II Lithostratigraphy

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II LITHOSTRATIGRAPHY

IIa LITHOSTRATIGRAPHY OF THE MOLENAARSGRAAF STUDY AREA

IIa.1 The standard-sequence

The local sequence of beds, as found in the Molenaarsgraaf study area, has been presented in a generalised way in the left half of Fig. 5. The sand-subsoil, including its clayey top (the *loam*) and the locally outcropping river dunes, can be distinguished as a separate unit from the superposed sequence of (minero-)clastic and organic beds. Within this sequence, four clastic fluviatile beds are discerned: cl 1, cl 2, cl 3, and cl 4; the superficial clay bed ('cover') is left out of consideration here. These clastic beds could mainly be distinguished because of their alternation with organic beds consisting of peat and/or gyttja. As ROELEVELD (1974) and GRIEDE (1978) did in the marine districts in the Northern Netherlands, so too, in this study, the organic layers have been named lithostratigraphically: ol b as the basal organic bed, ol 1-2, ol 2-3 and ol 3-4 as the organic beds between the clastic cl- beds, ol u as the upper organic bed.

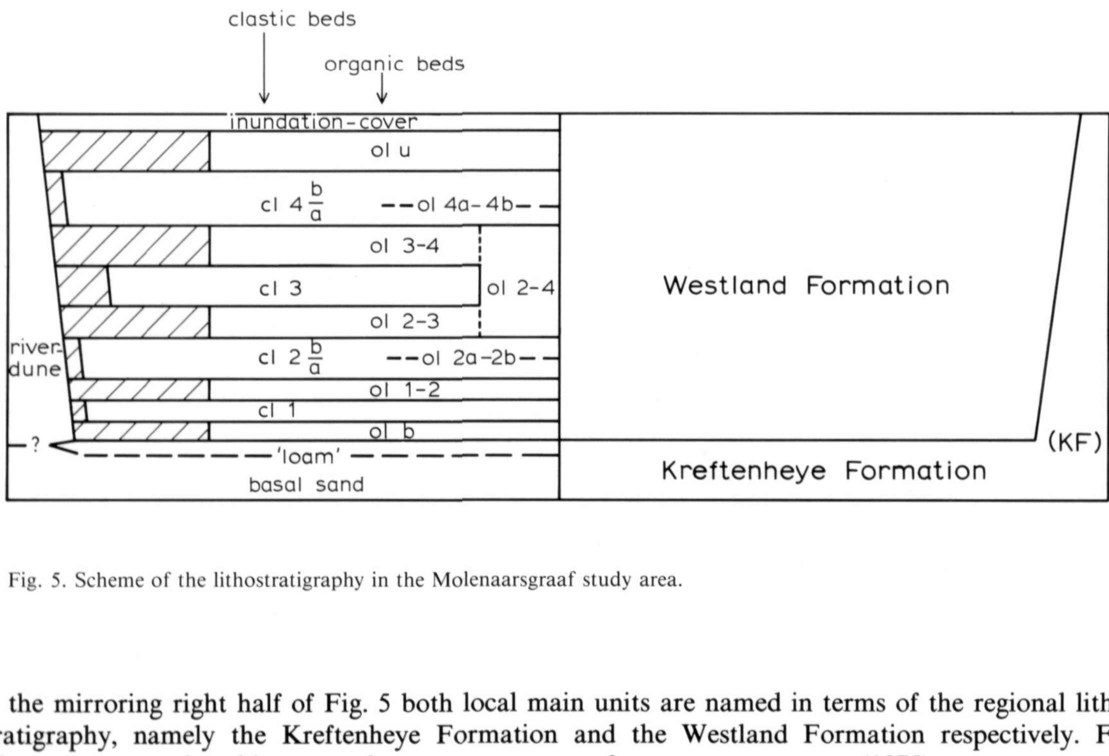

Fig. 5. Scheme of the lithostratigraphy in the Molenaarsgraaf study area.

In the mirroring right half of Fig. 5 both local main units are named in terms of the regional lithostratigraphy, namely the Kreftenheye Formation and the Westland Formation respectively. For references concerning this nomenclature, see ZAGWIJN & VAN STAALDUINEN (1975).

Of the 'predominantly coarse, gravel-bearing sands' comprising the Kreftenheye Formation (ibid., p. 25), the covering *loam* bed and river dunes in particular have been studied here. The Westland Formation consists predominantly of marine deposits, but the fluvial deposits of the coastal plain (the fluviatile perimarine deposits) are also included in it. In addition the intercalated peat beds, both between the marine and between the fluvial deposits, are (as 'Holland Peat') included in the Westland Formation (ibid., p. 47; see also DE JONG 1971, p. 149).

The subdivision of the fluviatile deposits of the Westland Formation into the 'Gorkum I, II, III and IV' deposits and the 'Tiel 0, I, II, IIIa and IIIb' deposits (Geological Survey: HAGEMAN 1963, ZAGWIJN & VAN STAALDUINEN 1975, p. 47) is not used here. This subdivision is not purely lithostratigraphically, but mainly chronostratigraphically defined, namely as chronologic equivalents of the marine 'Calais I - IV' deposits and 'Dunkerque 0 - IIIb' deposits. The objections against the use of these, also mainly chronologically founded lithostratigraphic units have been put forward previously by ROELEVELD (1974). In these matters, one might refer to the International Stratigraphic Guide: the establishment and identification of lithostratigraphic units should be largely independent of time-concepts (HEDBERG 1976, p. 94). The consequence of all this is that in the discussion of the various deposits belonging to the Westland Formation, besides to the local, informal units mentioned above, no reference will be made to the units used by the Geological Survey for the whole region.
As a tangible example of the lithological succession in the Molenaarsgraaf study area, Table 1 shows the detailed description of the standard boring (boring Molenaarsgraaf H1110). We mentioned previously in Ch. I, that the standard boring was chosen so as to comprise all distinguished clastic fluviatile (cl-) and organic (ol-) beds as well as the *loam* bed. This means that no sandy channel fills (stream ridges) and no river-dune sand occur in the boring; these would have resulted in the sequence of clay- and peat beds being incomplete due to erosion of underlying beds or partial non-deposition. In the selected cross-profiles (Figs.*6,*7 and*8) both these elements (stream ridges and river dunes) are however amply represented. The standard boring is incorporated in the northern part of profile I (Fig.*6).

IIa.2 The Kreftenheye Formation

The *loam*

The *loam* is a diamicton of clay and sand, mostly developed as sandy clay, usually with considerable toughness and stickiness. The term *loam* is set in italic to prevent confusion with the pedogenetic term loam: sand soil with more than 32.5% in the grain size fraction smaller than 50 mu (STICHTING VOOR BODEMKARTERING 1965), but also: this grain size fraction itself (ibid.), or: 'soil material that contains 7-27% clay, 28-50% silt and less than 52% sand' (SOIL SURVEY MANUAL 1962). The italic setting also indicates that the term involves a lithostratigraphic unit, not only a lithological description. Notwithstanding the objections against this use of the term loam (PONS & BENNEMA 1958, p. 125), the clayey top of the Kreftenheye Formation is indicated as (the) *loam* in recent literature (VERBRAECK 1974, ZAGWIJN & VAN STAALDUINEN 1975) too. For the sake of its compactness we have maintained the term, although perhaps a more correct expression would be e.g. the 'upper loamy (or clayey) bed of the Kreftenheye Formation'.
The thickness of the *loam* varies from less than 1 dm to over 1 m and is on the average c. 0.5 m. In the profiles of Figs.*6,7*and*8 the thickness has not been shown, because of the often incomplete gouging of the sticky *loam*. The depth of the top of the *loam* varies considerably locally (see e.g. the northern half of profile I, Fig.*6) and amounts on an average to c. 10.5 m below N.A.P. (Dutch Ordnance Datum).
The upper part of the *loam* is, where it is not covered by river-dune sand, dark blue-grey to blackish grey, and non- or poorly calcareous, whereas the lower part (and the *loam* as a whole where it is covered by river-dune sand) is light grey and strongly calcareous. HAGEMAN (1961) concluded, on the basis of preliminary results of the geological mapping of the Alblasserwaard (the region in the centre of which Molenaarsgraaf is situated), that we are concerned here with two different *loam* beds, a dark-grey one and a light-grey one. These and other geogenetic aspects of the *loam* will be treated in Ch. IVc.

Table 1. Lithological description of standard boring (boring Molenaarsgraaf H1110).

depth in cm below landsurface	litho-logical unit	litho-strati-graphic unit	lithological description and subdivision
0-30	**clay**	'cover'	
30-117	peat	ol u	with vertically varying content of fine and coarse wood fragments. 45-55 rather amorphous, decreasing downward. 105-117 no coarse wood fragments. 107-117 downward increasingly clayey.
117-433	clay	cl 4	117-132 non-calcareous, downward decreasingly humic, topmost part somewhat peaty; with some vertical plant remains. 132-268 calcareous, weakly humic, weakly sandy, light brown-grey. 176-180 scattered amorphous plant remains, partly vertical. 188-268 some vertical plant remains, some sand laminae. 268-293 idem, very sandy. 293-305 peaty, laminated. 305-328 sandy, calcareous, somewhat humic, with peat remains. 328-332 sand lamina. 332-360 downward decreasingly sandy; humic, few plant remains. 355-360 non-calcareous. 360-400 wood. 400-433 weakly sandy, downward increasingly humic and peaty. 417, 422 sand laminae 2 mm thick.
433-490	peat	ol 3-4	with fine wood fragments. 461-471 with vertical marsh plant remains. 471-481 with coarse wood fragments.
490-617	clay	cl 3	strongly humic, entirely non-calcareous, non-sandy, few plant remains, with weakly humic laminae. 512-537 some fine wood fragments. 608-613 very strongly humic.
617-677	gyttja	ol 2-3	amorphous, downward decreasingly clayey. 615-677 calcareous. 655-670 with opercula of Bythinia. 667-677 downward increasingly peaty, with tiny plant remains, also leaf fragments.
677-712	peat	ol 2-3	rather amorphous, with some fine wood fragments. 683-690 wood.
712-862	clay	cl 2	calcareous at 720-816 and 855-862. 712-722 downward decreasingly peaty; weakly sandy. 722-823 weakly humic, weakly sandy, with some weak humic laminae, with very few plant remains. 764-809 moderately sandy. 812-823 downward increasingly humic.

			823-830 strongly peaty, with vertical plant remains. 830-847 strongly humic, non-sandy, very few plant remains. 847-862 moderately humic, non-sandy, very few plant remains.
862-875	peat	ol 1-2	amorphous, compact, weakly clayey, with few fine wood fragments. 870-875 moderately clayey.
875-928	clay	cl 1	calcareous 883-924; with few plant remains. 875-878 strongly humic, weakly peaty. 878-905 moderately humic, with indistinct humic laminae. 905-919 weakly humic. 919-925 strongly humic. 925-928 peaty, with some vertical wood fragments.
928-961	gyttja	ol b	amorphous, clayey. 928-935 peaty, with some fine wood fragments. 938-951 with opercula of Bythinia.
961-966	peat	ol b	amorphous. 963-966 clayey.
966-1040	clay	'loam'	sandy ('loamy').
1040-	sand	basal sand	coarse.

In most borings, the *loam* becomes sandier downward, and the transition to the underlying, rather coarse 'basal sand' (see the scheme in Fig. 5) is often very gradual. Locally, remarkably coarse sand was found in the upper few cms of the *loam*.
Outside the Western Netherlands perimarine fluviatile coastal plain the top of the Kreftenheye Formation has been found developed as *loam* in many places; a few of these will be mentioned. SCHELLING (1951) and PONS (1957) described the *loam* in the Eastern Netherlands stream area of Rhine and Meuse. There too, the thickness of the layer varies considerably, and is on the average 1 to 1.5 m. In the northern part of the IJssel valley, WIGGERS (1955) found the *loam* bed to be only a few cms to 2 dm thick.
SCHELLING (1951, p. 94) and PONS (1957, p. 15) also found coarse sand in the upper part of the *loam*. They regard this as mainly of eolian origin. We come back to this in Ch. IVc.

The river-dune sand

The lithostratigraphic position of the river-dune sand in the top of the Kreftenheye Formation is shown in Fig. 5. The larger part of the *loam*-surface is not covered by dune sand; on the other hand, it is not certain that *loam* will always be found below the dune sand, although this was established in a limited number of — sufficiently deep — borings (see Fig. 37).
The characteristic dune topography, with locally steep gradients, can be seen in profiles II and III (Figs.*7 and*8). The dunes in these profiles have no outcrop, in contrast to the Hazendonk river dune, which is not shown in these profiles (cf. Fig. 3; see for geologic profiles across the Hazendonk LOUWE KOOIJMANS 1974, figs. 20, 34, 35 and 36). Most river dunes in the fluviatile coastal plain have no outcrop (VERBRAECK 1974, fig. 2).

The river-dune sand can be distinguished from the channel-filling sand of the Westland Formation mainly by means of its darker colour, caused by a higher content of dark, heavy minerals, and also by means of the absence of micas and nearly everywhere of lime. The fluviatile 'basal sand', that must have been the source material during the dune building, likewise contains many dark minerals (VERBRAECK 1974, p. 4). Also in the northern part of the IJssel valley, source material and river dunes (both also belonging to the Kreftenheye Formation) are characterised by this mineralogic composition, rendering the sand a 'variegated colour' (WIGGERS 1955, p. 39). A concentration of the heavy (dark) minerals relative to the source material, as occurs in the formation of (river-)dunes according to REINECK & SINGH (1975, p. 262), is supposed by us, but has not been investigated.
For details concerning granulometry and sedimentary structures we refer to VERBRAECK (1974 and 1970 respectively).

IIa.3 The Westland Formation

Lateral continuity

Most of the clastic minerogenic fluviatile beds (cl-) and organic beds (ol-) in the local lithostratigraphy of the Westland Formation can be traced nearly continuously in the illustrated cross-sections (Figs.*6,*7 and*8). Interruptions are virtually only found where gullies have eroded underlying beds and where emerging river dunes of the Kreftenheye Formation have prohibited the deposition of a part of the Westland Formation (see also Ch. IIa.1). The minor, very thin, organic horizons within the clastic beds cl 2 and 4 (ol 2a-2b and ol 4a-4b respectively; see the scheme in Fig. 5) have a strongly discontinuous lateral distribution.

Lower and upper boundary of the formation

The lower boundary of the Westland Formation is formed everywhere by the upper boundary of the Kreftenheye Formation. The latter's relief has naturally influenced the sedimentary development of the Westland Formation particularly at the river dunes. An example of this can be seen in profile III (Fig.*8) around boring H2106: due to the presence of the river dune, clastic bed cl 1 has not been deposited, and clastic beds cl 2, 3 and 4 are developed more thinly than outside the river-dune perimeter. In addition, outside the river dunes the relief of the Kreftenheye Formation has exerted a certain influence on the sedimentation of the Westland Formation, especially so where depressions are present in the top of the former. Such a depression can be seen in the northern end of profile I (Fig.*6). Its influence is expressed among others in the lithology of the lower organic beds of the Westland Formation. These are developed largely as gyttja, so in a deeper position with respect to the water table than the lithostratigraphically corresponding peat beds.
The upper boundary of the Westland Formation, the present land-surface, is very flat and consists of a continuous, only few dm thick clay bed, the so-called 'Alblasserwaard cover' (LOUWE KOOIJMANS 1974, p. 130, 182). Only at the highest parts of the previously mentioned Schoonrewoerd stream ridge is this cover lacking,or indistinguishable because of post-sedimentary homogenisation (see e.g. boring H1114 in profile I, Fig.*6). The flat nature of the upper boundary of the Westland Formation is caused not only by the clay cover, but also by the underlying thick organic bed ol u, the so-called Upper Peat (BENNEMA 1949). This peat bed has a widespread lateral extension throughout the Western Netherlands coastal plain and it largely levelled out pre-existing relief features.

Clastic deposits

The sedimentary material of the Westland Formation in the study area is very varied: weakly to strongly clayey sand, weakly to strongly sandy clay, weakly to strongly humic clay, weakly to strongly peaty clay, weakly to strongly clayey peat (wood peat and *Phragmites* peat) and (detritus-)-gyttja. First the clastic (clay and sand) deposits will be discussed.
Sandy, calcareous channel-filling deposits (the stream ridges, see Ch. Ia) have been found, within the study area, mainly in the fluviatile clastic beds cl 2 and cl 4. This is clearly illustrated by profile I (Fig.*6), a section perpendicular to the general stream direction of the filled channels. These sand bodies provide the stable framework between the clay- and peat beds which are instead subject to compaction. Although these channel fills have been completely bored through in only few places (DE FRETES 1979), their lower boundary is supposed to lie on the compaction-free Kreftenheye Formation in most cases. This is very plausible in the case of the stream ridges belonging to clastic bed cl 2, as the top of these lies only c. 4 m above the Kreftenheye Formation (see e.g. the two channel fills at borings H1009 and H1541, Fig.*6). VERBRAECK mentions that the Schoonrewoerd stream ridge (belonging to bed cl 4) lies also on the Kreftenheye Formation, at least for the stretch near Molenaarsgraaf (pers. comm. in LOUWE KOOIJMANS 1974, p. 95). A cross-section of this stream ridge can be seen at boring H1114 in profile I (Fig.*6).
The clay beds that have been deposited from these gully systems belonging to the units cl 2 and cl 4 are generally weakly to moderately humic and non- or weakly, but at some places moderately, sandy (Figs.*6 and*7). Both beds have a nearly continuous distribution in the study area. At many places they show a vertical uniformity; according to ALLEN (1965, p. 150 f.) this is characteristic for flood-basin deposits.
Clearly, the fluviatile clastic beds cl 1 and cl 3 have been developed differently within the study area from beds cl 2 and cl 4. Cl 1 is a thin, discontinuous, usually sand-free, weakly to moderately humic clay bed. Cl 3 is less continuous and less sandy than beds cl 2 and cl 4. Cl 3 is generally moderately to strongly humic; the bed is at several places peaty or traceable as a clayey bed in the peat (see e.g. boring H2106, Fig.*8 and H1009, Fig.*6 respectively). This variation in thickness and facies is to a large extent connected with the facial variations in the underlying bed cl 2: above a stream ridge of cl 2, cl 3 is generally strongly peaty and thin, or absent (see especially profile I, borings H1009 and H1541). Where, in such a case, bed cl 3 has not been deposited, the under- and overlying peat beds (ol 2-3 and ol 3-4 respectively, see Fig. 5) are not separable, and are taken together as the peat complex ol 2-4.

Organic deposits

The organic beds (ol-) of the Westland Formation are developed in the Molenaarsgraaf study area mainly as peat, but partly also as gyttja. The beds ol b, ol 1-2, ol 2a-2b, and the basis of ol 2-3 and of ol 3-4, consist at many places of *Phragmites* peat, or at any rate peat with remains of *Phragmites* and other water- and marsh plants: the German *Schilf* (OVERBECK 1975, p. 88). The beds ol 2-3 (except base and top), ol 3-4 (except the base) and ol u are developed in most places as wood peat. Thus the deeper organic beds of the Westland Formation in the study area appear to consist mainly of *Phragmites* peat, the higher ones mainly of wood peat. A similar bipartition was found by VERBRAECK (1970, p. 75) in the eastern part of the perimarine fluviatile coastal plain.
The lowermost organic beds (ol b, ol 1-2, ol 2a-2b) have been developed occasionally as gyttja (see e.g. profile I, Fig.*6). Important gyttja occurrences have been found in the upper part of organic bed ol 2-3, at the base of the generally strongly humic or peaty clay bed cl 3. It concerns an organic sediment, which can be named, on the basis of field characteristics, as *Feindetritus-gyttja* (fine detritus gyttja), partly also as *Grobdetritus-gyttja* (coarse detritus gyttja), in the terminology summarized by GROSSE BRAUCKMANN (1961) from the older Swedish and German literature (especially

from the works of VON POST and of LUNDQVIST). The material is light- to brownish green, somewhat elastic, and consisting mainly of fine-grained structureless organic material. It contains varying quantities of clay, is mostly somewhat calcareous, and contains shell remains of freshwater snails (*Lymnea*, *Planorbis*, opercula of *Bythinia*). A useful field characteristic is also provided by very tiny, shiny cleavage planes. In general, only very small quantities of coarse plant remains are present in this gyttja. Where there are larger quantities, the sediment may be regarded as the above-mentioned *Grobdetritus-gyttja;* in such cases the transition (lateral or vertical) to peat is gradual.
Detritus gyttja is regarded as a deposit of all sorts of decayed vegetable and animal material on a lake-bottom. Fine detritus gyttja is mainly formed in the deeper, quiet parts of a lake, coarse detritus gyttja in the shallower, less quiet parts (OVERBECK 1975, p. 87). WIGGERS (1955, p. 66 f.) describes detritus gyttja beds in the subsoil of the IJsselmeer area and has evidence that the deposit there consists partly of the remains of eroded, older peat beds ('peat-detritus'). PONS & VAN OOSTEN (1974, p. 21) ascribe a similar genesis to the organic deposits at the bottom of the recent lakes in the peat areas of the province of Noord-Holland. We think that this component of detrital peat is virtually absent in the gyttja of our study area (see further in Chs. III and V).

IIb LITHOSTRATIGRAPHY OF THE LEERDAM STUDY AREA

IIb.1 *General comparison with the lithostratigraphy of the Molenaarsgraaf study area*

The outline of the lithostratigraphy of the Leerdam study area is in its main characteristics similar to that of the Molenaarsgraaf area (compare Figs. 11 and 5). The Kreftenheye Formation is represented by the same components, namely the 'basal sand', the *loam*, and the river-dune sand. The Westland Formation is here also subdivided into clastic fluviatile beds and organic beds. To prevent confusion, the units of the Westland Formation have been coded for the Leerdam area in a different way from those of the Molenaarsgraaf area. Instead of numbering of the beds, the adjectives lower (l), intermediate (i) and upper (u) have been used here. Since all organic beds are developed almost exclusively as peat, the code p (peat) is used instead of o (organic). The main units of the Westland Formation are lcp, ip, uc and up. The unit lcp (lower clastic and peat beds) is a complex of clay beds with irregularly intercalated peaty beds and a broad sandy channel fill. This mainly clastic unit is nearly everywhere separated by a peat bed ip (intermediate peat bed) from the overlying clastic unit uc (upper clastic bed). As is the case with the peat bed ol u in the Molenaarsgraaf area, here too the sequence of clastic and organic beds is closed towards the top by the peat bed up (upper peat). Also, above it there is a usually thin clay cover, comparable to the 'Alblasserwaard cover' at Molenaarsgraaf.
The lithological variation within both formations (Kreftenheye Formation and Westland Formation) is about the same as in the Molenaarsgraaf area. An important difference is however that in the Leerdam area the peat beds are generally more amorphous (i.e., contain less macroscopically recognizable plant remains) and the clay beds have at several places a somewhat tougher consistency than at Molenaarsgraaf.
In the selected profile (profile IV, Fig.*10), all lithostratigraphic units from the scheme in Fig. 11 are represented. The position of the profile (see Fig. 4) can be traced back easily on sheet 38 Oost of the Geological map of the Netherlands, scale 1:50000 (VERBRAECK 1970), on the basis of the most conspicuous elements (stream ridges and river dunes).The northern end of the profile is situated on the stream ridge with code E0g, c. 1 km W of the village Schoonrewoerd; the southern end of the profile is situated on the stream ridge with code A1k, c. 1.5 km N of Leerdam.

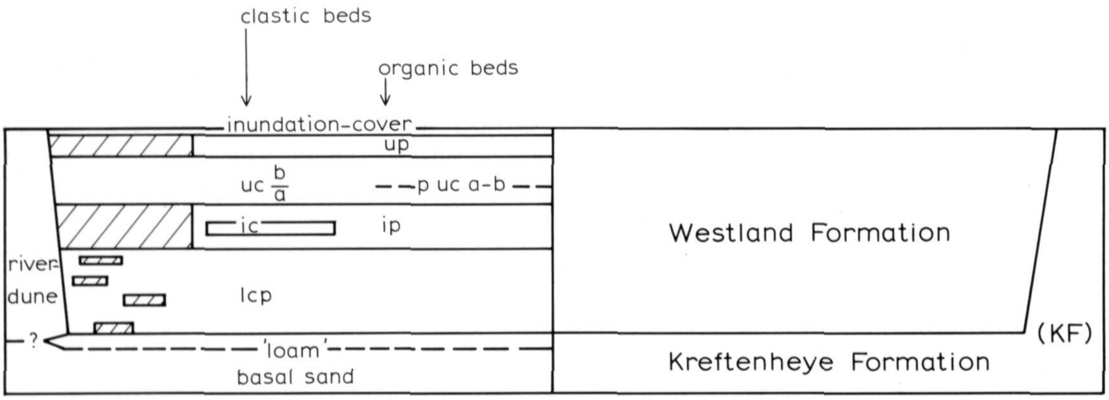

Fig. 11. Scheme of the lithostratigraphy in the Leerdam study area.

IIb.2 The Kreftenheye Formation

The surface of the Kreftenheye Formation has, as at Molenaarsgraaf, a considerable relief, particularly where the river dune is concerned (the Schaikse donk, see Ch. Ib; the place of outcrop of this dune lies outside the profile of Fig.*10, see the location in Fig. 4). The relief of the river dune (see the southern part of the profile, Fig.*10) compares well with that of the western river dune complex in the Molenaarsgraaf study area (see profile III, Fig.*8). At the foot of the dune (at borings S341 and S342 in the profile) the dune sand lies on top of the *loam*. The depth of the top of the *loam* varies in the profile with a magnitude comparable to that in e.g. the northern part of profile I of the Molenaarsgraaf area (see Fig.*6). The depth amounts on an average to c. 6 m below N.A.P., which is more than 4 m higher than in the Molenaarsgraaf area 20 km downstream.
A depression in the top of the Kreftenheye Formation (boring S322, in the northern end of the profile, Fig.*10) descends to c. 10.25 m below N.A.P. Part of this depression is filled with dune sand. Also in the southern end of the profile, dune sand seems to fill a depression in the *loam*-top of the Kreftenheye Formation.

IIb.3 The Westland Formation

Lower deposits

The lowermost lithostratigraphic unit of the Westland Formation in the Leerdam study area, the 'lower clastic and peat beds' (lcp), has not been lithologically subdivided in the profile (Fig.*10), except where the bed is developed as sandy clay or sand. The lithological variation, namely the alternating bedding of clay and peat, is too great to indicate in this schematic profile. With some difficulty four clay beds can be distinguished within the complex lcp, which, as a whole, is mainly clastic. The base of the unit lcp is at the same time the base of the whole Westland Formation. Contrary to the situation in the Molenaarsgraaf area, this base consists in the Leerdam area generally not of peat or gyttja, but of clay, well distinguishable in texture and structure from the underlying *loam*. So the proper basal peat, as usually met with in the coastal areas of the Netherlands (JELGERSMA 1961), is lacking here. Where the basal peat is present though, it is often clayey (see e.g. the northern part of profile IV, Fig.*10). VERBRAECK (1970, p. 62) associates the lack of the basal peat in this region to depositional activity of a river situated in the South of the region.

The variation in thickness of unit lcp is firstly connected with the relief of the top of the Kreftenheye Formation (compare e.g. boring S364 with boring S322 in the profile, Fig. *10). Secondly, the unit has of course a considerable thickness where, in the middle part of the profile, it is developed as a stream ridge (channel fill). This stream ridge is one of the most conspicuous fossil phenomena of the area; the profile shows a cross-section from boring S355 up to S361, over a distance of c. 500 m. Under the profile-type code A3k, this stream ridge, the Middelkoop stream (VERBRAECK 1970, p.84), occupies an important place on the before-mentioned geological map 38 Oost. The (completely buried) stream ridge has a strongly sinuous course on this map, and branches off towards the West.

The sandy nature of unit lcp, where it rests on the buried river dune in the middle part of the profile (Fig.*10), should not be connected to distinct channel deposition, but can be explained by slight erosion of the underlying dune sand.

Unit lcp of the Leerdam area can lithostratigraphically be correlated with the layer-sequence ol b + cl 1 + ol 1-2 + cl 2 in the Molenaarsgraaf area (see also Fig. 5). It goes without saying that the base of both bed complexes is correlative - in both areas it involves the boundary between the Kreftenheye Formation and the Westland Formation. The upper boundary of lithostratigraphic unit cl 2 in the Molenaarsgraaf area is, via profiles D and E belonging to the geological map 38 Oost and the map itself (VERBRAECK 1970), well traceable to the top of the bed in which the westward branching Middelkoop stream ridge is situated. This means that also the top of both bed complexes is lithostratigraphically correlative.

Upper and intermediate deposits

Of the two main clastic fluviatile beds in the Westland Formation of the Leerdam area, the above-discussed unit lcp forms the lower one, the unit uc (upper clastic bed, see Fig. 11) the upper one.

Profile IV (Fig.*10) is, also with regard to the stream ridges belonging to this bed uc, perpendicular to the stream direction. The bed's facies and thickness change rapidly with distance from the stream ridges: the clay bed is thinner and peatier further from the stream ridge. The bed is subdivided into uc a and uc b by an intercalated peaty horizon (bed) p uc a-b (see Fig. 11). This horizon is locally only weakly peaty and remarkably black; on these places, it may perhaps be compared to the so-called *lak* (lacquer) layers, as described by DE BOER & PONS (1960, p. 60) and DE BAKKER & EDELMAN-VLAM (1976, p. 123).

The stream ridge at the northern end of profile IV (at boring S320), with its relatively strong topographic expression, is known as the Schoonrewoerd stream ridge, the smaller one at the southern end of the profile as the Schaik stream ridge (DE BOER & PONS 1960, p. 25; VERBRAECK 1970, p. 85; LOUWE KOOIJMANS 1974; to VINK (1954) the Schoonrewoerd stream ridge was known as the 'Overlek stream'; the names derive from small villages located in the study area). Both stream ridges belong lithostratigraphically to unit uc. As previously mentioned (Ch. Ib), the Schoonrewoerd stream ridge forms the topographically visible link between the Leerdam and the Molenaarsgraaf study areas (cf. Figs. 3 and 4; see also LOUWE KOOIJMANS 1974, fig. 18). In the Molenaarsgraaf area, this stream ridge forms part of clastic bed cl 4. Due to this, unit uc of the Leerdam area is lithostratigraphically correlative with unit cl 4 of the Molenaarsgraaf area.

For this region VERBRAECK (1970, p. 85) indicates that the Schoonrewoerd stream has incised into the Kreftenheye Formation but the Schaik stream has not. In profile IV these data have been processed.

As in the Molenaarsgraaf area, in the Leerdam area the top of bed cl 4-bed uc has been covered by the Upper Peat (coded as 'up' here). In contrast to the Molenaarsgraaf area, here the peat bed (wood peat) is in several places clayey. Along the southern border of the Schoonrewoerd stream ridge it is even absent, so that bed uc passes directly into the superficial clay bed ('cover'). At a few places an iron-stained level can be seen separating the two.

Table 2. Correlation of the lithostratigraphies of the Molenaarsgraaf and the Leerdam study areas. Compare with Figs. 5 and 11.

	Molenaarsgraaf study area	Leerdam study area	
WESTLAND FORMATION	clay cover organic bed ol u clastic bed cl 4	clay cover organic bed up clastic bed uc	upper part
	organic bed ol 3-4 clastic bed cl 3 organic bed ol 2-3	organic bed ip (with intercalated clastic bed ic)	intermediate part
	clastic bed cl 2 organic bed ol 1-2 clastic bed cl 1 organic bed ol b	bed complex lcp	lower part
KREFTENHEYE FORMATION	'loam' basal sand	'loam' basal sand	

By the lithostratigraphical correlations between the Leerdam and the Molenaarsgraaf study areas indicated above (namely the correlation of the top of lcp with the top of cl 2 and the correlation of uc with cl 4), peat bed ip (intermediate peat) of the Leerdam area can be correlated with the organic bed complex ol 2-4 of the Molenaarsgraaf area (compare the schemes in Figs. 5 and 11).
In peat bed ip a thin clay bed locally occurs, the intermediate clastic bed ic, as can be seen in the profile (Fig.*10). It seems plausible to conclude from a comparison of both lithostratigraphic schemes (Figs. 5 and 11) that this clay bed ic in the Leerdam area is correlative with clay bed cl 3 in the Molenaarsgraaf area.

The above correlations of the lithostratigraphies of both study areas have been summarized in Table 2. By this correlation of the lithostratigraphy of the Molenaarsgraaf area with that of the Leerdam study area 20 km away, the latter has made the former in a sense clearer. For the tripartition in the lithostratigraphy of Leerdam can be translated to that of Molenaarsgraaf: the lower and upper parts of the Westland Formation at Molenaarsgraaf are strongly clastic units (leaving the Upper Peat out of consideration here) and, as at Leerdam, they contrast with the strongly organic intermediate part. This gross subdivision is encountered also in the biostratigraphy and the paleoenvironmental evolution (Chs. III and V).