Soil map of Denmark according to the FAO-UNESCO Legend

N. Kingo Jacobsen

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A soil map of Denmark is presented, according to the FAO legend. 14 soil types are mapped taking advantage of existing information about the biophysical environment. These cover mapping of geology (pre-glacial sub-soil) and morphology of landscapes (quaternary deposits) as well as mapping of landscape bodies f.inst. coastal landscapes of different age or valley landscapes of 5 different types.

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The soil map of the world 1:5,000,000 (1974) and the latest edition for Europe 1:1,000,000 is, of course, as far as Denmark concerns, only indicating the distribution of Danish soil types in a rough sketch. It is felt necessary for several reasons to arrange for details already at hand by using existing knowledge about the biophysical environment. This is possible partly because of the FAO system with a continuous interplay between low and high levels as well as the possibility of indicating associations and inclusions. This is also made possible by the connection between permanent soil characteristica, state factors of soil formation and genetic processes, i.e. the existence of soil landscape bodies, the land forms which can be delineated on the basis of soil observations and landscape analyses (J. Schelling 1974). The scale of the map will be about the same but drawn in colours and given in connection with information (mappings) concerning the preglacial subsoil, the morphology of landscapes, i.e. the quaternary deposits, the stages of ice margins and ice retreat during the Würm glaciations etc. as well as a rough map of natural regions of Denmark (I-VII) and the climatic data for the included regions.

According to climatic criteria Denmark can be divided into the following regions, indicated on fig. 1 by a grey tint: SW-Jutland with mild winters, early spring, high precipitation. N-Jutland with less precipitation, colder winters. SE-Denmark with later spring, warm summers and mild authumns, often cold winters. The Storebælt- and the Kattegat-region are both poor in precipitation.

NATURGEOGRAFISKE REGIONER

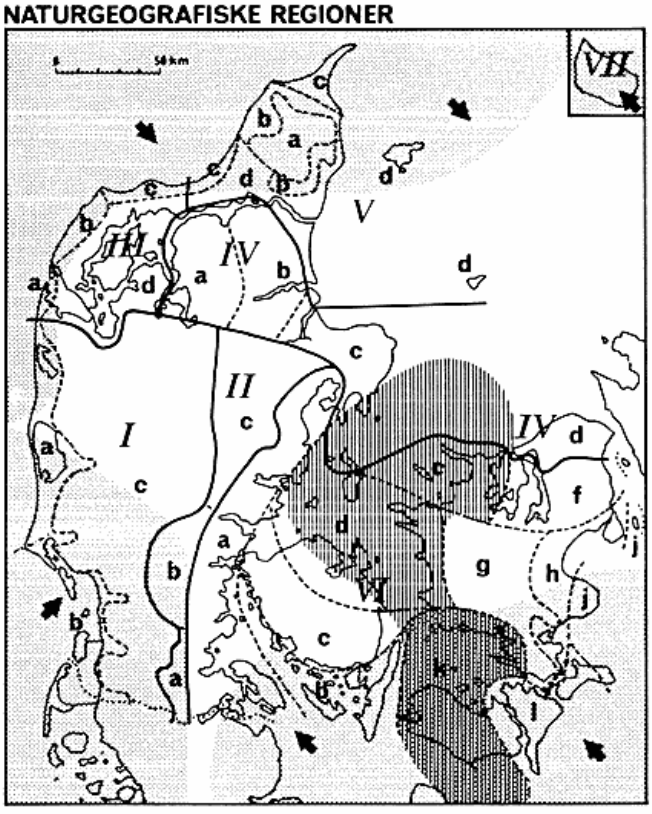

Fig. 1. Natural-geographical regions of Denmark.

Geomorphologically, a division will be as follows: W-Jutland S and W of the main stationary line for the last glaciation (Würm). SE-Denmark S and E of the Harder ice marginal line (the Pommeranian stage). Between the two ice marginal lines we find the central Jutland lake region. N-Jutland consists of a mosaic of elements which fall naturally into three regions: Thy, Vendsyssel and Himmerland (including Djursland and the northern N-Sjælland).

THE SOIL CONCEPTS, I.E. THE FAO MAPPING UNITS

The list of soil units used is a mono categorial classification of soils grouped on the basis of generally accepted principles of soil formation: Fluvisols influenced by a flood plane regime, Gleysols dominated by the hydromor-

Region	Station	Temperatur °C jan.	apr.	juli	okt.	året	Antal dg. Tmin. <0°	Nedbør mm/år	Fordampning mm. maj/juni/juli	1/5-31/10
Ia	24340 Lyngvig Fyr	0,9	5,9	16,2	9,8	8,2		688	311	
Ib	26370 Højer, Hohenwarte	0,0	6,6	16,4	8,9	8,1	86,1	702	286	468
Ic	24420 Studsgård	-0,4	6,0	16,1	8,1	7,5	104,7	783	282	441
IIa	26400 Store Jyndevad	-0,1	6,4	16,4	8,5	7,9			260	408
IIb	25270 Askov	-0,2	6,1	16,0	8,6	7,7	90,6	791	206	335
IIc	22540 Skanderborg	-0,3	6,0	16,4	8,5	7,7	95,1	637	296	484
IIIa	24010 Thyborøn	1,2	5,9	16,2	9,9	8,3		704		
IIIb,c	21010 Hanstholm Fyr	0,5	5,2	15,5	9,1	7,6	75,7	668		
IIId	20410 Livø	0,0	5,7	16,1	9,0	7,8		618	270[1]	466[1]
IVa	20500 Hornum	-0,5	5,9	16,2	8,1	7,5	100,4	705	229	383
IVb,c	22020 Hald	-0,7	5,7	16,2	7,9	7,3	102,5	722		
IVc	22120 Fornæs Fyr	0,5	5,7	16,7	9,3	8,1		501	272	422
IVd	30010 Nakkehoved Fyr	-0,4	5,7	16,9	8,8	7,8		535		
Va	20060 Hjørring Vandværk	-0,6	5,3	16,2	7,8	7,3		676		
Vb	20080 Sindal	-0,6	5,3	16,2	7,4	7,2				
Vc	20000 Skagen Fyr	0,4	5,3	16,7	9,3	8,0		613		
Vd,1	20210 Tylstrup	-0,5	5,7	16,4	8,0	7,5		637	231	358
Vd,2	27010 Vesterøby, Læsø	-0,1	5,8	17,0	9,0	8,0	82,6	571		
Vd,3	27020 Anholt by	0,4	5,4	17,2	9,7	8,2	65,5	536		
VIa	23310 Brakker (Aagaard)	-0,4	6,0	16,2	8,3	7,6		770	239	374
VIb	28550 Keldsnor Fyr	0,5	5,8	16,8	10,0	8,3		514		
VIc	28145 Årup (Gelsted)	-0,2	6,1	16,4	8,6	7,8	90,2[4]	661	270[2]	435[2]
VId	28180 Blangstedgård	0,1	6,7	16,8	8,8	8,1	89,3	537[5]	233	380
VIe	29200 Søndersted	-0,4	6,2	16,8	8,4	7,8	96,9	585	284[3]	434[3]
VIf	30420 Ledreborg Allé	-0,2	6,4	16,9	8,6	8,0		554	277	470
VIg	29280 Sorø Syd	-0,4	6,6	17,1	8,6	8,0	79,0	639		
VIh	31090 Tågerup							519		
VIj	31060 Tinghøj	-0,1	6,3	17,3	8,8	8,1				
VIk	29440 Tystofte	0,0	6,4	17,0	9,2	8,2	76,4	537	275	454
VIl	31290 Næsgård	0,0	6,4	17,1	9,3	8,2	72,6	629	225	357
VII	32240 Åkirkeby	-0,3	5,1	16,9	8,8	7,6	82,1	673	255	412

[1]) 21060 Sildstrup. [2]) 28460 Svendborg. [3]) 29070 Svinninge. [4]) 28400 Korinth. [5]) 28070 Hofmansgave.

Table 1. Climatic data for the involved regions. Temperature and precipitation data: Meteorological Institute 1931-60. Potential evaporation data: State Experimental Farms for Plant Culture. Stations cfr. fig. 2.

Tabel 1. Klimatiske parametre for de naturgeografiske regioner. Temperaturer og nedbørsmålinger refererer til Meteorologisk Instituts lister over normaler for 1931-60. Frostdøgn: upubliceret materiale fra Meteorologisk Institut, normaler for 1931-60. Fordampning (potentiel): Statens Forsøgsvirksomhed i Plantekultur. Anførte stationsnumre (jfr. fig. 2) er de af Meteorologisk Institut anvendte. Oplysninger indhentet af J. Bjørnevad Jensen.

phic soil forming proces, Luvisols and Acrisols characterized by illuviation of clay under conditions of high and low base saturation respectively. Podzols in which illuviation of organic matter and/or sesquioxydes is determining. Cambisols characterized by weak weathering of a parent material without important migration of weathering processes within the profile.

According to these soil types, a division will be: W-Jutland has predominantly podzol-types, SE-Denmark and Thy have luvisols; central Jutland has podzols and luvisols, Himmerland mainly podzols, apart from the region around Randers and N-Sjælland which are dominated by luvisols. Vendsyssel contains several types with gleysols, podzols, and regosols as the most characteristic types.

In total 9 higher classes of soils are mapped. For easy reference and communication the use of soil names is a necessity specially as the map units (14 are indicated) include associations and inclusions. This mixture is a reality in all soil maps as soil horizons intergrade laterally, vertically and in time with other horizons, sometimes over a short distance, in other cases horizons intergrade laterally over long distances. This is important because all the horizons do not intergrade at the same time rate. This is why a fundamental system of classification is not possible. The best method to divide up a landscape is trying to establish reference segments and use symbols, i.e. a formula system.

Of the 26 higher classes of soil units in the FAO system only the following 9 are mapped, even if further 8 would be represented on a more detailed map of Denmark. The first mentioned 9 soil units are No. 1-4, No. 6-8 (3 types of Podzols), and No. 10-13. Further the map present 3 soil units (no. 5, 9, and 14) which are landscape bodies of soil units already mentioned.

1. Regosols (R)

Soils from unconsolidated materials with an ochric A hor. and lacking hydromorphic properties within 50 cm of the surface.

Dystric Regosols (Rd) – 1b, coarse textured, (⟨18% clay ⟩65% sand) and rolling to hilly (dominant slopes ranging between 8 and 30%). Base saturation ⟨50%.

Associations: Eutric Regosols (Re) – 1b. Base saturation ⟩50%.

Inclusions: Dystric Histosols (Od) – a, level to gently undulating (dominant slopes ranging between 0 and 8%).

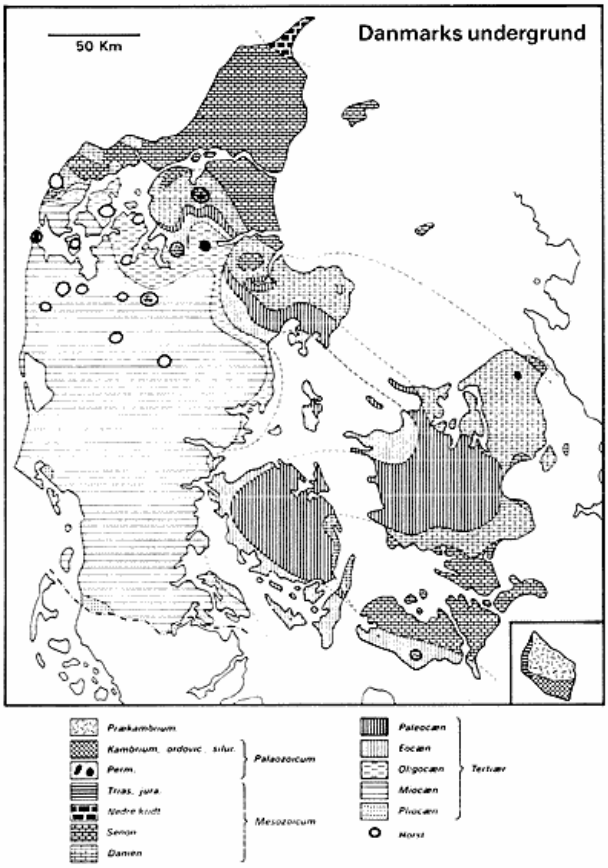

Fig. 2. The pre-glacial sub-soil of Denmark. (Efter T. Sorgenfrei).

2. Fluvisols (J)

Soils from alluvial deposits with an ochric or an umbric A hor., a histic H hor. or a sulfuric hor. The alluvial deposits are marine lacustrine or fluviatile sediments characterized by a) receiving fresh material at regular intervals and/or showing fine stratification, b) having an organic matter content that decreases irregularly with depths or c) having sulfidic material within 125 cm of the surface.

A. Along the westcoast of Jutland south of Bovbjerg, i.e. south of the main stationary line of the ice from the Würm glaciation.
Eutric Fluvisols (Je) – 3a, fine textured ()35% clay) and level to gently undulating.
Associations: Eutric Histosols (Oe) – a, Dystric Histosols (Od) – a, and Eutric Fluvisols (Je) – 2a (medium textured).

B. N- and E-Denmark, the part covered by ice during the Würm glaciation.
Eutric Fluvisols (Je) – 2a, medium textured and level to gently undulating.
Associations: Eutric Histosols (Oe) – a.
Inclusions: Eutric Fluvisols (Je) – la, coarse textured.

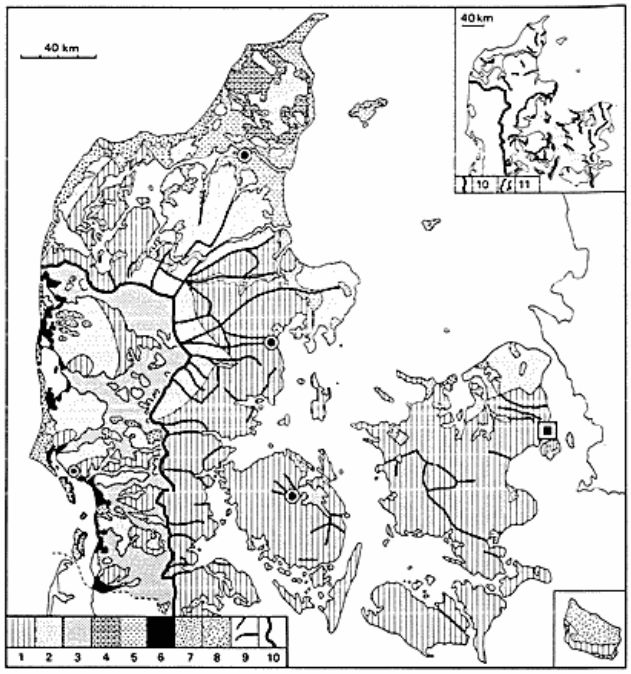

Fig. 3. Geomorphological map of Denmark
1. Young moraine landscape, mainly clayey soil
2. Young moraine landscape, mainly sandy soil
3. Outwash plain
4. Late glacial raised sea-floor
5. Raised sea-floor, Litorina
6. Salt marsh
7. Dune landscapes
8. Granite landscapes
9. Tunnel valley
10. Main stationary line of the ice (Würm glaciation)
11. Recession stage of the ice (Würm glaciation)

Fig. 3. Landskabskort over Danmark
1. Ungt morænelandskab, overvejende leret
2. Ungt morænelandskab, overvejende sandet
3. Hedeslette
4. Yoldiaflade
5. Litorina aflejringer
6. Marsk
7. Klit
8. Grundfjeld
9. Tunneldal
10. Hovestilstandslinjen
11. Vigtige stilstandslinjer og endemorænestrøg

3. Gleysols (G)

Soils from unconsolidated materials showing hydromorphic properties within 50 cm of the surface, showing an A hor. and as further diagnostic horizons, a histic H hor., a cambic B hor. or a calcic or a gypsic hor. Is mostly found on raised Litorina deposits in NE-Denmark.

Eutric Gleysols (Ge) – la, coarse textured and level to gently undulating.

Associations: Dystric Histosols (Od) – a, and Dystric Fluvisols (Jd) – la.

Inclusions: Eutric Fluvisols (Je) – 2a, and Mollic Gleysols (Gm) – 1a.

Histosols (O)

Histosols or peat soils have a H hor. of 40 cm or more (60 cm or more in Sphagnum upland-moors). Organic accumulations as such are parent material of its own in which geogenetic processes are as important as the pedogenese as they for the former lake deposits (basin- moors) include different horizons or layers with specific properties and types of formation. The material can be recognized in different stages of decomposition (fibric, hemic, sapric) and in the basin moors with inclusions of gytje, silt, sand, and clay in varying quantities. In a scale of the map presented only 3 sites are indicated: A. The Blanket Histosols of the upland moors: 1. Store Vildmose (Vendsyssel) and 2. Lille Vildmose (Himmerland) of which the first mentioned to day is reclaimed apart from two minor remnants. The Blanket Histosols are acid (*Dystric Histosols* with a pH ⟨5,5 between 20 and 50 cm from the surface) because the water is derived directly from precipitation. They are usually not more than 4 m thick and rest upon an old soil (Placic Podzol) of an age of 3-4,000 years. B. The Basin Histosols: 3. Holmegaard Mose (basin moor) found in the Susså area, Sjælland. These Histosols vary widely in content of cations and pH values, determined by the composition of the water causing the anaerobism. *Eutric Histosols* have a pH ⟩5,5 between 20 and 50 cm from the surface.

5. Valley-soils

Valley-soils form a geomorphic soil unit of Histosols with associations of Fluvisols and Gleysols. Fire types of valley landscapes with a characteristic complex of soil units are represented on the map:

a. The mature valley bottom in its normal stage formed by river erosion and characterized by levees, ox-bow lakes, and sheet wash plains giving rise to formation of Gleysols, Fluvisols and Histosols. In the lower course of the valley peat basins are met with which further W show a transition to silty and sandy deposits, mostly even with clay deposits in lagoons. The W-Jutland having a stable land surface why the described geo-genese is due to the rising sea level during postglacial times.

b. Valleys on a rising coast (10-60 m). Vendsyssel where a fluvio-glacial valley continues on the Yoldia plateau 20-40 m (late glacial) and on the Litorina plain 2-10 m (Atlanticum) and the marine foreland.

c. Valleys in most of E-Denmark on a rising area (0-10 m) comprising the geo-genetic types of

1) tunnel valleys with lake basins formed by the carving melt-water streams in and/or under the ice-masses or as dead-ice depressions.

2) Glacio-fluvial valleys with terraces, resistant parts of earlier valley bottoms. Repeated lowering of base level has produced the valley-in-valley complex (fig. 4).

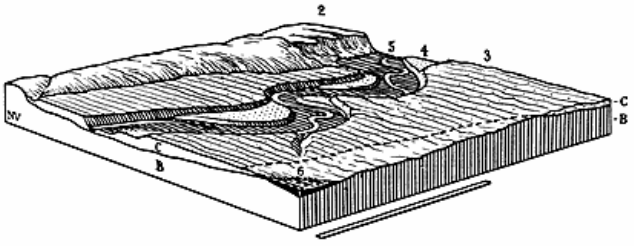

Fig. 4. The Valley-in-vally complex. By lowering of base level a new cut-in river valley has been formed. 2. Moraine landscape. 3. Outwash plain. 4. Valley terraces. 5. Recent valley complex with levees, oxbow-lakes and back-swamps. 6. Basin moor. B. Moraine. C. Meltwater deposits.
Fig. 4. Dal-i-dal landskab. Gentagen sænkning af erosionsbasis har skabt nyt, nedskåret dalsystem. Alm. daltype i de nordlige, hævede dele af Danmark. 2. Morænelandskab. 3. Hedeslette. 4. Dalterrasse. 5. Recent å-dal med leveer, back-swamps og hesteskoformede søer. 6. Mose, tilgroet sølavning. B. Moræne. C. Hedeslettesand. Efter Axel Schou: Atlas over Danmark.

d. Post glacial erosion valleys.

6. Podzols (P). Inland dunes

Formed on dune sands partly on inland dunes, coarse blown sand from the glacial melt water deposits and partly on blown sand from the sea, fine textured.
Orthic Podzols (Po)
Associations: Gleyic Podzols (Pg) and Humic Podzols (Ph) are found all over in the dunes. These types indicate the great variety in the intensity of bleaching as well as in the thickness of the bleached horizon. In some cases there is no distinctly bleached horizon often because of wind erosion, there is just a dark organic mineral mixture, but it does contain numerous bleached sand grains. Generally however, there is a bleached horizon of variable depth (not more than 10 cm) but the foremost variation is the amount in the B-hor. of iron, aluminum and humus. At the dryer end this horizon has a high chroma with the characterisation of mainly iron and aluminum. As the soil becomes wetter the B-hor. becomes dark due to an increase in the amount of humus deposits.
Inclusions: Dystric Histosols (Od) – a.

7. Podzols (P). Outwash plains

Formed on the melt water deposits. Rather coarse sand.
Orthic Podzols (Po) – 1a.
Inclusions: Dystric Histosols (Od) – a, and Gleyic Podzols (Pg) sporadically with Placic Podzols (Pp).

8. Podzols (P). Old moraine

Formed on the diluvial sandy deposits which have been exposed to leaching during a long time, i.e. since the Riss glaciation.

Orthic Podzols (Po) – 1b.
Associations: Orthic Fluvisols (Lo) – 2 b, Humic Podzols (Ph) – 1 b, and Ferric Podzols (Pf) – 1 a.
Inclusions: Gleyic Luvisols (Lg) – 2 a, Gleyic Podzols (Pg) – 2a, and Dystric Histosols (Od) – a.

9. Hilly, sandy soils

Podzols (P) and Arenosols (Q) formed on diluvial sands from the Würm glaciation. Most types found in Himmerland, but this type must also be said to characterize parts of Vendsyssel and Djursland.

Orthic Podzols (Po) – 2 b (Himmerland), 1 b (Vendsyssel and Djursland), and Luvic Arenosols (Ql) – 1 b.
Associations: Orthic Luvisols (Lo) – 2b, and Albic Arenosols (Qa) – 2b.
Inclusions: Gleyic Luvisols (Lg) – 2 a, and Dystric Histosols (Od) – a.

Arenosols are weakly developed, coarse textured soils with an ochric A-hor. They consist of albic material occurring over a depth of at least 50 cm from the surface or showing characteristics of argillic or cambic B-hor. which, however, do not qualify as diagnostic horizons because of textural requirements.

10. Arenosols (Q)

Cambic Arenosols (Qc). The colour of these soils range from reddish-yellow to yellowish-brown as determined in part of the origin of the material and moisture status. The A-hor. is an ochric epipedon, the B-hor. is a uniformly coloured, coarse, sandy cambic B. It is found in the glaciation area of the Würm, W and N of the Harder E-Jutland ice margin as well as in N-Sealand.
Associations: Dystric Cambisols (Bd) – 2 b, Orthic Luvisols (Lo) – 2 b, and Orthic Podzols (Po) – 1 b.
Inclusions: Gleyic Cambisols (Bg) – 2 a, Gleyic Luvisols (Lg) – 2 a, and Dystric Histosols (Od) – a.

11. Acrisols (A)

Soils having an argillic B-hor. with a base saturation of ⟨50%. Lacking a mollic A-hor. and an albic E-hor. Found on the clayey, but strongly leached old moraines in W-Jutland and in a zone just E of the main stationary line of the ice from the Würm glaciation.
Orthic Acrisols (Ao) – 2 b. Having an ochric A-hor.
Associations: Dystric Cambisols (Bd) – 3 b and Humic Cambisols (Bh) – 3 b.
Inclusions: Gleyic Acrisols (Ag) – 1 a showing hydromorphic properties within 50 cm of the surface. Dystric Histosols (Od) – a.

12. Luvisols (L)

Soils having an argillic B-hor. with a base saturation at 50% or more. Lacking a mollic A hor. and an albic E-hor. These soils appear to be formed by progressive migration of material downwards. Initially any soluble salts and carbonates are removed by the moderate amount of precipitation. This is followed by the gradual translocation of the clay (at pH values 5,5 – 4,9) from the upper horizons to form the Bt-hor. where the clay is deposited as clay coatings on the surfaces of peds and pores.

Luvisols forms under aerobic conditions in which there is usually free movement of water through at least the upper and middle parts of the soil. It appears that a distinct dry season is required for the soils to develop. Formed on the moraine clay deposits (Würm glaciation) of E-Denmark.
Orthic Luvisols (Lo) – 2 b.
Associations: Eutric Cambisols (Be) – 2 b.
Inclusions: Orthic Podzols (Po) – 1 b, Gleyic Luvisols (Lg) – 2 a, and Eutric Histosols (Oe) – a.

13. Cambisols (B)

Soils having a cambic B-hor. and an ochric or umbric A-hor. It is soils which usually have fairly uniform brown pedounits with a total thickness of 1-1,5 m. There is an upper moderate humose, granular A-hor. that grades into a blocky cambic B-hor. Hydrolysis is fairly active throughout the soil with most of the iron and aluminium released being precipitated fairly close to the point of release. The clay max at the surface indicates that this is the position of max hydrolosis which is aided by the acid decomposition products of the organic matter. Leaching of the basic cations is one of the principal processes.

Formed on deposits of silty and loamy textures often of a basic or calcareous composition. If it is developed on acid parent materials it is based on a high content of silt which gives a large surface area from which cations are released. This release by weathering must keep pace with the removal by leaching. Otherwise the soil will become proportionally more acid and form a Luvisol (or a Podzol).

Cambisols are found on all glacial deposits of Würm age in Thy, Vendsyssel, E-Himmerland and E-Denmark as such. There has been discussions about these brown calcareous soils whether they belong to Cambisols or Luvisols. They are of course found in associations; most of them – as indicated on the map – as Luvisols with Cambisols in associations, but on minor spots the opposite is the case.

Dystric Cambisols (Bd) – 3 a, have an ochric A-hor. and a base saturation of ⟨50% between 20 and 50 cm from the surface. *Eutric Cambisols* (Be) – 3 a have an ochric A-hor. and a base saturation of ⟩50% between 20 and 50 cm from the surface.

Associations: Gleyic Cambisols (Bg) – 3 a have an ochric or umbric A-hor. and show hydromorphic properties between 50 and 100 cm of the surface. Humic Cambisols

(Bh) – 3 a have an umbric A-hor. which is thicker than 25 cm when a cambic B-hor. is absent.

Eutric Histosols (Oe) – a.

14. Soils of the Yoldia Plateau

In Vendsyssel a raised late glacial sea floor is found 20-60 m above sea level. These deposits are fine textured sand and silt. The landscape is further characterized by flat-bottomed dry-valley systems.

Dystric Cambisols (Bd) – 3 a.

Associations: Eutric Gleysols (Ge) – 1 a and Gleyic Cambisols (Bg) – 1 a.

The geographical distribution of the above mentioned 14 soil types is given on plate 1.

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