

Recent results of Pleistocene periglacial research in the Netherlands

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Periglacial research as conducted by the Vrije Universiteit Amsterdam in the last decade is especially concerned with the reconstruction of former, Pleistocene, periglacial processes and environments. It has been focused on two themes: 1) the derivation of palaeoclimatic conditions from periglacial relict features and 2) the determination of the periglacial processes which have shaped the morphology of presently temperate zones during the Pleistocene. The results of this research have been presented and discussed by means of field examples at the occasion of the Symposium on 'Periglacial Environments in relation to Climatic Change' (Amsterdam-Maastricht, 3–6 May, 1991; Vandenberghe 1991b). The highlights and main conclusions are briefly reported below.

1. Early Pleistocene interglacial stages were obviously warmer than later ones as shown by Zagwijn (1957). The glacial stages, however, showed similar temperature conditions throughout the Pleistocene. This means that permafrost was also present during parts of the Early Pleistocene glacials. This could be illustrated clearly for the Beerse glacial, a cold period within the Tiglian stage, by the occurrence of incipient ice-wedge casts and large cryoturbations at Beerse (Fig. 1, site 8) (Vandenberghe & Kasse 1989, Kasse 1993).
2. Although the Saalian ice sheet proceeded further southward than any other Pleistocene ice sheet in northwestern Europe, its peripheral zone with permafrost was poorly developed and probably of only minor extent. This situation sharply contrasts with the Weichselian period which was characterized by a very broad periglacial zone. Indications for permafrost during the Saalian have for the first time been established in the Belvédère excavation (site 2) near Maas-

tricht by the occurrence of large cryoturbations in terrace gravels of the river Maas (= Meuse). They are slightly older than the human occupation of the 'Belvédère interglacial' at about 250 000 years ago (Vandenberghe et al. 1987, 1993).

3. The last glacial (Weichselian) is characterized by two periods with general permafrost: one at the beginning of the Pleniglacial (c. 72–61 ka) and one at the end of the Pleniglacial and corresponding with the last glacial maximum (c. 24–17 ka). During the other periods of the Weichselian, conditions of deep seasonal frost prevailed. Occasionally and in favorable sites, for instance in silty subsoils like those at Kesselt (site 3, Huijzer 1991, 1993), permafrost was established. Similarly, discontinuous permafrost was present during a few hundred years at the beginning of the Younger Dryas (10.9–10.6 ka; Bohncke et al. 1993).
4. Fluvial cyclicality as a function of climate could be demonstrated at several stratigraphic levels and in different geomorphological positions. Fluvial cycles in alternating periglacial and temperate climates comprise a sequence starting with a short phase of incision at the beginning of a cold period, followed by rapid accumulation in a braided system during the early stage of that period, stability or wind activity in the later stages of the cold period, a new incision by meandering rivers at the transition to the next warm period and finally stability (equilibrium between slight aggradation and accumulation) during the warm period. This sequence has been observed in the Maas valley at Maastricht-Belvédère (Saalian), Grubbenvorst (Weichselian Late Pleniglacial) and Lottum (Weichselian Late Glacial) as well as in the Dinkel basin (Weichselian Late Pleni-



Fig. 1. Location map of excursion sites. 2: Maastricht-Belvédère, 3: Kesselt, 4: Grubbenvorst, 5: Bosscherheide, 6: Lottum, 7: Groote Peel, 8: Beerse, 9: Meerle, 10: Twente, Dinkel valley.

glacial). For a more elaborate analysis of the relation between the described morpho-sedimentary sequence and climate see Vandenberghe (1993) and Vandenberghe et al. (1992).

5. The interference between aeolian and fluvial ac-

tivity during the maximum and final part of a cold period strongly depends on geomorphological position, more particularly on the proximity of river activity (Bryant 1983, Vandenberghe 1985). Complex transitions and interfingering

between aeolian and fluvial deposits comprise process sequences from shallow gully erosion, to surface runoff, aeolian infilling of shallow pools in alluvial plains, wet aeolian deposition and finally coversand or dune formation (Ruegg 1983, Schwan 1987, 1988, 1991, Vandenberghe & Van Huissteden 1988, Van Huissteden 1990, Vandenberghe 1991a). Such a characteristic type of periglacial sedimentation, called fluvio-aeolian sedimentation, is well exemplified for the Late Pleniglacial at Grubbenvorst and along the Dinkel river (sites 4 and 10).

6. Cryoturbations of large amplitude and areally regular development are shown to be independent of lithology or frost susceptibility: silts may be involuted in coarse sands (site 5, Bosscherheide) as well as sands are sunk down in highly cohesive clays (site 9, Meerle). This means that processes of differential frost penetration are unable to explain these cryoturbations. Periglacial loading as a consequence of supersaturation due to melting of the ice-rich permafrost top is still the best hypothesis to explain all observed phenomena (Vandenberghe & Van den Broek 1982).

Occasionally, upward sand intrusion occurs following a preexisting fissure polygon (site Beerse). The resulting sedimentary structure is completely different from structures that are caused by loading (Vandenberghe 1992).

7. Circular, closed depressions in the Netherlands are known since a long time. The deeper ones in the northern Netherlands have been well-documented by De Gans (1981) and interpreted by him as closed-system pingos. In the southern Netherlands (Peel plateau, site 7) similar but shallower depressions have been found. Like those in the northern Netherlands they show practically no ramparts. Also their age is similar: they were formed in the Weichselian Late Pleniglacial and filled mainly during the Late Glacial. Their exact origin is still debated, but it seems probable that the depressions are due to melting of ground ice (Kasse & Bohncke 1992).
8. The geomorphology of the Netherlands and adjacent northern Belgium is characterized by extensive erosive plains, dipping very slightly to

the valley axes. Their dips are generally equivalent to the longitudinal gradients of the small tributary rivers flowing on these plains. Contemporaneous sediments on top of the plains are rare; only in a few cases thin deposits of shallow gullies are found (site Meerle). An origin as river terraces or litho-structural forms may be excluded. On the basis of their large areal extent, low dips, covering sediments and geomorphological relationship with the main valley system, the origin of these plains is attributed to erosion by intense and widely distributed surface runoff. The involved periodically high discharges over a presently highly permeable subsoil could have been achieved by a (temporarily) frozen surface. The similarity with semi-arid pedimentation forms allows to interpret the plains as cryopediments.

References

- Bohncke, S., J. Vandenberghe & A.S. Huijzer 1993 Periglacial environments during the Weichselian Late Glacial in the Maas valley. The Netherlands – Geol. Mijnbouw (this issue)
- Bryant, I.D. 1983 The utilization of arctic river analogue studies in the interpretation of periglacial river sediments from southern Britain. In: K.J. Gregory (ed.): *Background to Paleohydrology* – Wiley & Sons, Chichester: 413–431
- De Gans, W. 1981 The Drentsche Aa valley system – PhD. Thesis, Vrije Universiteit Amsterdam, 132 pp
- Huijzer, A. 1991 Micromorphological analysis of the late Middle and Upper Pleniglacial (Weichselian) sequence of Kesselt (Belgium). In: J. Vandenberghe (ed.): *Symp. 'Periglacial Environments in relation to Climatic Change'*, Maastricht/Amsterdam, 3–6 May 1991, Excursion Guide, Amsterdam, Vrije Universiteit: 61–67
- Huijzer, A. 1993 Cryogenic microfabrics and macrostructures: interrelations, processes, and paleoenvironmental significance – PhD. Thesis, Vrije Universiteit Amsterdam, 245 pp
- Kasse, C. 1993 Periglacial environments and climatic development during the Early Pleistocene Tiglian stage (Beerse glacial) in northern Belgium – Geol. Mijnbouw (this issue).
- Kasse, C. & S. Bohncke 1992 Weichselian Upper Pleniglacial eolian and ice-core morphology in the southern Netherlands (Noord-Brabant, Groote Peel) – *Permafrost and Periglacial Processes* 3: 327–342
- Ruegg, G.H.J. 1983 Periglacial eolian evenly laminated sandy deposits in the Late Pleistocene of NW Europe, a facies unrecorded in modern sedimentological handbooks. In: E. Brookfield & T. Ahlbrandt (eds): *Eolian Sediments and Processes* –

- Elsevier Science Publishers, Amsterdam; *Developments in sedimentology* 38: 455–482
- Schwan, J. 1987 Sedimentologic characteristics of a fluvial to aeolian succession in Weichselian Talsand in the Emsland (F.R.G.) – *Sedimentary Geology* 52: 273–298
- Schwan, J. 1988 The structure and genesis of Weichselian to Early Holocene aeolian sand sheets in western Europe – *Sedimentary Geology* 55: 197–232
- Schwan, J. 1991 Palaeowetness indicators in a Weichselian Late Glacial to Holocene aeolian succession in the southwestern Netherlands – *Zeitschr. f. Geomorphologie, Suppl.-Band* 90: 155–169
- Vandenbergh, J. 1985 Paleoenvironment and stratigraphy during the Last Glacial in the Belgian-Dutch border region – *Quaternary Research* 24: 23–38
- Vandenbergh, J. 1991a Changing conditions of aeolian sand deposition during the last deglaciation period – *Zeitschr. f. Geomorphologie, Suppl.-Band* 90: 193–207
- Vandenbergh, J. (ed.) 1991b Symposium 'Periglacial Environments in relation to Climatic Change', Maastricht/Amsterdam, 3–6 May 1991, Excursion Guide, Amsterdam, Vrije Universiteit, 171 pp
- Vandenbergh, J. 1992 Cryoturbations: a sediment structural analysis – *Permafrost and Periglacial Processes* 3: 343–352
- Vandenbergh, J. 1993 Changing fluvial processes under changing periglacial conditions – *Zeitschr. f. Geomorphologie, Suppl.-Band*, 88: 17–28
- Vandenbergh, J. & C. Kasse 1989 Periglacial environments during the Early-Pleistocene in the southern Netherlands and northern Belgium – *Palaeogeogr. Palaeoclimat, Palaeoecol.* 72: 133–139
- Vandenbergh, J. & P. Van den Broek 1982 Weichselian convolution phenomena and processes in fine sediments – *Boreas* 11: 299–315
- Vandenbergh, J., W. Roebroeks, T. Van Kolfschoten, H. Mùcher & T. Meijer 1987 Sedimentary processes, periglacial activity and stratigraphy of the loess and fluvial deposits at Maastricht-Belvédère (The Netherlands). In: M. Pecsì & H. French (eds): *Loess and Periglacial Phenomena* – Akad. Kiado, Budapest: 51–62
- Vandenbergh, J. & J. Van Huissteden 1988 Fluvio-aeolian interaction in a region of continuous permafrost. *Proc. 5th Int. Conf. Permafrost, Trondheim*: 876–881
- Vandenbergh, J., W. Roebroeks & T. Van Kolfschoten (eds) 1993 Maastricht-Belvédère: stratigraphy, palaeoenvironment and archaeology of the Middle and Late Pleistocene deposits, Part II – *Meded. Rijks Geol. Dienst* (in press).
- Van Huissteden, J. 1990 Tundra rivers of the Last Glacial: sedimentation and geomorphological processes during the Middle Pleniglacial in Twente, eastern Netherlands – *Meded. Rijks Geol. Dienst* 44–3: 1–138
- Zagwijn, W. 1957 Vegetation, climate and time-correlations in the Early Pleistocene of Europe – *Geol. Mijnbouw N.S.* 19: 233–244