2 Soil characteristics

5.2.1 Morphology of soil profile A-5

Location: Döllach (Austrian General Map 1:50.000, No. 180)

Height above sea level: 1.110 m

Topography: slope 14^{0} WSW

Parent material: ground morain and slope debris (mainly calcareous mica schists)

Land use: pasture

Ah_1 0-20 cm: black to very dark gray (10 YR 2/1 - 3/1) loamy sand with few gravels; light to medium crumb structure, high porosity; very humic, very friable, plastic non sticky, abundant roots, gradual boundary

Ah_2 20-40 cm: very dark gray to dark gray (10 YR 3/1 - 4/1) loamy sand with some gravel content; medium angular structure, high porosity, very friable; medium humic; plastic, sticky, abundant roots, gradual boundary

AC 40-60 cm: dark grayish brown (10 YR 4/2) loamy coarse sand; medium angular to blocky structure, high porosity, very friable, plastic, sticky, clear boundary

C_v 60 + cm: morain blocks and coarse gravels

5.2.2 Classification:

A: Pararendsina

FAO: Calcaric Phaeozem

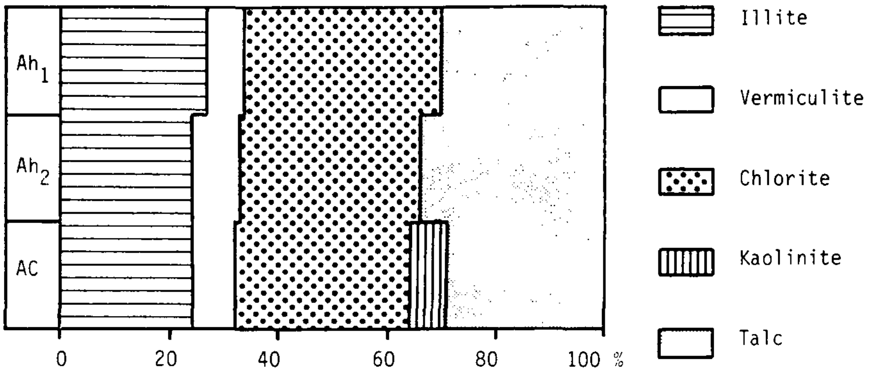
Physical and chemical characteristics of the profile A-5

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil sand c	m	f	Σ	silt c	m	f	Σ	clay	k_f cm/d	var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_{h1}	0-20	-	9,5	12,1	22,0	43,6	27,2	10,3	7,7	45,2	11,2	109	±97
2	A_{h2}	20-40	-	17,6	15,9	22,5	56,0	20,1	9,4	6,2	35,7	8,3	55	±13
3	AC	40-60	-	17,8	16,7	25,9	60,4	16,9	10,3	5,7	32,9	6,7	-	-
4	C_v	60+	-	23,2	19,1	22,7	65,0	16,7	9,0	4,6	30,3	4,7	-	-

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	$CaCl_2$	Fed mg/g	Feo mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_{h1}	1,15	58,9	54,1	44,4	35,5	13,4	7,5	7,3	10,0	5,1	0,51	1044	4,8
2	A_{h2}	1,46	47,7	41,4	31,5	23,3	7,8	8,1	7,5	9,3	3,6	0,39	721	-
3	AC	-	-	-	-	-	-	8,3	7,6	11,9	3,8	0,32	716	-
4	C_v	-	-	-	-	-	-	8,4	7,6	11,5	1,6	0,14	261	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_{h1}	6,4	5,0	7,5	3,4	301	-	276	4	20	1	-	-	100
2	A_{h2}	2,6	1,0	15,0	6,8	158	-	150	2	6	-	-	-	100
3	AC	1,5	0,6	14,0	10,8	111	-	107	1	3	-	-	-	100
4	C_v	0,7	0,5	7,8	17,1	57	-	54	1	2	-	-	-	100

Clay mineral distribution profile A-5



S I T E A 6

Senfteben

6.1 Physio-geography

6.1.1 Location of the profile, geomorphology and geology

The remains of a late glacial morain rampart are asserted at ca. 1900 - 1950 meters on the steep SE - slope of the "Wasserrad Kopf" (3032 m). The morain 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.

Here the surface is strongly heterogeneous: the sandy initial material of the soil is a local, partly water-carried, weathering resideum 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, kilometer-sized serpentinite body.

6.1.2 Climate

Mean annual temperature:	1,9^{o} C
Mean temperature at 2 p.m. from April - August:	10,1^{o} C
Mean annual precipitation:	1490 mm

6.1.3 Vegetation

See page 212

Geomorphological sketch map of the area around
the profile A-6 ("Sanfteben")

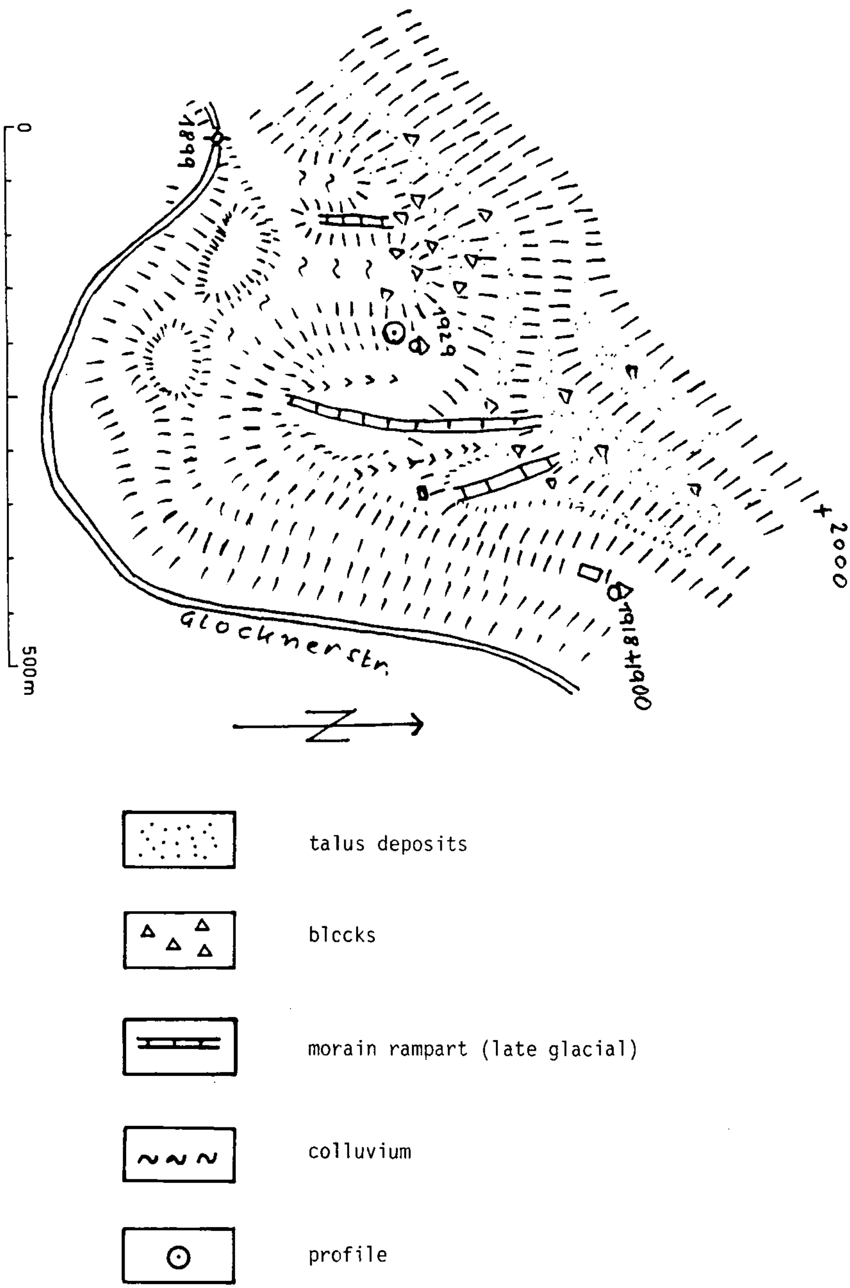


Tabelle 3: Subalpine Fettwiesen

Number of soil profile		6	
Number of analysis	5	6	
Date of analysis /day	22.	22.	
/month	7.	7.	
Height above sea level in 10 m	192	193	
Inclination	16	20	
Exposition	SW	SSW	
Surface analyzed in m^2	50	50	
Surface covered by plants in %	100	100	
Annual yield in dt/ha	27	21	
Number of species	33	58	
Poion alpinae-Arten:			Arten der Alpenfettweiden:
Trifolium pratense ssp.nivale	2	1	Schnee-Klee
Poa alpina	2	1	Alpen-Rispengras
Achillea millefolium ssp.sud.	2	+	Sudeten-Schafgarbe
Ranunculus montanus	+	1	Berg-Hahnenfuß
Crepis aurea	+	+	Gold-Pippau
Phleum alpinum	+	+	Alpen-Lieschgras
Trifolium badium	+	+	Alpen-Braun-Klee
Silene vulgaris ssp. latifol.	+	+	Aufgeblasenes Leimkraut
Cerastium fontanum	+	+	Quell-Hornkraut
Polygono - Trisetion-Arten:			Arten der Berg-Fettwiesen:
Viola tricolor	+	+	Wildes Stiefmütterchen
Rumex alpestris	+	+	Berg-Sauer-Ampfer
Crocus albiflorus	+	+	Weißer Safran
Myosotis sylvatica	+	+	Wald-Vergißmeinnicht
Geranium sylvaticum	+	+	Wald-Storchschnabel
Centaurea pseudophrygia	+	+	Perücken-Flockenblume
Arrhenatheretalia-Arten:			Arten der Wiesen und Weiden:
Festuca nigrescens	2	2	Schwarzer Schwingel
Alchemilla monticola	2	1	Frauenmantel
Agrostis tenuis	1	2	Rotes Straußgras
Anthoxanthum odoratum	+	2	Gewöhnliches Ruchgras
Veronica chamaedrys	+	+	Gamander-Ehrenpreis
Trisetum flavescens	+	+	Gold-Hafer
Trifolium repens	+	+	Weiß-Klee
Avena pubescens		1	Flaum-Hafer
Prunella vulgaris		+	Kleine Brunelle
Molinietalia-Arten:			Arten der Feuchtwiesen:
Trollius europaeus	3	2	Trollblume
Parnassia palustris	+	1	Studentenröschen
Nardion-Arten:			Arten der subalpinen Borstgrasrasen:
Crepis conycifolia	2	2	Großköpfiger Pippau
Arnica montana		2	Berg-Wohlverleih
Nardus stricta		2	Borstgras
Luzula campestris		1	Hain-Simse
Hieracium hoppeanum		1	Hoppe's Habichtskraut
Rhinanthus aristatus		1	Schmalblättriger Klappertopf
Campanula barbata		+	Bärtige Glockenblume
Potentilla aurea		+	Gold-Fingerkraut
Gentiana acaulis		+	Stengelloser Enzian
Coeloglossum viride		+	Hohlzunge
Seslerietalia variae-Arten:			Arten der alpigenen Kalkmagerrasen:
Scabiosa lucida	+	2	Glattblättriges Grindkraut
Gentiana solstitialis	+	+	Sommer-Enzian
Pedicularis foliosa	+	+	Vielblättriges Läusekraut
Anthyllis vulneraria ssp.alp.		1	Alpen-Wundklee
Lotus alpinus		1	Alpen-Hornklee
Carex sempervirens		1	Immergrüne Segge
Phleum hirsutum		+	Rauhes Lieschgras
Potentilla erecta		+	Blutwurz
Phyteuma orbiculare		+	Rundköpfige Rapunzel
Biscutella laevigata		+	Brillenschötchen

Weiters vorkommende Arten in beiden Aufnahmen: Soldanella alpina 1, Stellaria graminea +, Ranunculus nemorosus +, Campanula scheuchzeri +, Polygonum viviparum +; in Aufnahme 6: Carlina acaulis 2, Avena versicolor 2, Briza media 1, Festuca pseudodura +, Thesium alpinum +, Luzula luzuloides +, Juncus trifidus +.

Ort der Aufnahmen: Senfteben an der Glocknerstraße in Kärnten, Aufnahme 6 Hangrücken, Aufnahme 5 Unterhangmulde.

6.2 Soil characteristics

6.2.1 Morphology of soil profile A-6

Location: Senfteben (Austrian General Map 1:50.000, No. 153)

Height above sea level: 1.930 m

Topography: slope 20^{o} SW

Parent material: sediments over ground morain

Land use: pasture

Ah 0-11 cm: very dark grayish brown to dark grayish brown (10 YR 3/2 - 4/2) loamy sand with some gravels; fine to medium crumb structure, fine pores, very friable, plastic non sticky, abundant roots, gradual boundary

AB 11-22 cm: dark brown to dark yellowish brown (10 YR 4/3 - 4/4) loamy sand with some gravels; fine angular blocky structure, fine pores, very friable, non plastic non sticky, some small light grayish stains, abundant roots, gradual boundary

Bv_1 22-36 cm: dark yellowish brown (10 YR 4/4) light loamy sand with some gravels; fine to medium blocky structure, very friable, non plastic, non sticky, gradual boundary

Bv_2 36-52 cm: yellowish brown (10 YR 5/4) sand with some gravels; medium to fine angular blocky structure, fine pores, friable, non plastic, non sticky, gradual boundary

D_1 52-84 cm: brown (10 YR 5/3) gravelly sand, clear boundary

D_2 84-102 + cm: grayish brown (2,5 Y 5/2) sand with ground morain blocks

6.2.2 Classification:

A: kalkfreie Lockersedimentbraunerde

FAO: Dystric Cambisol

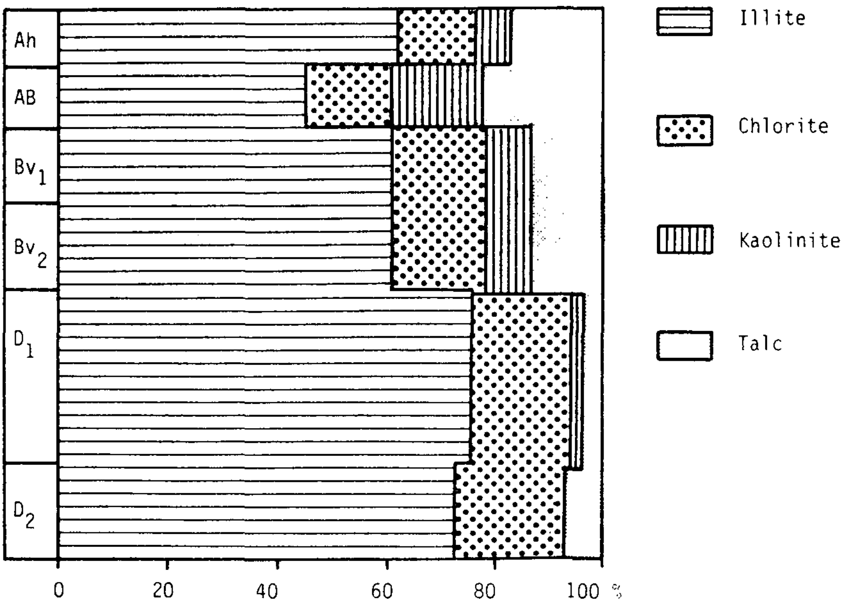
Physical and chemical characteristics of the profile A-6

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil sand c	m	f	Σ	silt c	m	f	Σ	clay	k_f cm/d	var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_h	0-11	-	6,0	19,0	31,4	56,4	16,9	8,1	5,1	30,1	13,5	310	±34
2	AB	11-22	-	12,0	26,2	28,9	67,1	10,7	7,5	4,6	22,8	10,1	-	-
3	B_{v1}	22-36	-	6,4	24,5	35,0	65,9	11,1	5,3	5,6	22,0	12,1	349	±35
4	B_{v2}	36-52	-	8,2	30,4	31,4	70,0	12,9	6,8	3,3	23,0	7,0	-	-
5	D_1	52-84	-	9,8	29,2	34,1	73,1	12,8	5,3	1,9	20,0	6,9	-	-
6	D_2	84-102	-	22,0	28,2	24,4	74,6	12,4	7,2	2,1	21,7	3,7	-	-

No	hor.	bulk dens. g/cm^3	poro-sity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	$CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_h	1,00	61,2	59,2	47,2	42,0	20,0	5,4	4,9	23,0	8,9	0,39	585	2,2
2	AB	-	-	-	-	-	-	5,5	4,8	29,9	11,6	0,39	1164	-
3	B_{v1}	1,17	57,2	56,5	39,1	30,6	12,1	5,7	4,8	26,3	10,5	0,40	1454	-
4	B_{v2}	-	-	-	-	-	-	5,8	4,9	22,2	10,2	0,46	1596	-
5	D_1	-	-	-	-	-	-	6,6	6,0	19,5	5,1	0,26	1388	-
6	D_2	-	-	-	-	-	-	7,9	7,2	11,2	1,3	0,12	492	-

No	hor.	org. %	N_t mg/g	C:N	carbo-nate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_h	5,7	3,1	10,6	0	189	-	82	1	23	1	-	-	57
2	AB	2,2	2,0	6,5	0	97	-	23	-	6	1	-	-	31
3	B_{v1}	1,5	1,0	9,0	0	70	-	14	-	3	1	-	-	26
4	B_{v2}	0,7	0,6	-	0	48	-	12	-	3	1	-	-	33
5	D_1	0,5	0,4	-	0	42	-	23	-	4	1	-	-	67
6	D_2	0,2	0,2	-	52,9	-	-	-	-	-	-	-	-	-

Clay mineral distribution profile A-6



SITE A7

Fallbichl

7.1 Physio-geography

7.1.1 Location of the profile, geomorphology and geology

The same carbonate-poor Bündner Schiefer (Bündner schists) of Brennkogel facies, which are exposed here at the cirque floor, on the crest between the south-wards-lying Lacknerberg and the eastwards-lying Schareck are lying clearly above the bright marbles of the Seidlwinkl Triassic System, which towards north extends upto the Hochtor Tunnels. Moreover some morainic circles of a young local glacier are visible, which came from the east. The geomorphology is shown on page 218.

7.1.2 Climate

Mean annual temperature:	0,2° C
Mean temperature at 2 p.m. from April - August:	7,8° C
Mean annual precipitation:	1550 mm

7.1.3 Vegetation

See table next page

Tabelle 4: Alpiner Krummseggenrasen 7a, Schneeboden-Gesellschaft 7b

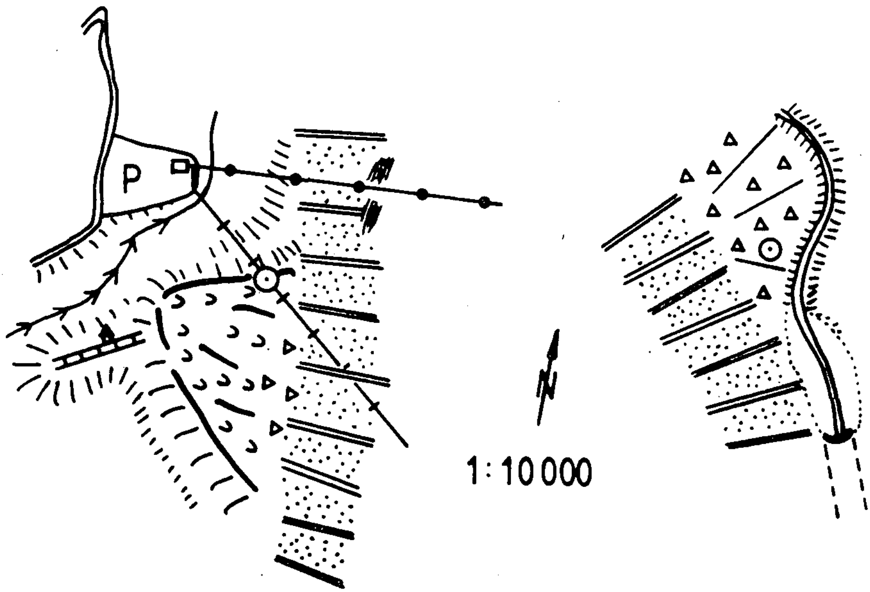
Number of soil profile	7a	7b
Number of analysis	7a	7b
Date of analysis /day	18.	17.
/month	8.	8.
Height above sea level in 10 m	218	225
Inclination	18	0
Exposition	SSW	-
Surface analyzed in m^2	50	6
Surface covered by plants in %	85	100
Annual yield in dt/ha	5	2
Number of species	32	20

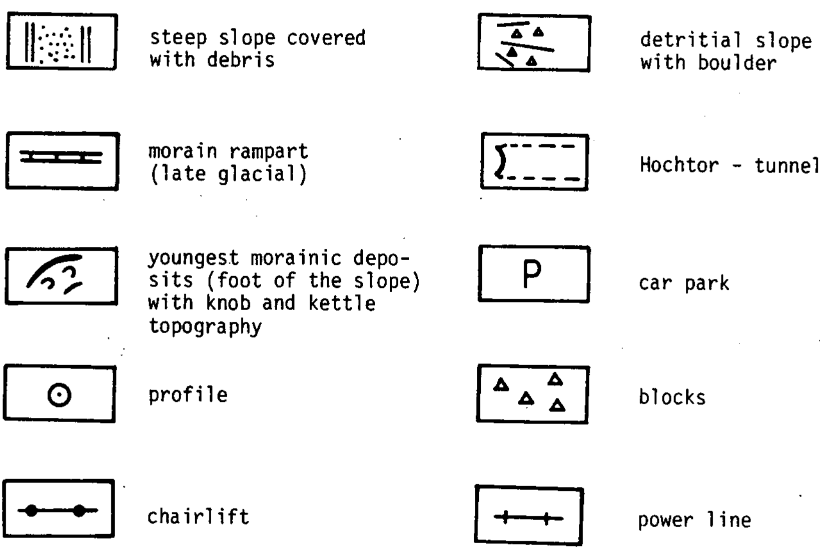
	7a	7b	
Elynetalia-Arten:			Arten der Nacktried-Gesellschaften:
Trifolium pallescens	+		Verbleichender Klee
Gentiana tenella	+		Zarter Enzian
Cerastium alpinum	+		Alpen-Hornkraut
Dianthus glacialis	+		Gletscher-Nelke
Caricetalia curvulae-Arten:			Arten der alpinen Krummseggenrasen:
Carex curvula	3		Krumm-Segge
Primula minima	2		Kleine Primel
Festuca pseudodura	1		Harter Schwingel
Ligusticum mutellinoides	1		Kleine Mutterwurz
Avena versicolor	1		Bunter Hafer
Juncus jacquinii	+		Gemsen-Binse
Phyteuma globularifolium	+		Armblütige Rapunzel
Senecio carniolicus	+		Krainer Greiskraut
Oreochloa disticha	+		Zweizeiliges Blaugras
Androsace obtusifolia	+		Stumpfblättriger Mannsschild
Phyteuma hemisphaericum	+		Halbkugelige Teufelskralle
Thamnolia vermicularis	+		
Cetraria nivalis	+		
Cetraria cucullata	+		
Cladonia rangiferina	+		
Alectoria ochroleuca	+		
Juncetea trifidi-Arten:			Arten d.Dreiblattsimsen-u.Krummseggenr.
Euphrasia minima	+		Kleiner Augentrost
Juncus trifidus	+		Dreiblatt-Binse
Seslerietalia variae-Arten:			Arten der alpigenen Kalkmagerrasen:
Minuartia gerardii	+		Alpen-Miere
Galium anisophyllum	+		Ungleichblättriges Labkraut
Nardion-Arten:			Arten der subalpinen Borstgrasrasen:
Leontodon helveticus	2	+	Schweizer Löwenzahn
Geum montanum	+		Berg-Nelkenwurz
Hieracium alpinum	+		Alpen-Habichtskraut
Homogyne alpina	+		Alpen-Brandlattich
Nardus stricta		+	Borstgras
Potentilla aurea		+	Gold-Fingerkraut
Poion alpinae-Arten:			Arten der Alpen-Fettweiden:
Poa alpina	+		Alpen-Rispengras
Salicion herbaceae-Arten:			Arten der bodensauren Schneetälchen:
Polytrichum norvegicum		2	
Soldanella pusilla		2	Zwerg-Alpenglöckchen
Sibbaldia procumbens		2	Gelbling
Phleum commutatum		1	Falsches Lieschgras
Luzula alpino-pilosa		1	Braune Hainsimse
Chrysanthemum alpinum		1	Alpen-Wucherblume
Cerastium cerastoides		1	Dreigriffeliges Hornkraut
Gnaphalium supinum		+	Zwerg-Ruhrkraut
Salix herbacea		+	Krautige Weide
Carex lachenalii		+	Lachenal's Segge
Arabidion caeruleae-Arten:			Arten der Kalk-Schneetälchen:
Arabis caerulea		1	Blaue Gänsekresse
Taraxacum alpinum		+	Alpen-Kuhblume
Salicetea herbaceae-Arten:			Arten der alpinen Schneeboden-Gesellsch.
Poa supina		3	Läger-Rispengras
Ligusticum mutellina		2	Alpen-Mutterwurz
Alchemilla fissa		1	Frauenmantel
Veronica alpina	+	+	Alpen-Ehrenpreis
Chrysanthemum alpinum	+		Alpen-Wucherblume
Gnaphalium supinum	+		Niedriges Ruhrkraut
Montio - Cardaminetea-Arten:			Arten der Quellfluren:
Deschampsia alpina		1	Alpen-Draht-Schmiele

Ort der Aufnahmen: Fallbichl an der Glocknerstraße in Kärnten, 7a Kuppe, 7b Mulde

Geomorphological sketch map of

Fallbichl (Profiles A-7A and A-7B) Hochtor (Profile A-8)





7.2 Soil characteristics

7/a 2.1 Morphology of soil profile A-7a

Location: Fallbichl (Austrian General Map 1:50.000, No. 154)

Height above sea level: 2.250 m

Topography: small ridge

Parent material: morain material, slope debris and dust deposits

Land use: pasture

Ahe 0-5 cm: dark gray (10 YR 4/1) light loamy sand with some gravels, moderate granular structure, very friable, non plastic, non sticky, distinctive light-grayish and brown stains, abundant roots, clear boundary

Bsh 5-17 cm: dark brown to dark yellowish brown (10 YR 4/3 - 3/4) light loamy coarse sand, moderate to medium granular to subangular structure, very friable, non plastic, non sticky, abundant roots, gradual boundary

B_v 17-24 cm: brown (10 YR 5/3) light loamy sand, moderate subangular structure, very friable, non plastic, non sticky, many roots, gradual boundary

C_v 24-45 + cm: pale brown (10 YR 6/3) sand with many skeletal fragments

7/a 2.2 Classification:

A: Semipodsol

FAO: Septic podzol

Physical and chemical characteristics of the profile A-7a

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14 *	15 *
1	A_{he}	0-5	-	13,7	20,1	27,8	61,6	15,1	5,1	4,1	24,3	14,1	33	±65
2	B_{sh}	5-17	-	27,0	23,2	21,6	71,8	19,8	2,6	0,1	22,5	5,7	-	-
3	B_v	17-24	-	20,9	23,7	26,3	70,9	13,4	7,3	1,0	21,7	7,4	52	±31
4	C_v	24-45+	-	28,0	20,5	22,9	71,4	20,0	3,4	0,2	23,6	5,0	326	±106

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16 *	7 *	18 *	19 *	20 *	21 *	22	23	24	25	26	27	28
1	A_{he}	0,92	63,8	62,8	54,1	36,5	16,8	4,6	3,8	13,0	1,6	0,12	181	9,6
2	B_{sh}	-	-	-	-	-	-	4,8	4,0	33,1	20,1	0,61	661	0,8
3	B_v	1,38	50,6	47,2	40,8	26,8	6,9	4,9	4,2	33,9	8,5	0,25	612	0,4
4	C_v	1,22	57,5	51,2	35,9	21,9	2,9	5,7	4,5	28,7	7,4	0,26	760	0,4

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_{he}	7,2	3,2	13,1	0	136	-	35	2	9	1	-	-	35
2	B_{sh}	2,5	1,2	12,1	0	137	-	9	-	2	1	-	-	9
3	B_v	1,3	0,7	10,8	0	69	-	5	-	1	1	-	-	10
4	C_v	0,5	0,4	5,8	0	42	-	4	-	-	1	-	-	12

* volumes from profile nearly

7/b 2.1 Morphology of soil profile A-7b

Location: Fallbichl (Austrian General Map 1:50.000, No. 154)

Height above sea level: 2.250 m

Topography: small depression

Parent material: morain material slope debris and dust deposits

Land use: pasture

Ae 0-5 cm: very dark gray (2,5 Y 3/0) loamy sand with high content of fragments and cobbles, weak plates, weak very fine angular blocks, porous, very friable, plastic, non sticky with distinctive small brown stains, many roots, gradual boundary

AeP 5-12 cm: dark gray to dark grayish brown (2,5 Y 4/0 - 4/2) slight loamy coarse sand with high content of fragments and cobbles, fine to medium plates break to angular blocks, porous, friable, plastic, non sticky, many brownish-yellowish stains and concretions, many roots, clear boundary

Bsh 12-36 cm: dark grayish brown to dark brown (10 YR 4/2 - 4/3) sand with high content of course fragments, medium subangular blocky structure, very friable, non plastic, non sticky, few roots, gradual boundary

BC 36-50 cm: dark grayish brown (10 YR 4/2) sand with high content of coarse stone fragments and blocks

7/b 2.2 Classification:

A: Alpiner Pseudogley

FAO: Gleyic Podzol

Physical and chemical characteristics of the profile A-7b

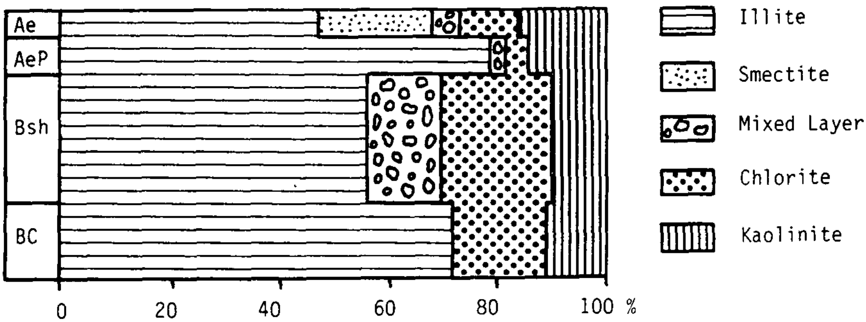
No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil sand c	m	f	Σ	silt c	m	f	Σ	clay	k_f cm/d	var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14*	15*
1	A_e	0-5	-	7,0	17,6	21,2	45,8	17,8	9,8	5,9	33,5	20,7	-	-
2	A_eP	5-12	-	23,5	19,7	21,4	64,6	12,4	8,2	1,8	22,4	13,0	50	±32
3	B_{sh}	12-36	-	32,1	21,9	20,6	74,6	11,1	5,7	2,3	19,1	6,3	26	±21
4	BC	36-50	-	23,1	29,0	24,9	77,0	12,1	5,3	1,9	19,3	3,7	-	-

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	$CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16*	7*	18*	19*	20*	21*	22	23	24	25	26	27	28
1	A_e	-	-	-	-	-	-	6,5	5,6	10,3	7,5	0,73	1798	36,6
2	A_eP	1,54	44,1	41,2	34,8	25,8	6,7	6,7	5,7	11,8	5,8	0,49	1929	3,1
3	B_{sh}	1,46	47,6	44,0	36,8	28,4	9,4	6,5	5,8	48,8	36,9	0,76	11367	0,4
4	BC	-	-	-	-	-	-	6,5	5,8	32,2	4,3	0,13	869	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_e	14,4	8,4	10,0	0	325		237	5	36	1	-	-	86
2	A_eP	2,3	1,8	7,4	0	92		62	1	11	1	-	-	82
3	B_{sh}	1,2	1,3	5,4	0	126		51	1	8	1	-	-	48
4	BC	0,6	0,7	-	0	53		22	-	4	1	-	-	51

*volumes from profile nearly

Clay mineral distribution profile A-7b



SITE A8

Hochtor

8.1 Physio-geography

8.1.1 Location of the profile, geomorphology and geology

To the W of the road, under the lime marble walls also yellowish dolomite and cellular rauhwackes (with extension according to a N-S axis)are visable. Old gold-galleries in the marbles.

Just above the Hochtor there begin the overlying Bündner Schiefer series (with small ophiolite masses), which builds up the mountains to the west of the road, and these also supply the till and colluvial deposits at the profile. This local talus has a strongly variable composition according to the origin. F.i. some blocks originate from the granate-carrying "eclogitic" prasinites of the Margrötzenkopf, and these are witness of an old alpidic high pressure metamorphism. Other boudlers show a dark gray phyllite (carbonate-poor, partly with chloritoid, and exeptionally cyanite), than quartzite to phengite quartzite schists with chloritoid-porphyroblasts; porous weathering carbonate-quartzite, partly transitional into a strongly squeezed out dolomite-breecia; granate-mica schist; prasinite; vein quartz. The geomorphology is shown on page 218.

8.1.2 Climate

Mean annual temperature:	-1.4° C
Mean temperature at 2 p.m. from April - August:	4° C
Mean annual precipitation:	1600 mm

8.1.3 Vegetation

See page 226

Fallbichl (Profiles A-7A and A-7B)

Hochtor (Profile A-8)

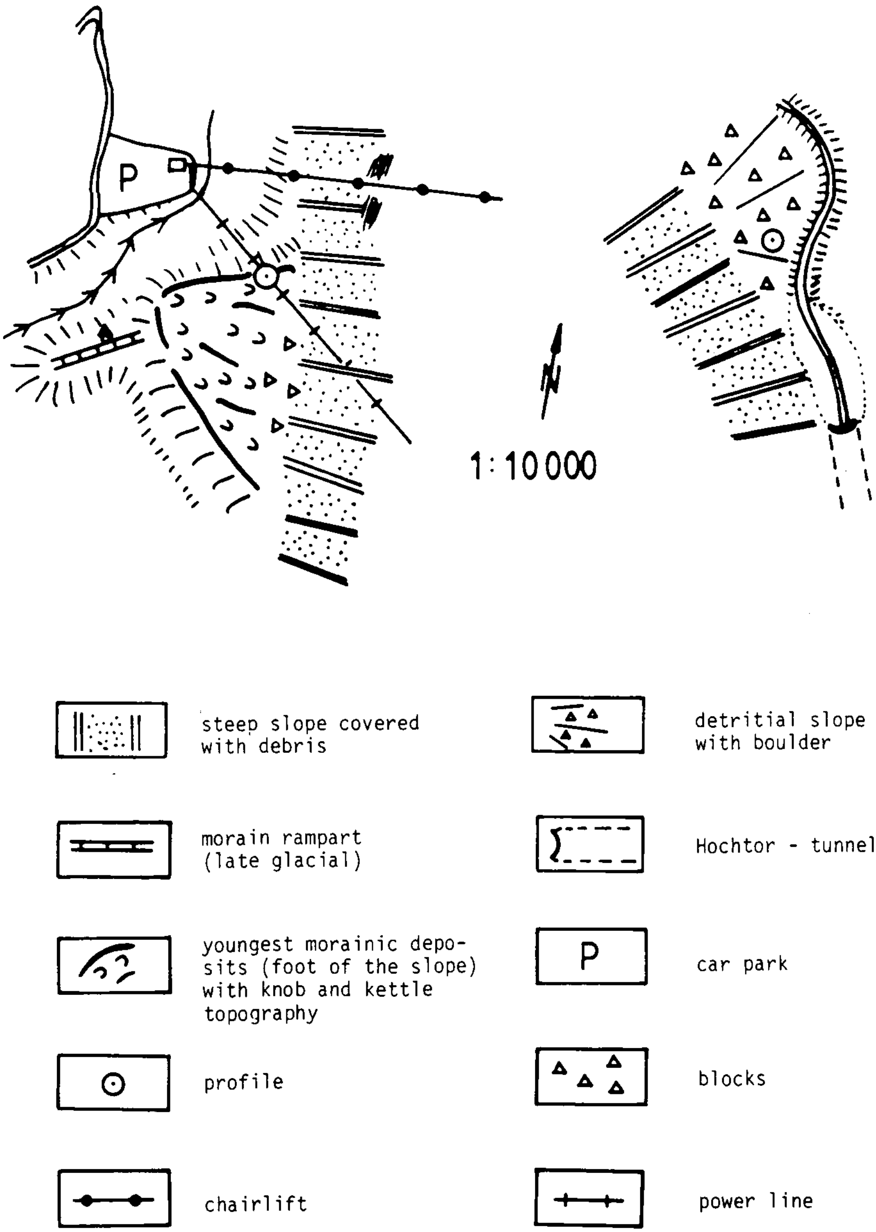


Tabelle 5: Subnivale Geröllfluren

Number of soil profile	8	
Number of analysis	8a	8b
Date of analysis /day	17.	17.
/month	8.	8.
Height above sea level in 10 m	252	251
Inclination	26	10
Exposition	NO	0
Surface analyzed in m^2	25	50
Surface covered by plants in %	8	95
Number of species	8	43

	8a	8b	
Androsacion alpinae-Arten:			**Arten der alpinen Silikatschutt-Ges.**
Androsacae alpina	+	2	Alpen-Mannsschild
Saxifraga rudolphiana	1	2	Rudolph's Steinbrech
Gentiana bavarica		2	Bayerischer Enzian
Saxifraga bryoides		+	Moos-Steinbrech
Oxyria digyna		+	Nierenblättriger Säuerling
Micarea lignaria		3	
Caloplaca leucoracea		3	
Psora decipiens		2	
Cladonia macrophyllodes		2	
Cladonia macroceras		2	
Drabetalia hoppeanae-Arten:			**Arten der alpinen Kalkschutt-Ges.**
Draba hoppeana	+	+	Hoppe's Hungerblümchen
Cladonia symphycarpa		1	
Pedicularis asplenifolia		1	Farnblättriges Läusekraut
Sesleria ovata		1	Eiköpfiges Blaugras
Gentiana orbicularis		+	Rundblättriger Enzian
Doronicum glaciale		+	Gletscher-Gemswurz
Thlaspietea rotundifolii-Arten:			**Arten der Steinschutt-und Geröll-Ges**
Saxifraga oppositifolia		1	Gegenblättriger Steinbrech
Arabis alpina		+	Alpen-Gänekresse
Cerastium uniflorum		+	Einblütiges Hornkraut
Arabidion caeruleae-Arten:			**Arten der Kalk-Schneetälchen:**
Saxifraga androsacea	+	2	Mannsschild-Steinbrech
Ranunculus alpestris	+	1	Alpen-Hahnenfuß
Hutchinsia alpina ssp brevic.	+	+	Kurzstengelige Gemskresse
Salix retusa		2	Gestutzblättrige Weide
Salix reticulata		2	Netzblättrige Weide
Carex parviflora		+	Kleinblütige Segge
Soldanella alpina		+	Gewöhnliches Alpenglöckchen
Arabis caerulea		+	Blaue Gänsekresse
Gnaphalium hoppeanum		+	Alpen-Ruhrkraut
Taraxacum alpinum		+	Alpen-Kuhblume
Salicion herbaceae-Arten:			**Arten der bodensauren Schneetälchen:**
Polytrichum norvegicum	1	2	
Salix herbacea		2	Krautige Weide
Luzula alpino-pilosa		1	Braune Hainsimse
Veronica alpina		1	Alpen-Ehrenpreis
Arenaria biflora		+	Zweiblütiges Sandkraut
Montio - Cardaminetea-Arten:			**Arten der Quellfluren:**
Saxifraga stellaris	2	+	Sternblütiger Steinbrech

Weiteres vorkommende Arten in Aufn. Nr. 8b: Silene acaulis 2, Primula minima +, Euphrasia minima +, Minuartia sedoides +, Polygonum viviparum +, Saxifraga moschata +, Minuartia gerardii +, Myosotis alpestris +, Poa alpina +.

Ort der Aufnahmen: Bereich Hochtor an der Glocknerstraße in Salzburg. Aufnahme 8a vegetationsarme Wanderschutthalde, Aufnahme 8b vor allem durch Moos- und Flechtenbewuchs stabilisierte Schutthalde auf Hangkuppe.

8.2 Soil characteristics

8.2.1 Morphology of soil profile A-8

Location: Hochtor (Austrian General Map 1:50.000, No. 154)

Height above sea level: 2.510 m

Topography: slope, 10^{o} E

Parent material: slope debris and dust

Land use: none

O 2-0 cm: litter of lichens and other plant material

Ai/AC 0-5/30 cm: dark gray (5 Y 4/1) slight loamy sand with high content of stone fragments, very weak plates and very fine granular structure, carbonate content, gradual boundary

C 5/30 + cm: coarse stone fragments and blocks of marbles, schists and phyllites, partly with stains of grayish brown weathering

8.2.2 Classification:

A: Subnivaler Rohboden

FAO: Lithosol

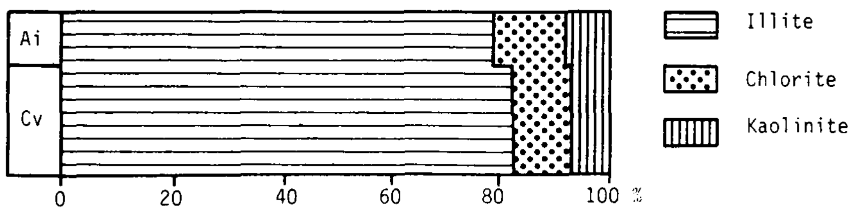
Physical and chemical characteristics of the profile A-8

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	2-0	-	-	-	-	62,0	-	-	-	33,0	5,0	-	-
2	A_i	0-10	-	12,2	16,6	33,0	61,8	21,0	9,1	3,0	33,1	5,1	-	-
3	C_v	10-30+	-	9,5	14,8	31,6	55,9	20,8	14,7	4,7	39,6	4,5	-	-

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	0	-	-	-	-	-	-	6,8	5,4	24,0	4,6	0,19	913	9,2
2	A_i	-	-	-	-	-	-	7,6	7,0	27,6	4,6	0,17	913	0,4
3	C_v	-	-	-	-	-	-	7,6	7,0	31,5	8,0	0,25	1290	0,4

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	0	8,7	4,1	12,3	0	216	-	161	8	35	1	-	-	95
2	A_i	1,0	0,8	7,3	8,4	55	-	42	-	12	1	-	-	100
3	C_v	0,7	0,7	5,8	10,1	63	-	50	-	12	1	-	-	100

Clay mineral distribution profile A-8



SITE A 9

Roßboden

9.1 Physio-geography

9.1.1 Location of the profile, geomorphology and geology

The profile is situated on a huge young allovial cone. This cone was accumulated by a torrent on the valley bottom of the Weixelbach. Many channels prove that the torrent changed its course during the sedimentation. The alluvial cone is mainly composed of crystalline schists and very seldom of silicate marble.

The composition of deposits is inhomogeneous. Next to big blocks one will find gritty, sandy as well as silty belts and lentils. Therefore the soil profile and property changes frequently. - The geomorphologic sketch map (next page) shows a broad and flatlying alluvial cone and torrential fan of Riegerbach. Catchment area is Bündner Schiefer formation in Fuscher facies and to the South in Glockner facies. A sandy to stony, mica-rich brooksediment with a few torrent -carried blocks. In the brook-sediment are prevalently carbonate-free to carbonate-poor Bündner Schiefer phyllites (Rauris phyllites). The boulders mostly represent yellowish quartzite and gray carbonate-quartzite, calcareous mica schists (mica marbles), green prasinite with albite nodes or porous leaching of the carbonate content; secretionary quartz-carbonate-lentils out of phyllites; rarely yellowish to light gray dolomite, and flattened dolomite-breeias with slaty to quartzitic cementing material.

9.1.2 Climate

Mean annual temperature:	4,9^{0} C
Mean temperature at 2 p.m. from April - August:	14,3^{0} C
Mean annual precipitation:	1230 mm

9.1.3 Vegetation

See page 232

Geomorphological scetch map of the area around
the profile A-9 ("Roßboden")

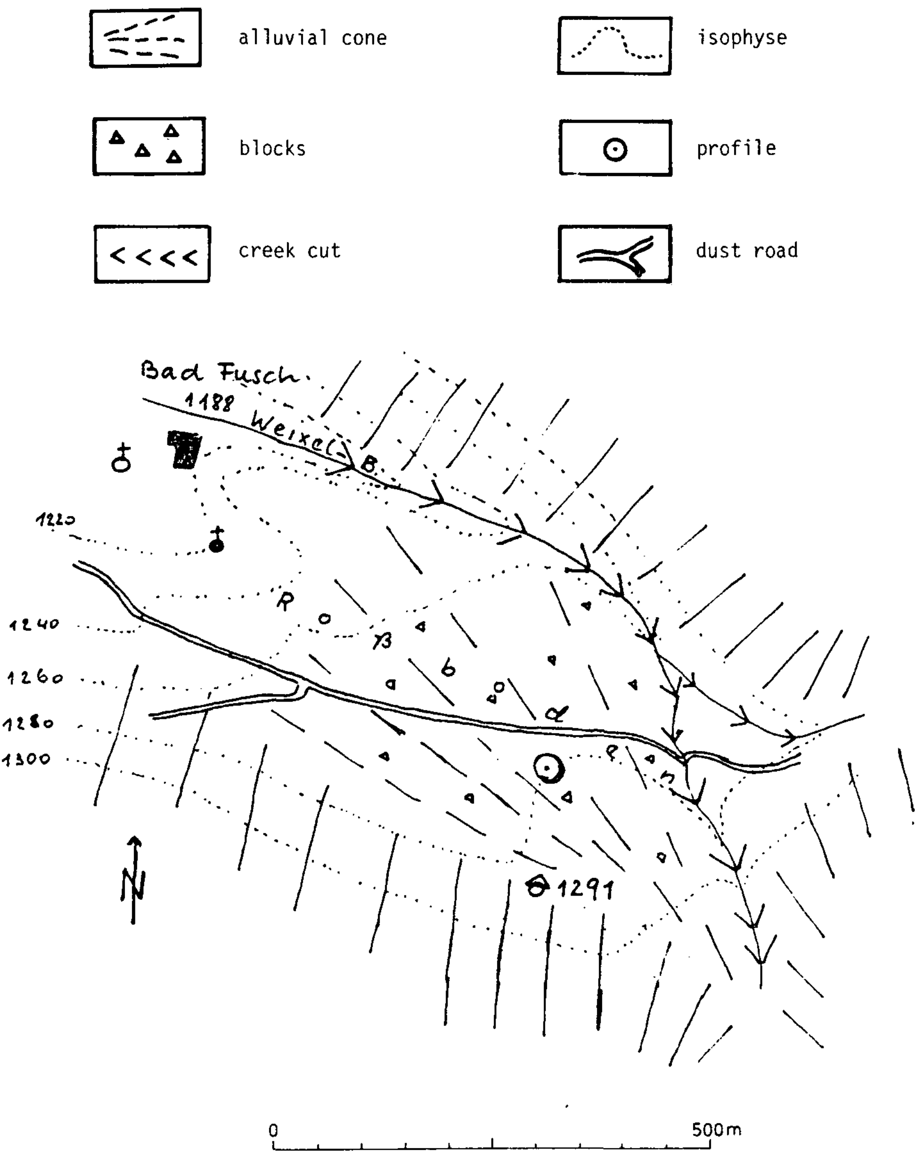


Tabelle 6: Hochmontane Fettweiden

Number of soil profile	9	
Number of analysis	9a	9b
Date of analysis /day	22.	22.
/month	6.	6.
Height above sea level in 10 m	128	128
Inclination	3	8
Exposition	NW	NW
Surface analyzed in m^2	100	25
Surface covered by plants in %	100	100
Annual yield in dt/ha	20	15
Number of species	34	33

	9a	9b	
<u>Caricion fuscae-Arten:</u>			<u>Arten der Flachmoore:</u>
Carex fusca	2	1	Braune Segge
Viola palustris	+	1	Sumpf-Veilchen
<u>Polygonion avicularis-Arten:</u>			<u>Arten der Trittgesellschaften:</u>
Poa annua	3		Einjahrs-Rispengras
Poa supina	2		Läger-Rispengras
<u>Poion alpinae-Arten:</u>			<u>Arten der alpinen Fettweiden:</u>
Poa alpina	2	+	Alpen-Rispengras
Phleum alpinum	2	+	Alpen-Lieschgras
Crepis aurea	+	+	Gold-Pippau
<u>Polygono - Trisetion-Arten:</u>			<u>Arten der Berg-Fettwiesen:</u>
Rumex alpestris	2	1	Berg-Sauer-Ampfer
Crocus albiflorus	1	+	Weißer Safran
<u>Arrhenatheretalia-Arten:</u>			<u>Arten der Fettwiesen und -weiden:</u>
Agrostis tenuis	1	2	Rotes Straußgras
Trifolium repens	2	+	Weiß-Klee
Alchemilla monticola	1	+	Frauenmantel
Carum carvi	1	+	Wiesen-Kümmel
Veronica chamaedrys	1	+	Gamander Ehrenpreis
Achillea millefolium	1	+	Gewöhnliche Schafgarbe
Leontodon autumnalis	1		Herbst-Löwenzahn
Dactylis glomerata	+		Knaulgras
<u>Molinietalia-Arten:</u>			<u>Arten der Feuchtwiesen:</u>
Deschampsia caespitosa	1		Rasen-Schmiele
<u>Molinio - Arrhenatheretea-A.:</u>			<u>Arten der Grünland-Gesellschaften:</u>
Festuca rubra	1	2	Rot-Schwingel
Ranunculus acris	2	+	Scharfer Hahnenfuß
Trifolium pratense	+	2	Rot-Klee
Poa pratensis	+	+	Wiesen-Rispengras
Plantago lanceolata	+	+	Spitz-Wegerich
Leontodon hispidus	+	+	Rauher Löwenzahn
Festuca pratensis	2		Wiesen-Schwingel
<u>Nardion-Arten:</u>			<u>Arten der subalpinen Borstgrasrasen:</u>
Nardus stricta	+	3	Borstgras
Carex leporina	1	+	Hasen-Segge
Luzula campestris	+	1	Hain-Simse
Hypericum maculatum	+	1	Geflecktes Johanniskraut
Potentilla aurea	+	1	Gold-Fingerkraut
Hieracium lactucella	+	1	Geöhrtes Habichtskraut
Ajuga pyramidalis		+	Pyramiden-Günsel

Weiters vorkommende Arten in beiden Aufnahmen: Carex hirta +, Campanula scheuchzeri +, Stellaria graminea +; in Aufnahme 9b: Homogyne alpina 2, Vaccinium myrtillus +, Anemone nemorosa +, Veronica officinalis +.

Ort der Aufnahmen: Embachalm bei Fusch in Salzburg. Aufnahme 9a stärker dungbeeinflußte Muldenlage, Aufnahme 9b weniger dungbeeinflußter Geländerücken.

9.2 Soil characteristics

9.2.1 Morphology of soil profile A-9

Location: Roßboden (Austrian General Map 1:50.000, No. 154)

Height above sea level: 1.280 m

Topography: slope, 2° NW

Parent material: holocene/recent alluvial deposits

Land use: pasture

AeP	0-9 cm: dark gray (2,5 Y 4/0) loamy sand with low content of coarse fragments,fine to medium plates, very friable, plastic, non sticky, many distinctive brownish Fe-concretions, many roots, clear boundary
Bvs	9-13 cm: grayish brown (2,5 Y 5/2) sand with low content of fragments and cobbles, fine subangular blocky structure, plastic, non sticky, many roots, clear boundary
AeP beg	13-17 cm: dark gray (2,5 Y 4/0) sand with low content of cobbles, fine plates, very friable, plastic, non sticky, clear boundary
Bvs beg	17-23 cm: grayish brown (2,5 Y 5/2) sand with medium content of stone fragments, fine subangular structure, friable, plastic, sticky, clear boundary
AeP beg	23-29 cm: gray (5 Y 5/1) sand with cobbles, fine plates, friable, plastic, non sticky, clear boundary
Bvs beg	29-50 cm: brown (10 YR 5/3) sand with medium content of stone fragments and blocks, fine to medium subangular structure, friable, plastic, non sticky, clear boundary
AeP beg	50-54 cm: dark gray (2,5 Y 4/0) sand with low content of cobbles, fine to medium plates, friable, plastic, non sticky, clear boundary
Bvs beg	54-90 cm: grayish brown (2,5 Y 5/2) sand with medium content of stone fragments and blocks, fine to medium angular blocky structure, friable, plastic, non sticky

9.2.2 Classification:

A: Alpiner Pseudogley über begrabenen Horizonten

FAO: Gleyic Podzol (over buried material)

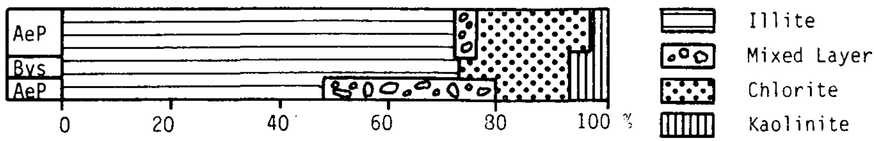
Physical and chemical characteristics of the profile A-9

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_eP	0-9	-	17,8	14,8	18,8	51,4	12,1	18,7	7,8	38,6	10,0	1	±1
2	B_{vs}	9-13	-	49,9	17,2	10,4	77,5	7,5	10,5	0,4	18,4	4,1	-	-
3	A_eP	13-17	-	40,3	19,4	16,0	75,7	10,2	8,5	2,2	20,9	3,4	-	-
4	B_{vs}	17-23	-	65,0	13,9	5,6	84,5	3,9	6,5	2,4	12,8	2,7	850	±328
5	A_eP	23-29	-	10,9	20,0	29,4	60,3	12,9	14,9	7,0	34,8	4,9	-	-
6	B_{vs}	29-50	-	34,3	22,9	17,6	74,8	10,2	8,0	2,4	20,6	4,6	-	-
7	A_eP	50-54	-	16,4	21,5	25,7	63,6	15,3	11,5	5,4	32,2	4,2	-	-
8	B_{vs}	54-90	-	28,8	21,6	19,5	69,9	13,0	9,0	4,5	26,5	3,6	-	-

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fed mg/g	Feo mg/g	Feo: Fed	Mno mg/kg	Pa mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_eP	1,32	50,4	50,1	48,6	44,4	13,4	5,4	4,5	20,3	5,9	0,29	174	3,5
2	B_{vs}	-	-	-	-	-	-	4,9	4,0	17,9	5,0	0,28	259	0
3	A_eP	-	-	-	-	-	-	4,9	4,2	11,2	3,7	0,33	315	0,9
4	B_{vs}	1,54	44,7	36,0	17,3	11,1	3,7	5,1	4,3	19,7	7,4	0,38	607	3,1
5	A_eP	-	-	-	-	-	-	4,8	4,1	17,2	4,6	0,27	220	0,4
6	B_{vs}	-	-	-	-	-	-	5,0	4,4	28,9	12,3	0,43	1197	2,2
7	A_eP	-	-	-	-	-	-	4,9	4,4	25,9	6,3	0,24	365	0,9
8	B_{vs}	-	-	-	-	-	-	5,1	4,5	24,1	6,0	0,25	716	0,9

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_eP	4,4	3,3	7,8	0	123	-	30	3	6	1	-	-	33
2	B_{vs}	1,1	0,6	10,7	0	51	-	2	1	1	1	-	-	10
3	A_eP	0,8	0,7	6,6	0	51	-	2	1	1	1	-	-	10
4	B_{vs}	0,6	0,4	8,7	0	45	-	2	1	0	1	-	-	9
5	A_eP	0,4	0,6	3,9	0	44	-	1	1	0	1	-	-	7
6	B_{vs}	0,6	0,4	8,7	0	59	-	3	1	0	1	-	-	8
7	A_eP	0,5	0,4	7,3	0	42	-	2	0	0	1	-	-	7
8	B_{vs}	0,6	0,1	-	0	39	-	4	0	1	1	-	-	15

Clay mineral distribution profile A-9



SITE A 10

Maishofen

10.1 Physio-geography

10.1.1 Location of the profile, geomorphology and geology

This profile is situated on a flat alluvial cone. 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.

10.1.2 Climate

Mean annual temperature:	6,5^{0} C
Mean temperature at 2 p.m. from April - August:	17,6^{0} C
Mean annual precipitation:	1070 mm

10.1.3 Vegetation

See page 238

Geomorphological scetch map of the "Zeller See Furche"
between the "Zeller See" and the "Saalach" river
(Profile A-10)

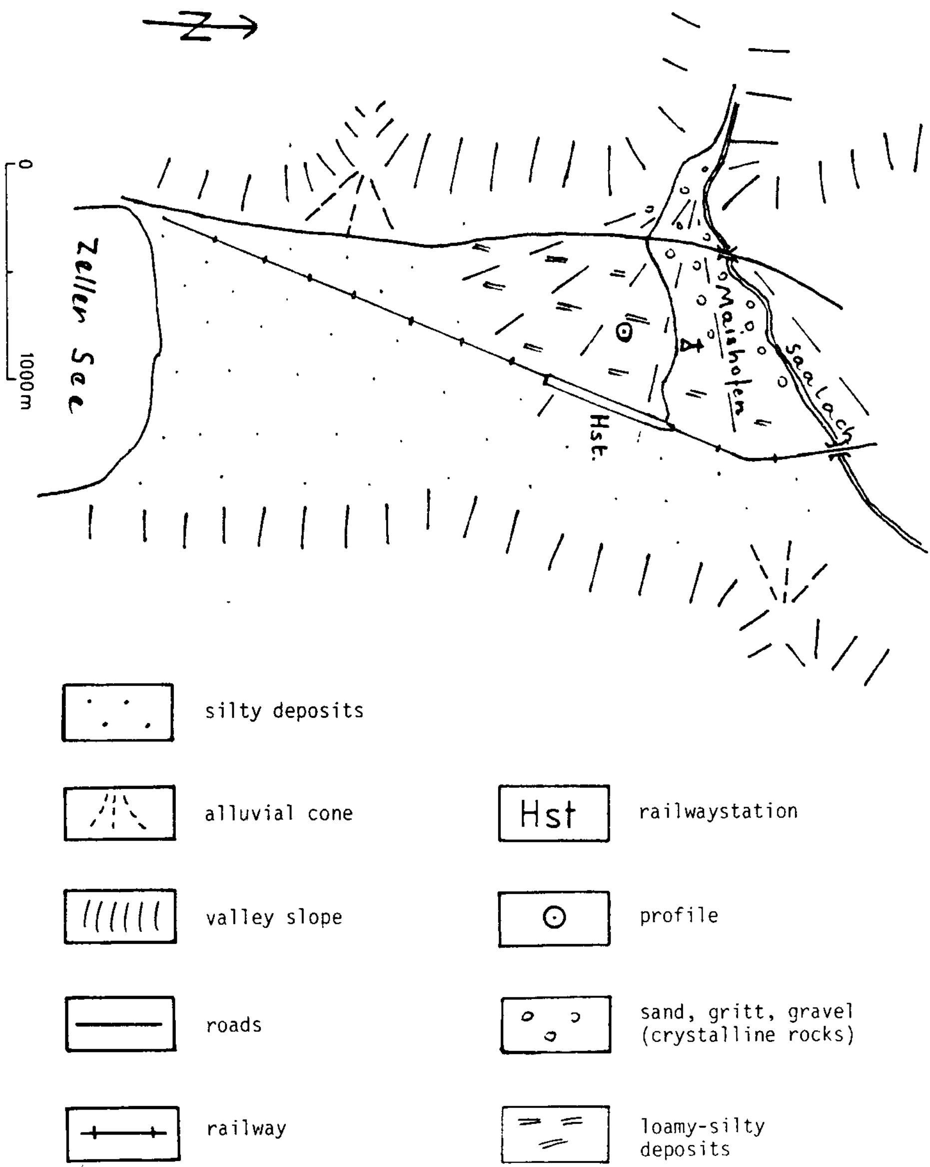


Tabelle 7: Montane Goldhaferwiesen

Number of soil profile	4	10
Number of analysis	10	11
Date of analysis /day	9.	9.
/month	6.	6.
Height above sea level in 10 m	69	77
Inclination	0	0
Surface analyzed in m^2	100	100
Surface covered by plants in %	100	100
Annual yield in dt/ha	90	98
Number of species	45	48

Polygono Trisetion-Arten:			Arten der Berg-Fettwiesen:
Melandrium rubrum	+	+	Rotes Marienröschen
Crocus albiflorus	+	+	Weißer Safran
Centaurea pseudophrygia	1	1	Perücken-Flockenblume
Chaerophyllum aureum		1	Gold-Kälberkropf
Arrhenatherion-Arten:			Arten der Tal-Fettwiesen:
Dactylis glomerata	1	1	Knaulgras
Crepis biennis	+	+	Zweijähriger Pippau
Pimpinella major	+	+	Große Bibernelle
Campanula patula		+	Wiesen-Glockenblume
Bromus hordeaceus		+	Weiche Trespe
Cynosurion-Arten:			Arten der Tal-Fettweiden:
Trifolium repens	1	2	Weiß-Klee
Phleum pratense	1	1	Wiesen-Lieschgras
Bellis perennis	1	1	Gewöhnliches Gänseblümchen
Poa annua	+	1	Einjahrs-Rispengras
Cynosurus cristatus	+		Kammgras
Leontodon autumnalis		+	Herbst-Löwenzahn
Arrhenatheretalia-Arten:			Arten der Wiesen und Weiden:
Trisetum flavescens	3	3	Goldhafer
Taraxacum officinale	1	1	Gewöhnliche Kuhblume
Alchemilla monticola	2	1	Frauenmantel
Achillea millefolium	1	1	Gewöhnliche Schafgarbe
Anthriscus sylvestris	+	1	Wiesen-Kerbelkraut
Carum carvi	+	+	Wilder Kümmel
Vicia sepium	+	+	Zaun-Wicke
Agrostis tenuis	+	1	Rotes Straußgras
Heracleum sphondylium	1	+	Wiesen-Bärenklau
Veronica chamaedrys	+	+	Gamander-Ehrenpreis
Chrysanthemum leucanthemum	+	+	Wiesen-Wucherblume
Molinietalia-Arten:			Arten der Naß- und Feuchtwiesen:
Lychnis flos-cuculi	+	+	Kuckucks-Lichtnelke
Angelica sylvestris	+	+	Wald-Engelwurz
Polygonum bistorta	+		Schlangen-Knöterich
Molinio - Arrhenatheretea-Arten:			Arten der Grünland-Gesellschaften:
Poa trivialis	2	2	Gewöhnliches Rispengras
Trifolium pratense	2	2	Rot-Klee
Poa pratensis	+	1	Wiesen-Rispengras
Festuca pratensis	1	1	Wiesen-Schwingel
Rumex acetosa	2	1	Wiesen-Sauerampfer
Ranunculus acris	1	1	Scharfer Hahnenfuß
Cerastium holosteoides	+	1	Gewöhnliches Hornkraut
Leontodon hispidus	+	+	Rauher Löwenzahn
Festuca rubra	+	+	Rot-Schwingel
Vicia cracca	+	+	Vogel-Wicke
Plantago lanceolata	+	1	Spitz-Wegerich
Prunella vulgaris	+	+	Kleine Brunelle
Lathyrus pratensis		+	Wiesen-Platterbse

Weiters vorkommende Arten in beiden Aufnahmen: Ranunculus repens 1, Anthoxanthum odoratum +, Rumex obtusifolius +, Plantago major +, Chaerophyllum hirsutum +, Agropyron repens +, Aegopodium podagraria +, Hypericum maculatum +.

Ort der Aufnahmen: Aufnahme 10 Oberndorf in Tirol, Aufnahme 11 Maishofen in Salzburg.

10.2 Soil characteristics

10.2.1 Morphology of soil profile A-10

Location: Maishofen (Austrian General Map 1:50.000, No. 123)

Height above sea level: 772 m

Topography: slope, 2° ENE

Parent material: recent/holocene alluvial deposits

Land use: pasture

Ah	0-7 cm: very dark grayish brown (10 YR 3/2) loamy sand, weak fine to medium crumb structure, very humic, very friable, non plastic, non sticky, some distinctive brownish stains abundant roots, clear boundary
ABg	7-15 cm: gray to grayish brown (10 YR 5/1 - 5/2) loamy sand, fine to medium plates, very friable, plastic, weakly sticky, many weak brownish stains and holes and light grayish stains, many roots, gradual boundary
B	15-30 cm: grayish brown to brown (10 YR 5/2 - 5/3) loamy sand, weak angular blocks and partly medium crumb structure, very friable, plastic, non sticky, some brown and grayish stains, few roots, gradual boundary
BC	30-45 cm: dark gray to dark grayish brown (10 YR 4/1 - 4/2) loamy coarse sand, weak medium angular blocky to weak crumb structure, very friable, non plastic, non sticky, few roots, clear boundary
C	45-60 cm: gravelly coarse sand
D	60 + cm: gravel

10.2.2 Classification:

A: krumenpseudovergleyte Lockersedimentbraunerde

FAO: Gleyic cambisol

Physical and chemical characteristics of the profile A-10

No	hor.	depth cm	sto. %	texture in % of humus-/carb. free fine soil: sand c	sand m	sand f	sand Σ	silt c	silt m	silt f	silt Σ	clay	k_f cm/d	k_f var.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	A_h	0-7	-	17,7	22,0	17,1	56,8	17,9	7,2	7,9	33,0	10,2	-	-
2	AB_g	7-15	-	13,2	20,5	21,7	55,4	19,6	7,5	7,0	34,1	10,5	-	-
3	B	15-30	-	13,7	21,1	18,3	53,1	29,7	3,2	5,4	38,3	8,6	-	-
4	BC	30-45	-	58,5	18,9	5,7	83,1	8,7	2,6	4,4	15,7	1,2	-	-
5	C	45-60	-	66,4	25,4	0,7	92,5	5,2	0,5	1,8	7,5	-	-	-
6	D	60+	-	-	-	-	-	-	-	-	-	-	-	-

No	hor.	bulk dens. g/cm^3	porosity %	volume water content at pF 0.6	1.8	2.5	4.2	pH H_2O	pH $CaCl_2$	Fe_d mg/g	Fe_o mg/g	Fe_o:Fe_d	Mn_o mg/kg	P_a mg/kg
1	2	16	7	18	19	20	21	22	23	24	25	26	27	28
1	A_h	0-7	-	-	-	-	-	6,0	5,0	7,8	5,3	0,68	416	-
2	AB_g	7-15	-	-	-	-	-	5,9	4,9	8,3	6,1	0,73	502	-
3	B	15-30	-	-	-	-	-	6,2	5,0	10,2	5,7	0,56	505	-
4	BC	30-45	-	-	-	-	-	6,1	5,0	6,7	2,6	0,39	272	-
5	C	45-60	-	-	-	-	-	6,1	5,1	3,9	1,5	0,38	191	-
6	D	60+	-	-	-	-	-	-	-	-	-	-	-	-

No	hor.	org. %	N_t mg/g	C:N	carbonate %	CEC p meq/kg	CEC e meq/kg	exchang. cations in meq/kg: Ca	K	Mg	Na	H	Al	V %
1	2	29	30	31	32	33	34	35	36	37	38	39	40	41
1	A_h	4,0	2,8	8,2	0	160	-	59	4	19	1	-	-	52
2	AB_g	1,9	-	-	0	118	-	39	1	12	2	-	-	46
3	B	1,6	-	-	0	65	-	22	1	6	2	-	-	48
4	BC	0,5	-	-	0	70	-	24	-	5	1	-	-	43
5	C	0,2	-	-	0	-	-	-	-	-	-	-	-	-
6	D	-	-	-	-	-	-	-	-	-	-	-	-	-

Clay mineral distribution profile A-10