Paleo-periglacial phenomena in Northwestern Europe, Version 1

USER GUIDE

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1 INTRODUCTION

Earth science literature abounds in descriptions of periglacial features that can be used for interpretation of palaeoenvironments. A single site description usually does not allow more than an interpretation of local environmental or palaeoclimatic conditions. However, if a large number of sites is taken into consideration, a synopsis of regional environmental conditions may emerge (Van Huissteden, 1990; Lowe *et al*., 1994; Huijzer & Isarin, 1997; Isarin, 1997a,b). Of course, inspecting a large amount of literature, some of which may be difficult to access, requires a considerable effort that may severely hinder the creation of such an overview.

With this database it is attempted to summarize the data from a large number of sites in northwestern Europe. The area covered by this database stretches in a west-east direction from Ireland to Poland (9° W to 23° E), and in a south-north direction from Norway to France (48° N to 59° N). The time span covered is that of the last glacial, with special attention to the part of the last glacial that falls within the limits of the radiocarbon dating method.

The data have been gathered as part of the EPECC project (Huijzer & Isarin, 1997) and the thesis research of Isarin (1997) and Renssen (1997). The database has proven to be an ideal tool for palaeoclimate reconstructions and comparison with climate model experiments.

Besides periglacial phenomena, the database also includes data on palaeosols, fluvial and aeolian deposits, botanical and faunal data. The database published here is abstracted from this larger data set, and includes only the periglacial features, palaeosols and depositional environment data.

Most of the data is derived from publications in scientific periodicals or books. Some of these may be more difficult to access for users outside the European continent. Also data from thesis research has been included. Only in a few cases data from unpublished reports have been included. The oldest publication dates from 1952. Updating of the database has continued up to 1996. Updating with newer literature will continue within short, and a newer version may be available in 1998.

Data quality management is an important topic when data are summarized from a large number of publications. Each site description contains a description of its source, allowing a check on the quality of the site. The publications themselves differ widely in the completeness of the description, and dating of the observed palaeoperiglacial phenomena. In the database we have included as much factual information on the described phenomena as possible. This allows the user to define her/his own quality standard by putting demands on the presence of certain descriptive elements of the data.

The tables are available as dBASE and ASCII text files. The latter format requires import in database software and establishment of the relations between the tables as described in the next paragraph. This format is easily annexed to GIS systems for production of palaeoclimatic maps.

2 STRUCTURE OF THE DATABASE

The database has a relational structure and consists of indexed dBASE files. These easily can be linked in queries, for example with the dBASE V or Visual dBASE user interface. A separate user interface for this dBASE version has not been developed, for most purposes the use of the dBASE user interface will be sufficient.

Figure 1. Layout of the database. A 1:1 relation indicates that a record in the first table is related to just one record in the second table. A 1:n (one to many) relation indicates that one record in the first table is is related to more records in the table where the arrow is pointing to.

Figure 1 summarizes the structure of the database and the links between the tables. The table PROXY is the central table of the database, linking the actual description of observed phenomena, the age information and site description. The observed phenomena are stored in four tables (PERIGLAC, PEDOLOGI, AEOLIAN, FLUVIAL), according to the nature of the phenomena. The chronological information is stored in a seperate table, AGE. The site information contains two tables, GENSITE and SUBSCRIP. These contain general site information (e.g. location, topography) and bibliographical information respectively. Below, an extensive description of the tables and their contents is given.

3 SITE INFORMATION

The tables GENSITE and SUBSCRIP contain information on the sites described in the other tables, and information on the data source respectively. These tables are linked by the field SITE-ID, that contains a unique site number.

3.1 Table GENSITE

The table 'GENeral SITE information' includes information on the site. General information items consists of the name of the site, country, province/state, county etc., X (latitude), Y (longitude), and Z (altitude) coordinates, and a short description of the site, including the present state and the period of the latest glaciation.

Table 1. Field description of database table GENSITE

Field name	Field type	Field length	Decimals	Description / Example
SITE-ID	Character	6		Unique site number e.g. S92354
SITENAME	Character	25		Site name e.g. Liastemmen
COMMENTS	Memo	10		Text with comments
COUNTRY	Character	3		Abbreviated country name, e.g. Nor = Norway
MAJORDIV	Character	25		Major political division (province names etc) or region, e.g. southern Norway
MINORDIV	Character	25		Minor Political Division e.g. Rogaland
LONGITUDE	Numeric	10	4	Geographic longitude (degrees), numbers behind decimal point indicate minutes and seconds
LONGIDEC	Numeric	10	4	Geographic longitude (degrees), with decimal subdivision
LATITUDE	Numeric	10	4	Geographic latitude (degrees), numbers behind decimal point indicate minutes and seconds
LATITUDE	Numeric	10	4	Geographic latitude (degrees), with decimal subdivision
ALTITUDE	Character	7		Altitude, in meters
PHYSIOGRAP	Character	45		Physiographic description of site e.g. River terrace of the Rhine
SITE_TYPE	Character	50		Characteristics of site, e.g. sandpit
LASTGLAC	Character	1		Indication of the last glaciation that occurred on the site, W=Weichselian, S=Saalian, E=Elsterian, N=Non-glaciated (name of glacial according to the northwest European terminology)

3.2 Table SUBSCRIP

In the table 'SUBSCRIPtion', general information on the name of the subscriber, date, project, period selected for data entry, and publications can be recorded. Publications (and/or unpublished reports) are inscribed as far as they present relevant (palaeoclimate) information related to the involved site. If necessary, this table may be extended for more than four publications.

Table 2. Field description of database table SUBSCRIP.

Field name	Field type	Field length	Decimals	Description / Example
SITE-ID	Character	6		Unique site number e.g. S92354
DATE	Date	8		Date of inscription, mm/dd/yy, e.g. 06011994
NAME	Character	20		Name of the present subscriber, e.g. Bundy, Al
PROJECT	Character	10		Name (or acronym) of the project to which the entry of data is related, e.g. EPECC
AUTHORS1	Character	40		Authors of publication related to subscription, e.g. Mol, J.A.M. et al.
YEAR1	Numeric	4	0	Year of publication, e.g. 1993
JOURNAL1	Character	40		Journal of publication, e.g. JQS 12, 123-145
AUTHORS2	Character	40		See AUTHORS1
YEAR2	Numeric	4	0	See YEAR1
JOURNAL2	Character	40		See JOURNAL1
AUTHORS3	Character	40		See AUTHORS1
YEAR3	Numeric	4	0	See YEAR1
JOURNAL3	Character	40		See JOURNAL1
AUTHORS4	Character	40		See AUTHORS1
YEAR4	Numeric	4	0	See YEAR1
JOURNAL4	Character	40		See JOURNAL1
AUTHORS5	Character	40		See AUTHORS1
YEAR5	Numeric	4	0	See YEAR1
JOURNAL5	Character	40		See JOURNAL1
AUTHORS6	Character	40		See AUTHORS1
YEAR6	Numeric	4	0	See YEAR1
JOURNAL6	Character	40		See JOURNAL1
AUTHORS7	Character	40		See AUTHORS1
YEAR7	Numeric	4	0	See YEAR1
JOURNAL7	Character	40		See JOURNAL1
AUTHORS8	Character	40		See AUTHORS1
YEAR8	Numeric	4	0	See YEAR1
JOURNAL8	Character	40		See JOURNAL1

4 PALAEO-PERIGLACIAL INFORMATION RECORDS

Information on palaeo-periglacial environments is stored according to the type of event and sedimentary environment in separate tables. Included in the database are tables referring to periglacial features, palaeosols, and fluvial and aeolian depositional environments. The age information on the events and their palaeoclimatic interpretation is stored in a seperate table, to be discussed in the next chapters.

Examples of periglacial features are sedimentary structures such as ice-wedge casts and cryoturbatic involutions, or periglacial landforms such as pingo or palsa remnants. The palaeosol table features information on soil type and stratigraphy. The table of fluvial events contains information on aggradation or downcutting, fluvial facies and sedimentary structures. The table of aeolian events includes landform and sedimentary facies.

The events are labelled by unique (identifiers), which consist of two capitals (indicating the type of event), followed by (maximal) 5 digits, e.g. the aeolian event AE2664, the fluvial event FL1008, or the periglacial feature PE1023.

4.1 Events recorded as features and phenomena

4.1.1 Table PERIGLAC

Periglacial events are described in the table periglacial. In the case that a number of interrelated periglacial events occur in the same stratigraphic position, the periglacial event with the most prominent palaeoclimatic information is primarily described. For example, if an ice-wedge cast is related to a large-scale periglacial involution level, the ice-wedge cast is described as the main feature, and the involutions are reported as interrelated cryogenic features in the same database record.

Table 3. Field description of database table PERIGLAC.

Field name	**Field type**	**Field length**	**Decimals**	**Description / Example**
PERIGL_ID	Character	7		Unique event number, e.g. PE1548
EVENT	Character	10		Abbreviated event type, description see par. 2.1.1.1.
DATED_BY	Character	50		Type of age information, description see par. 2.1.1.2.

Field name	Field type	Field length	Decimals	Description / Example
GEOMORPH	Character	1		The palaeogeomorphological position of the periglacial feature: Upland, Hillslope, Lowland or Bottomland, Channel,Other.
SEDENV	Character	4		The type of sedimentary environment in which the periglacial evidence is found: Aeolian sand/silt, Glacial, Fluvial,Lacustrine, Cave
LITHO_UP	Character	1		Lithological composition of the sediment body in which the feature is found: Fine-grained or Coarse-grained,Heterolithic
LITHO_LOW	Character	1		See LITHO_UP
REL_CRYO	Character	20		Type of interrelated cryogenic features, e.g. ice-wedge cast, Type 2a involution
TRUNCFEAT	Character	1		Truncated periglacial macrostructure, e.g. truncated ice-wedge casts (Y/N)
WCDEVELOP	Character	1		Time of development of the feature with respect to sedimentation surface: Syngenetic or Epigentic
WCVERTSIZE	Numeric	6	2	Maximum vertical size of wedges/cracks (in meters)
WCWIDTH	Numeric	6	2	Maximum width at the top of wedges/cracks (in meters)
WCPOLYGSIZ	Numeric	6	2	Size of the thermal contraction polygons (in meters)
WCRELPROC	Character	1		The evidence that thermal contraction cracking is the process by which a wedge or crack is formed: No, Desiccation, Cryo-desiccation.
AMPLITUDE	Numeric	6	2	Amplitude of the periglacial involution (in meters)
PINGODIAM	Numeric	6	0	Maximum diameter of the pingo, palsa, earth hummock, or thufur (in meters)
PINGODEPTH	Numeric	6	2	Maximum depth of pingo or palsa remnant (in meters)
PINGRAMPAR	Character	1		Presence of a rampart around the pingo scar? (Y/N)
PALSCOMPOS	Character	1		Composition of palsa: Mineral or Organic
CRYOPLGRAD	Numeric	2	0	Gradient of the cryoplanation terrace (in °)
CRYOPLEXT	Numeric	6	2	Extent of the cryoplanation terrace (in square kilometers)

Field name	Field type	Field length	Decimals	Description / Example
MWGRAD	Numeric	2	0	Gradient of the palaeotopography on which a mass-wasted deposit occurs (in °)
MWSTRUCT	Character	2		The internal sedimentary structure of mass-wasted sediment is: Lobate, Stratified, Massive, Other
CRYMITHICK	Numeric	6	0	Thickness (size) of the (individual) cryogenic microfabric aggregate (in m m)

4.1.1.1 Contents of field EVENT.

The different types of periglacial events recorded in the database are subdiveded in thermal contraction cracking, periglacial involutions, cryogenic macrofabrics, perennial frost mounds, cryoplanation and mass wasting features (French, 1996; Harris et al., 1988). The descriptive names of the features are abbreviated as follows.

Thermal contraction cracking:

Ice-**w**edge cast, **S**and-**w**edge cast, **C**omposite-**w**edge cast, **A**ctive **l**ayer soil wedge with **p**rimary infilling, **S**easonally **f**rozen ground soil wedge with **p**rimary infilling, **A**ctive **l**ayer soil wedge with **s**econdary infilling, **S**easonally **f**rozen ground soil wedge with **s**econdary infilling, **V**ertical **p**laty **m**icrostructures (Mol *et al.*, 1993).

A composite wedge cast is a wedge showing evidence of both primary and secondary infilling. Soil wedges differ from the sand and ice wedges that they do not occur in perennial frozen ground, i.e. either in seasonally frozen ground or in active layers (on permafrost). Discrimination between a soil wedge and a (permafrost) sand wedge may be problematic. For a soil wedge with secondary infilling, the soil wedge corresponds to the primordial soil wedge, ice vein, or sag vein.

Periglacial involution:

These are classified according to Vandenberghe (1988, 1992).
Type **1, 2a**, **2b** , **3a**, **3b**, **4a**, **4b**, **5a**, **5b**, **5c**, or **6**.

Type 1: individual folds of small amplitude, large wavelength.

Type 2: relatively regular, symmetrical and intensely convoluted forms arranged in closely spaced series and polygonal patterns over large areas (amplitude generally between 0.6 and 2.0 m) either down sinking (**Type 2a**) or updoming (**Type 2b**).

Type 3: same configuration as Type 2, but distinctly smaller dimensions ranging from cm to ca. 0.5 m either downsinking (**Type 3a**) or updoming (**Type 3b**).

Type 4: solitary forms of variable amplitude in drops (**Type 4a**) or diapirs (**Type 4b**).

Type 5: upward directed platy 'dykes' in a solitary form (**Type 5a**), in polygons (**Type 5b**) or the centres of the polygons may be updomed at the top and depressed at the base (**Type 5c**).

Type 6: other irregular structures.

Cryogenic microfabrics:

Banded **f**abrics, **L**enticular **p**laty **m**icrostructures, **O**ther **c**ryogenic **m**icrofabrics, **S**tructural **s**equence with a **g**radual increase of thickness of lenticular platy microstructure, **S**tructural **s**equence with a microstructural **u**nconformity.

Perennial and seasonal frost mounds:

Open-**s**ystem **p**ingo, **C**losed-**s**ystem **p**ingo, **Pa**lsa, **Ea**rth **h**ummock, **Th**ufur.

A frostmound is a mound-shaped landform produced by ground-freezing combined with groundwater movement or the migration of soil moisture. A thufur is a perennial hummock formed either in the active layer in discontinuous permafrost zone or seasonally frozen grounds during ground freezing (a type of nonsorted circle). An earth hummock is a hummock having a core of silty and clayey mineral soil and showing evidence of cryoturbation. It is a type of non-sorted circle, commonly found in the continuous permafrost zone.

Cryoplanation and mass-wasting:

Cryo**p**lanation **t**errace, **F**rost **c**reep, **G**eli**f**luction, **G**rèze **l**itées.

4.1.1.2 Contents of field DATED_BY.

This field describes the technique by which the periglacial feature is dated. Reference may be made to physical dating techniques (e.g. radiocarbon, thermoluminescence dating) or dating by stratigraphical correlation (abbreviated by ?strat? or ?s?). In the latter case reference may be made to locally known stratigraphical horizons, e.g. BGB = ?Beuningen Gravel Bed? (Van der Hammen & Wijmstra, 1971).

4.1.1.3 Palaeoclimatic information.

The periglacial events may be crudely related to palaeoclimatic information by means of a comparison with data from the modern periglacial zone (Karte, 1979, 1983; Huijzer, 1993; French, 1996; Huijzer & Isarin, 1997). However, the actual interpretation of cryogenic structures/phenomena should be based on multi-proxy data analysis, including for instance palaeobotanical data. The relation between specific periglacial features/phenomena and the palaeoclimate significance is listed in table 1.0 (cf. reference list).

The T_{july} i.e. mean air temperature of the warmest month may be inferred from the palaeobotanical record (e.g. by climatic indicator species); in most cases the derived T_{july}points to a *minimum* temperature. T_{an} i.e. a *maximum* mean annual air temperature may be inferred from the presence of ice-wedge casts (or thermal contraction cracks, e.g. -5°C). By means of setting the T_{july} at a specific (approximate) value e.g. 10°C and the *maximum* mean annual air temperature (T_{an}), the T_{jan} i.e. mean air temperature of the coldest month, may be calculated if a symmetric annual amplitude is assumed. The calculated mean annual temperature for T_{jan} represents a *maximum* temperature; in this example the calculated T_{jan} approximates -20°C (cf. Vandenberghe and Pissart, 1993).

The classification and interpretation of periglacial involutions follows that of Vandenberghe (1988). Involution type 1, 5 and 6 are attributed to cryostatic pressure (volumetric expansion of freezing water or frost heave) or cryohydrostatic pressure (pressure exerted by water between freezing fronts cf. Washburn, 1979) in seasonally frozen ground or permafrost. Involution type 2, 3 and 4 result from periglacial loading. In this case, sediments may sink down under gravitational force in the underlying sediments, while the lower material may rise in the upper deposits. Essential conditions are a reversed density gradient and liquefaction caused by overpressure of water in a water-saturated topsoil. Type 4b also may result of cryohydrostatic pressure.

Table 4. Palaeoclimatic interpretation of periglacial features. MAAT = mean annual air temperature, MAP = mean annual precipitation.

<table>
<tr><th>Event</th><th>Palaeoclimate information</th></tr>
<tr><td>Thermal contraction cracking</td><td></td></tr>
<tr><td>Ice-wedge cast (Iw)</td><td>coarse-grained substrate MAAT < -8°; fine-grained substrate MAAT < -4°C; MAP > 50-500 mm</td></tr>
<tr><td>Sand-wedge cast (Sw)</td><td>MAAT < -12°C to < -20°C; MAP < 100 mm</td></tr>
<tr><td>Composite-wedge cast (Cw)</td><td></td></tr>
<tr><td>Active layer soil wedge with primary infilling (Alp)</td><td rowspan="3">fine-grained substrate MAAT < -1 to 0°C; coarse-grained substrate MAAT < -3 to -4°C; indication of T_{jan} < -8°C</td></tr>
<tr><td>Seasonally frozen ground soil wedge with primary infilling (Sfp)</td></tr>
<tr><td>Active layer soil wedge with secondary infilling (Als)</td></tr>
</table>

Event	Palaeoclimate information
Seasonally frozen ground soil wedge with secondary infilling (Sfs)	
Vertical platy microstructures (Vps)	thermal contraction cracking of relatively thin layer; sudden temperature drop
Type 1 individual folds of small amplitude and large wavelength	seasonally frozen ground, permafrost
Type 2 down sinking (Type 2a) or updoming (Type 2b)	fine-grained substrate MAAT < -4°C, and coarse-grained substrate MAAT < -8°C
Type 3 down sinking (Type 3a) or updoming (Type 3b)	seasonally frozen ground, permafrost
Type 4 drops (Type 4a) or diapirs (Type 4b)	seasonally frozen ground, permafrost
Type 5 solitary form (Type 5a), polygons (Type 5b), or updomed and depressed (Type 5c)	seasonally frozen ground, permafrost
Type 6 other irregular structures	cryostatic pressure or cryohydrostatic pressure: seasonally frozen ground, permafrost
Perennial frost mounds	
Open-system pingo (Osp)	MAAT < -2° - -4° C; continuous and discontinuous permafrost zone
Closed-system pingo (Csp)	MAAT < -6°C; continuous permafrost zone
Palsa (Pa)	organic palsa MAAT < -1°C; mineral palsa MAAT < -4 to -6°C
Earth hummock (Eh), thufur (Th)	seasonally frozen ground, permafrost zone, MAAT < +3°C
Cryoplanation and mass-wasting	
Cryoplanation terrace (Cpt)	MAAT < -1°C
Frost creep (Fc)	periglacial environment
Gelifluction (Gf)	MAAT < -2°C
Grèze litées (Gl)	periglacial environment
Cryogenic microfabrics	
Banded fabrics (Bf)	frost action: seasonally frozen ground or active layer
Lenticular platy microstructures (Lpm)	ice segregation process (seasonally frozen ground, active layer, permafrost)

Event	Palaeoclimate information
Structural sequence with a gradual increase of lenticular platy microstructure (Ssg)	seasonally frozen ground
Structural sequence with a microstructural unconformity (Ssu)	transition from active layer to permafrost horizon: permafrost conditions
Cryogenic microfabrics in cave deposits	MAAT < 0°C

4.1.2 Table PEDOLOGI

The table PEDOLOGI describes palaeopedological information related to palaeoperiglacial environments.

Table 5. Field description of database table PEDOLOGI.

Field name	Field type	Field length	Decimals	Description / Example
PEDOLOG_ID	Character	7		Unique event number, e.g. PD549
EVENT	Character	20		The local or regional name of the buried palaeosol e.g. Kesselt soil
DATED_BY	Character	40		Type of age information, e.g. age of the parent material
SEDENV	Character	2		Type of depositional environment, e.g. Fluvial, Aeolian sand/silt, Glacial, Lacustrine.
PARENTMAT	Character	2		Parent material of the palaeosol i.e. Clay, Silt, Sand, Gravel, *in situ* weathered Hard rock, Other
NONUNIFPM	Character	2		Non-uniform parent material, i.e. Lithological Contact or Erosional Surface within parent material
MINERALPM	Character	10		Mineralogical composition of the parent material (in %) Quartz, Feldspar, and Heavy Minerals (e.g. Q67F33)
GEOMORPH	Character	1		Palaeogeomorphological position in which the palaeosol formed, e.g. Upland, Hillslope, Bottomland, Channel, Other
TOPOSEQ	Character	1		Is the palaeosols developed as a toposequence ? (Y/N)
DRAINAGE	Character	1		Drainage of the palaeosol: Excessively drained, Well drained, Imperfectly to moderately drained, Poorly drained
CHARCOAL	Character	1		Presence of charcoal (Y/N)

Field name	Field type	Field length	Decimals	Description / Example
ORGANISM	Character	2		Presence of traces of soil organisms or biological activity (Coleoptera, Molluscs, other Fauna, botanical Macroremains, Phytoliths, Roots, Bioturbation, etc.)
SOILCOLOUR	Character	8		Soil colour of the B horizon (as Munsell notation)
RELCRYOSTR	Character	1		Cryogenic macrostructure(s) or microfabric(s) directly related to the palaeosol (Y/N)
DESCR_CRYO	Character	40		Short description of the related cryogenic macrostructure(s) or microfabric(s). See par. 2.1.1.1.
ADDPROPERT	Character	40		Short description of additional soil properties, see par. 2.1.2.1.
TYPE	Character	2		Type of palaeosol: Truncated palaeosol, Polycyclic palaeosol, Pedocomplex, Accretionary palaeosol, Exhumed palaeosol, or Unknown type of palaeosol
SOILFORMR	Character	2		Generalized soil-forming regime, e.g. Gleization, Podzolization, Lessivage, Ferrallitization, Calcification, Salinization, Braunification, Other
SEQSOILHOR	Character	12		Sequence of soil horizons from top to bottom, e.g. AbtCCr
THICKNESS	Numeric	5	2	Total thickness of the palaeosol profile (in metres)
STAGEDEV				Stage of development of the palaeosol (see par. 2.1.2.2: Vw, W, M, S, Vs)
CLASSSYST	Character	1		Classification of the palaeosol according to Usda Soil Taxonomy system, Fao, Other
CLASSNAME	Character	20		Name of the classified palaeosol, e.g. Gelic Gleysol
CLASSAUTH	Character	1		Is the classification of the palaeosol in accordance with the opinion of the author (Y/N)?
MICROANAL	Character	1		Is the interpretation of palaeosol features/properties based on micromorphological analysis (Y/N)?

4.1.2.1 Contents of field ADDPROPERT.

This field contains a short description of additional soil properties, e.g. organic matter content of the A horizon, clay content due to weathering, type of clay minerals, illuviated clay content in the Bt horizon, decrease in calcium carbonate content in the soil profile, stage of calcium carbonate accumulation, e.g. stage V. The stage of of calcium carbonate accumulation is classified according to Retallack, 1990:

Table 6. Stage of calcium carbonate accumulation according to Retallack, 1990 (table 13.2).

Stage	Palaeosol developed in gravel	Palaeosol developed in sand, silt or clay
I	Thin discontinuous coatings of carbonate on underside of clasts	Dispersed powdery and filamentous carbonate
II	Continuous coating all around and in some cases between clasts: additional discontinuous carbonate outside main horizon	Few to common carbonate nodules and veinlets with powdery and filamentous carbonate in places between nodules
III	Carbonate forming a continuous layer enveloping clasts: less pervasive carbonate outside main horizon	Carbonate forming a continuous layer formed by coalescing nodules: isolated nodules and powdery carbonate outside main horizon
IV	Upper part of solid carbonate layer with a weakly developed platy or lamellar structure capping less pervasively calcareous parts of the profile	
V	Platy or lamellar cap to the carbonate layer strongly expressed: in places brecciated and with pisolites of carbonate	
VI	Brecciation and recementation as well as pisoliths common in association with the lamellar upper layer	

4.1.2.2 Description of contents of field STAGEDEV.

The stage of palaeosol development is classified according to Retallack, 1990:

Table 7. The stage of palaeosol development according to Retallack, 1990 (table 13.1).

Stage	Features
Very weakly developed	Little evidence of soil development apart from root traces: abundant sedimentary, metamorphic or igneous textures remaining from the parent material.
Weakly developed	With a surface rooted zone (A horizon) as well as incipient subsurface clayey, calcareous, sesquioxidic or humic, or surface organic horizons, but not developed to the extent that they would qualify as USDA argillic, spodic or calcic horizons or histic epipedon.

Stage	Features
Moderately developed	With surface rooted zone and obvious subsurface clayey, sesquioxidic, humic or calcareous or surface organic horizons: qualifying as USDA argillic, spodic, or calcic horizons or histic epipedon and developed to an extent at least equivalent to stage II of calcic horizons (Table 13.2).
Strongly developed	With especially thick, red, clayey or humic surface (B) horizons or surface organic horizons (coals or lignites) or especially well developed soil structure or calcic horizons at stages III to V (Table 13.2).
Very strongly developed	Unusually thick surface horizons (B) or surface organic horizons (coals or lignites) or calcic horizons of stage VI: such a degree of development is mostly found at major geological unconformities.

The palaeoclimate interpretation of a palaeosol is either based on the analysis of the individual soil properties, i.e. an environmental factor approach or comparison of the classified palaeosol with the present-day distribution of similarly classified soils (e.g. Bronger & Catt, 1989; Catt, 1979, 1991; FitzPatrick, 1983).

Time and climate related soil properties include organic matter content, clay content and clay mineralogy, illuviated clay content (Bt), soil colour, calcium carbonate content and depth to calcic horizon (Bk horizon). As far as palaeoclimate information is based on individual soil properties, only general palaeoclimate information can be inferred (see table 2.6). Nevertheless, the environmental factor approach is preferred, as changes in a particular (environmental) factor (e.g. climate) at a specific (geological) time-slice can be studied by choosing palaeosols for which other environmental factors (e.g. drainage, parent material, palaeotopography, etc.) were similar. In order to infer palaeoclimate information from a palaeosol, an advanced assessment of the relevant environmental factors of the involved palaeosol should be included; palaeoclimate information is only reliable when local environmental factors are eliminated.

Comparison of the palaeosols with the present-day distribution of similarly classified soils is primarily based on the **zonal** distribution of soils (i.e. climate and vegetation controlled). However, the **intrazonal** soils are developed as a result of the ('overruling') influence of some specific local factor (i.e. environmental factor) other than climate. For example, gleization is such a process, i.e. gleization reflects local waterlogging rather than wider effects of climate and vegetation evident from other soil-forming processes. Finally, **azonal** soils are poorly developed soils such as recent alluvial or stony mountain soils.

Table 8. Paleoclimatic information from palaeosols.

EVENT (palaeosol property)	**PALAEOCLIMATE (indication/information)**
Classified palaeosol	The classified palaeosol may be compared with the areal distribution of its present-day equivalent; the present distribution of the soil gives an indication of the palaeoclimate parameters
Distribution and size of roots	good criteria of palaeosol identification
Cryogenic macrostructure or microfabric	see record periglacial
Phytoliths, Charcoal	Indication of grasses and fire in (wooded grassland) vegetation respectively; under natural conditions, charcoal suggests a seasonally dry climate.
Soil colour	Red colour: haematite, seasonal climate with hot warm summers. Brown colour: goethite, cool humid regions with little seasonal variation in climate. Time-controlled feature as well.
Clay content produced by mineral weathering	Low temperature and low precipitation: no increase in clay content. Weathering under high temperature and high precipitation: greatly increased clay content.
Clay illuviation (illuviated clay content)	Bt horizons: favoured by pH 4.5 - 6.5, small amount of cementing and flocculating agents, permeable soil profile, seasonal rainfall distribution, and a deciduous broadleaf woodland vegetation.
Clay mineralogy	Tropic regions: kaolinite and gibbsite (halloysite). Semi-arid: montmorilloniet (very arid regions: palygorskite and sepiolite). Temperate humid: vermiculite and illite. Smectite: semi-arid, evotranspiration exceeds rainfall. Humid regions: kaolinite, halloysite. Tropic regions: gibbsite. Impeded drainage: smectite.
Calcium carbonate content	see Table; as calcium carbonate is easily weathered, its presence suggests a dry climate. Calcium carbonate stabilizes the organic matter and reduces the humification process. Time-controlled feature as well.
Depth of calcic horizon (Bk)	Depth below surface reflects depth of wetting of the soil by available water (seasonal distribution of precipitation, evapotranspiration): in climates with a marked dry-season the calcic horizon is closer to surface. Other factors are drainage, parent material, and influx of calcareous dust. Time-controlled feature as well.
Organic matter content	Hot and cold desert have little organic matter production (low precipitation); tropical forest have a high production and rapid decomposition; humid temperate regions have high rainfall, weak evapotranspiration, and a relatively low temperature prevents decomposition. Time-controlled feature as well.

EVENT (palaeosol property)	**PALAEOCLIMATE (indication/information)**
Drainage	Chemical weathering below the water table is slow (pyrite, marcasite and siderite nodules in permanently waterlogged soils). Within zone of fluctuation oxidizing and reducing conditions (nodules and mottles of gleyed horizons, e.g. Bg). Above the zone of water-table fluctuation are formed most other kinds of soil horizons, such as Bt horizon (oxidized horizons with red, yellow, or brown iron oxyhydrate colours.

4.2 Events recorded in depositional environments

The tables in this category pertain to events recorded in sedimentary environments such as aeolian, fluvial, lacustrine, or glacial. Because the compilation of data for the lacustrine and glacial environments is still under progress, these tables have not been included.

4.2.1 Table AEOLIAN.

The table AEOLIAN stores information on aeolian deposits (including sedimentary facies and structures) and related geomorphological features such as dunes.

Table 9. Field description of database table AEOLIAN.

Field name	**Field type**	**Field length**	**Decimals**	**Description / Example**
AEOLIAN_ID	Character	7		Unique event number, e.g. AE3847
EVENT	Character	40		Type of event, e.g. formation of (river)dunes, ridges, coversand sheet, loess, tephra, desert pavement
DATED_BY	Character	40		Type of age information, e.g. initiation aeolian activity. See par. 2.1.1.2.
RELATEDDAT	Memo			Comments on age information
DURATION	Numeric	8	0	Estimation of duration event in years
LITHSTRAT	Character	10		Lithostratigraphical position, e.g. Older Coversand I
MORPHOLOGY	Character	6		Landform, e.g. Parabolic, Linear, Slightly undulating, Sand Sheet
FACIES	Character	20		Sedimentary facies of the deposits. See par. 2.2.2.1.
PALAEOGEOM	Character	20		Palaeogeomorpholocal position, e.g. upland, river terrace
CROSSBED				Cross bedding/lamination present? Y/N

Field name	Field type	Field length	Decimals	Description / Example
HEIGHT_CB	Numeric	6	2	Height of the cross-bedded/laminated strata in cm
DIR_CB	Numeric	3	0	Direction of the cross-bedded/laminated strata (foreset direction in ° over north)
FLUVIAL	Character	40		Short description of any fluvial structures within the aeolian strata, e.g. low-energy sheet flow
LITHOLOGY	Character	40		Lithological characteristics, e.g. loamy fine sand
MODE	Numeric	5	0	Modal grainsize in m m
THICKNESS	Numeric	6	2	Thickness of deposit in m.
ACCUMRATE	Numeric	6	2	Estimation of accumulation rate (in cm/year)
SOURCEAREA	Character	20		Source area of deposit, e.g. Maas river plain
VEGETATION	Character	40		Short description (palaeo)vegetation surrounding the site
HUMAN_INFL	Character	40		Description of possible human influence on event/, e.g. reactivation processes by slash-and-burn

4.2.1.1 Contents of field FACIES.

The field FACIES contains a description of the type of eolian deposit encountered in terms of lithology and overall sedimentary sturcture. In most cases the description will speak for itself. ?Alternating bedding? refers to a typical facies encountered in the west-European aeolian sands deposited in the periglacial zone of the last glacial. It consists of an alternation of thin beds (cm scale) of sand and silty sand or silt (Schwan, 1986).

4.2.2 Table FLUVIAL

The table FLUVIAL contains information on the fluvial sedimentary environment, in particular information on the fluvial facies and erosion / aggradation events. Although quantitative palaeoclimatic or palaeohydrologic information rarely can be derived from this type of data, a qualitative interpretation of climate-related changes in water and sediment discharge of palaeoperiglacial rivers still may be obtained (e.g. Van Huissteden, 1990; Mol, 1997).

Table 10. Field description of database table FLUVIAL

Field name	Field type	Field length	Decimals	Description / Example
FLUVIAL_ID	Character	7		Unique event number, e.g. FL653
EVENT	Character	25		Type of event, e.g. fluvial aggradation
DATED_BY	Character	40		Type of age information, e.g. initiation of channel downcutting. See par. 2.1.1.2.
RIVERTYPE	Character	6		River type: Braided, Meandering, Anastomosing, Sheet Floods, Incising river
RELATEDDAT	Memo			Comments on age information
DURATION	Numeric	7	0	Estimation of duration event (in years)
NAME	Character	20		River name e.g. Schwarze Elster
PRES_TYPE	Character	2		Actual river characteristics e.g. Meandering, Braided, Anastomosing, Straight, Not known
TERRACE	Character	40		Regional or local name of river terrace, e.g. Main Terrace
FACIES	Character	40		Short description of the fluvial facies, e.g. channel fill
MASSIVE	Character	1		Presence of massive (non-stratified) sediment Y/N
HORBED	Character	1		Presence of horizontal bedding/lamination Y/N
CROSSBED	Character	1		Presence of cross bedding/lamination Y/N
HEIGHTCB	Numeric	6	2	Height of cross bedded/laminated sets in cm
FINCOUPW	Character	1		Presence of Fining or Coarsening upward sequence(s)
FCLENGTH	Numeric	6	0	Length of fining/coarsening upward sequence(s) in cm
BEDLOAD	Numeric	8	0	Maximum grainsize in channel in m m
GRAINSIZE	Numeric	8	0	Average grainsize in m m
ICERAFTED	Character	1		Is there evidence for sediment transport via ice-rafting? Y/N
WDRATIO	Numeric	6	2	Channel width/depth ratio
GRADIENT	Numeric	6	0	Gradient of river at time of event in cm/km
SINUOSITY	Numeric	6	2	Sinuosity value for meandering river
FLOODING	Character	1		Is there evidence for floodings? Frequent, Rare, No

Field name	Field type	Field length	Decimals	Description / Example
VEGETATION	Character	40		Short description of the (palaeo)vegetation that surrounds the site
AEOLIAN	Character	40		Short description of any aeolian activity related with fluvial deposit, e.g. fluvial reworked aeolian sands
TECTONICS	Character	15		Tectonic setting, e.g. uplift, subsidence
HUMAN	Character	40		Short description of human influence on river system/event

5 CHRONOSTRATIGRAPHICAL INFORMATION IN TABLE AGE

Within the table 'age' the absolute age of an event can be inscribed. An event may take place at a specific moment or during a period/interval; a period/interval is embraced by two absolute radiometric datings (^{14}C, TL), i.e. a lower and an upper age. In addition, related (intervening) dates may be classified as 'Additional' ('many ages to one event') such as a TL and an OSL date of one event. Finally, the date of an event may be inferred from a synchronous event (e.g. Laachersee Tephra), or inferred from its stratigraphic position (according to the chronostratigraphic classification, e.g. Late Pleniglacial).

Table 11. Field description of database table AGE.

Field name	Field type	Field length	Decimals	Description / Example
AGE_ID	Character	6		Unique age identifier, e.g. A4375
AGE	Numeric	8	0	Age in siderial or radiocarbon years, depending on dating method
LABNR	Character	11		Laboratory number of age determination
SAMPLE_POS	Character	1		<u>L</u>ower age of the event, i.e. sample from the base, or <u>U</u>pper age, i.e. sample from the top, or (related) <u>A</u>dditional
METHOD	Character	5		Dating method, e.g. conventional ^{14}<u>C</u>, <u>Ams</u>, <u>D</u>endrochronological, <u>TL</u>, OSL, <u>U</u>/Th, <u>V</u>arve, <u>Strat</u>igraphical correlation
AGEBASEDON	Character	50		Further information on dating method, e.g. the age of an associated dated event in the database
SDEV_UP	Numeric	8	0	Upper standard deviation of age determination

Field name	Field type	Field length	Decimals	Description / Example
SDEV_LO	Numeric	8	0	Lower standard deviation of age determination
CALIBRATED	Numeric	8	0	Calibrated age in years BC/AD
CALSDEV_UP	Numeric	8	0	Upper standard deviation of calibrated age
CALSDEV_LO	Numeric	8	0	Lower standard deviation of calibrated age
CALMETHOD	Character	1		Calibration method e.g. Stuiver and Pearson, Unknown
INFINITE	Character	1		Age beyond limit of applied dating technique ('infinite age') Y/N
MATERIAL	Character	25		Dated material, e.g. betula leaf, organic bulk, fine sand (quartz, K-feldspar)
FROM	Character	25		Context of sample, e.g. gyttja in palaeomeander
TYPEDAT	Character	2		^{14}C-dating is on the Extract (coarse/fine), Residue (coarse/fine), $CaCO_3$, or Unknown
VERTDIST	Numeric	7	2	Vertical distance over which a bulk sample is taken in cm
DELTAC13	Numeric	7	2	d ^{13}C value in ?
SOURCE_ERR	Character	50		Possible sources of error on age determination and error correction measures
ENRICHED	Character	1		Isotopic enrichment has been applied by Thermal diffusion column or Laser beam
STANDARD	Character	1		Standard that has been applied to quote isotopic ratios: PDB, SMOW, Other
DELTA18O	Numeric	7	2	d ^{18}O in ?

6 TABLE PROXY

Within the table 'proxy', the properties of the proxies such as age, type of event (e.g. periglacial, fluvial, aeolian etc.), and site information is jointed together. First of all, one site may have one or more events. Each event is linked to an age, although **different** events may have a similar age (e.g. thermal contraction cracking related to soil formation). In addition, **one** event may have more than one age, e.g. a base and top age (and possibly (a cluster of) related ages in between).

Table 12.

Field name	Field type	Field length	Decimals	Description / Example
PROXY_ID	Character	8		Unique proxy identifier, e.g. 2335
EVENT_ID	Character	7		Event identifier, e.g. a periglacial event, PE3241
AGE_ID	Character	6		Age identifier, e.g. A3242
SITE_ID	Character	6		Site identifier, e.g. S345

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8 DOCUMENT INFORMATION

8.1 Publication Date

1998

8.2 Date Last Updated

2021

APPENDIX A – GLOSSARY

Accretionary soil

Buried slowly so that development continues, to produce a accretionary soil (may be a clue that the soil formed n a low-lying part of the landscape).

Buried soil

A soil that is buried rapidly beneath thick deposits which seal it from the atmosphere and prevent further development.

Cryostatic pressure

Volumetric expansion of freezing water (i.e. frost heave)

Cryo(hydro)static pressure

Pressure exerted by water between freezing fronts (conform Washburn, 1979).

Composite wedge cast

A wedge showing evidence of both primary and secondary infilling

Drainage

Classification slightly modified according to the Soil Survey Manual (1975). Entirely above the water table (excessively and well drained), partly or wholly within the water table fluctuation (imperfectly to moderately drained), or entirely below the water table (poorly drained).

Earth hummock

A hummock having a core of silty and clayey mineral soil and showing evidence of cryoturbation; a type of non-sorted circle; commonly found in the continuous permafrost zone (a type of nonsorted circle).

Exhumed soil

Buried and then re-exposed by erosion, to form an exhumed soil.

Frost mound

Mound-shaped landform produced by ground-freezing combined with groundwater movement or the migration of soil moisture.

Palaeosol

A soil formed in a landscape of the past (including buried soils, relict soils and exhumed soils !).

Pedocomplex/Compound soil

Where two or more soils, perhaps partly truncated, are separated by a thin sediment layer showing pedogenetic alteration, the resulting profile is termed a compound soil or pedocomplex.

Periglacial loading

Sediments may sink down under gravitational force in the underlying sediments, while the lower material may rise in the upper deposits. Essential conditions: reversed density gradient and liquefaction

Polycyclic/Composite soil

A soil in which a similar soil-forming phase is at least repeated twice (e.g. clay illuviation), interrupted by another soil-forming phase (cryogenic disruption of clay coatings).

Relict/Ancient soil

Soils that continue to develop beneath a stable land surface subject to changing environmental conditions (relict soils or ancient soils, i.e. polygenetic).

Seasonally frozen ground

Zone in the periglacial environment beyond the (sporadic) permafrost zone where the ground freezes seasonally.

Soil wedge

The soil wedge differs from the sand and ice wedges that they do not occur in perennial frozen ground, i.e. either in seasonally frozen ground or in active layers (on permafrost).

Soil wedges with primary infilling

Remark: discrimination between a soil wedge and a (permafrost) sand wedge may be problematic

Soil wedge with secondary infilling

Soil wedge corresponds to the primordial soil wedge, ice vein, or sag vein

Truncated soil

Partially eroded to form a truncated palaeosol

Thufur

Perennial hummock formed either in the active layer in discontinuous permafrost zone or seasonally frozen grounds during ground freezing (a type of nonsorted circle).

APPENDIX B – NOTES ON FILE TYPES

The file types of the data files have the following extensions.

dBASE files:

.DBF Table file

.DBT Memo text field contents of table

.MDX Index file

.QBE Query-by-example

.QBO Result table of query

ASCII text files:

.TXT Table file in SDF format

. SCH Field description of tables

In SDF format files, records are terminated by newline characters. Fields are not separated by special characters and contain the same number of characters as the original dBASE field length.