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BURIED CHANNEL AQUIFERS AND PRESENT OPEN DRAINAGE SYSTEM OF EAST GELDERLAND, THE NETHERLANDS

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ABSTRACT

In the eastern part of the province of Gelderland, two buried valley systems have been traced. One system is filled with fluvioglacial deposits dating from the Saalian Ice Age, the other with preglacial fluvial sediments which are remarkable rich in vulcanic minerals.

Both systems have a course which is almost perpendicular to the present drainage system. This change in stream direction is explained by postglacial replacement of the main drainage channel in the area, tectonic movement perpendicular to the old channels, and postglacial filling of the old channels with wind blown sand.

INTRODUCTION

In the eastern part of Gelderland Pleistocene buried valleys occur. The presence of an old buried channel system near Winterwijk and Aalten was mentioned by F a b e r (1960) and is shown in fig. 1. From the results of more recent investigations by W a l t e r (1965), C s o n k a (1965), R o m e i n (1967) and d e R i d d e r (1966) the course and depth of the valley system have been traced.

Another buried valley system was traced west of the former (d e R i d d e r, 1966; and E r n s t, d e R i d d e r and d e V r i e s, 1970). The channels of this system are filled with very coarse sand. The heavy mineral content of these channel deposits differs significantly from the composition of the formations that were known to occur in this region.

The buried channel aquifers are of great importance for the water supply of municipalities and industries.

The age and course of these old valley systems in relation to the geomorphologic developments of the area is discussed in this paper.

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GENERAL GEOLOGY OF THE AREA

From a geological point of view, two different areas may be distinguished in Eastern Gelderland: the East Netherlands plateau and the Pleistocene basin (see fig. 2).

The East Netherlands plateau extends from the German frontier to the line Groenlo-Aalten. Here thick layers of marine clays and clayey sands of mainly Oligocene and Miocene age are found at the land surface or at shallow depth. At many places these Tertiary deposits are covered by a thin layer of wind-blown sands. Locally, however, coarse, gravel-bearing layers of fluvial Middle-Pleistocene (Sterksel/Enschede Formation) and fluvioglacial origin, as well as boulder clay (Drente Formation), occur.

In westerly direction the Tertiary deposits dip rather abruptly under the Pleistocene basin. The transition from the plateau to the Pleistocene basin is marked by a terrace escarpment along the line Groenlo-Aalten which at several places reaches an elevation of several meters.

The Pleistocene basin is filled with predominantly

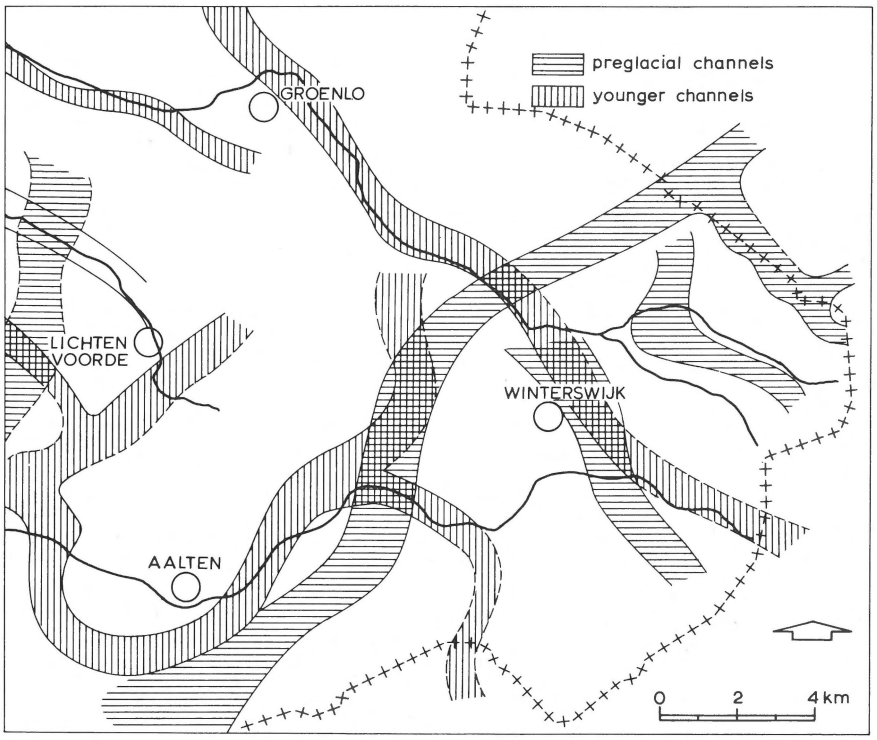

Fig. 1 Preglacial and younger buried channels in East Gelderland (after Faber, 1960).

gravel-bearing coarse sands of fluvial and fluvioglacial origin, alternated by locally occurring boulder clay, fine sands and clayey deposits of the Eemian (Saale-Weichsel Interglacial). The youngest of these layers belong the the Kreftenheye Formation, the fluvio-glacial and boulder clay are indicative of the Drente Formation; their total thickness is from 20 to 40 meters. Windblown sands of the Twente Formation (Weichselian) cover these coarse sediments and vary in thickness from 0 to 10 meters.

BURIED CHANNELS OF THE EAST-NETHERLANDS PLATEAU

Buried channels are found carved in the Tertiary deposits of the plateau as well as in the Tertiary deposits underlying the coarse sediments of the Pleistocene basin. The valley system of the plateau runs from the north and northeast towards Dinxperlo in the south (fig. 2) and agrees with the direction of the preglacial valleys given on Faber's map (fig. 1). The younger systems given on Faber's map seem to be more shallow and less pronounced and could hardly be traced. Near Dinxperlo where the older system passes the German frontier, it reaches a depth of more than 100 meters below land surface or more than 70 m below sea level. In northeasterly direction the channel becomes less deep and near the river Berkel the bottom comes very near to the land surface. This deeply eroded valley has been gradually filled with coarse and gravel-bearing fluvio-glacial deposits, as shown in the geological section north of Bredevoort (fig. 3, section A-A').

Most likely this former drainage system was a tributary of the preglacial or glacial Rhine which was deeply incised as a result of the drop of the sea level with the advancing land ice during the Saalian. Underlying the present valley of the river IJssel (running, some 10 to 15 km west of the region discussed), relics of this Saalian Rhine have been found to a depth of more than 70 meters below sea level. Probably this deeply carved Rhine valley extended south-eastward meeting the present Rhine valley near Wesel in Germany (T h o m é, 1954).

The old valley system seems to have developed along the boundaries of the geological formations which were apparently the zones of least resistance in

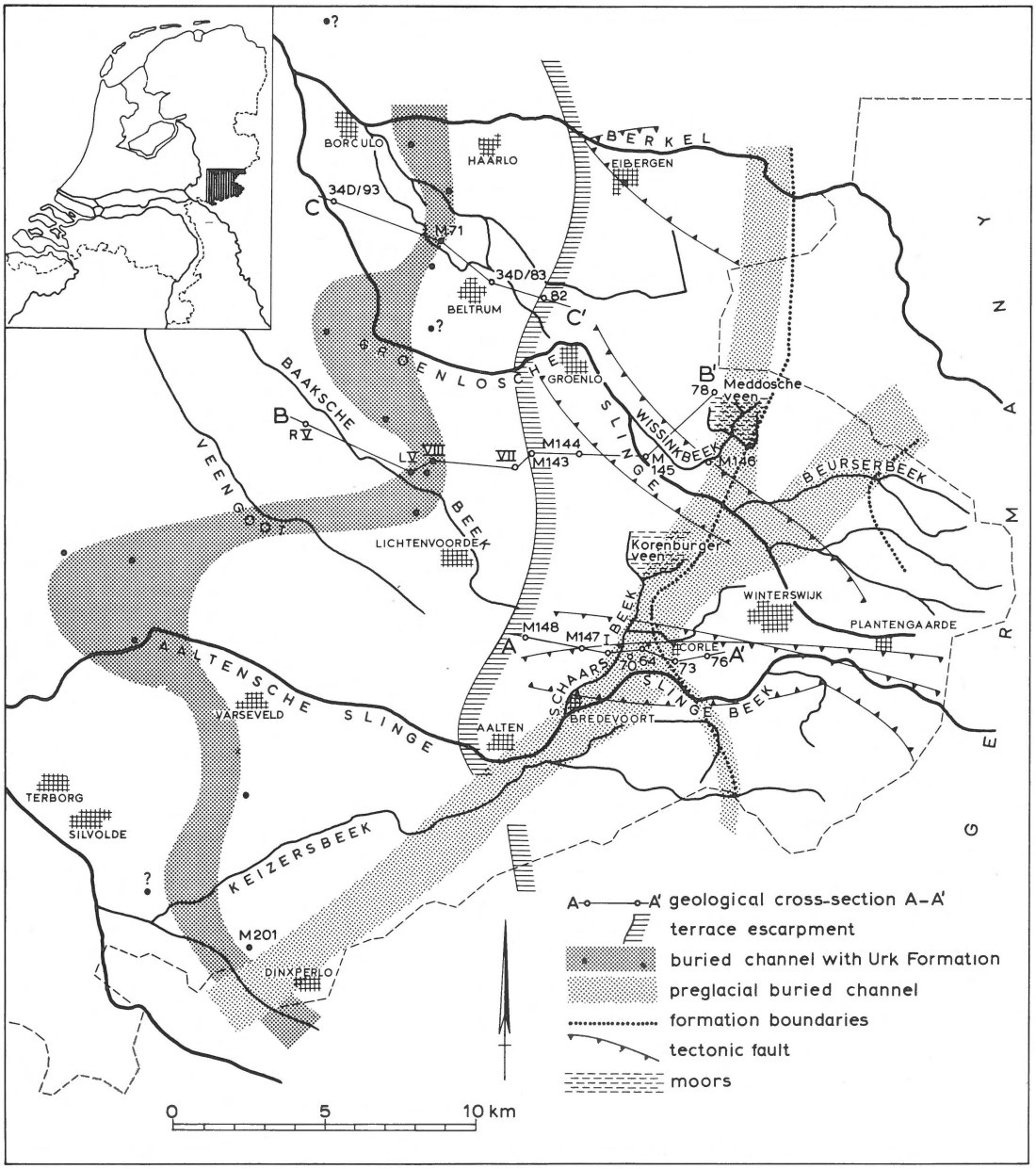

Fig. 2 Map showing the buried channels, the present river courses, the terrace escarpment, and the tectonic faults.

the area (fig. 2). In the adjacent area of Germany, comparable buried channels were found in the valleys of the Bocholter Aa, the Lippe and the Stever (B o l s e n k ö t t e r and H i l d e n, 1969).

BURIED CHANNELS WEST OF THE EAST NETHERLANDS PLATEAU

West of the present terrace escarpment investigations of d e R i d d e r (1966) revealed a buried valley system of the preglacial Rhine. This system consists of deep channels in the underlying Tertiary deposits to a depth of more than 70 meters below sea level or more than 80 meters beneath the land surface. Although these channels are also filled with gravel-bearing and very coarse sands, the deposits differ mineralogically from the material found in the channels on the Tertiary plateau.

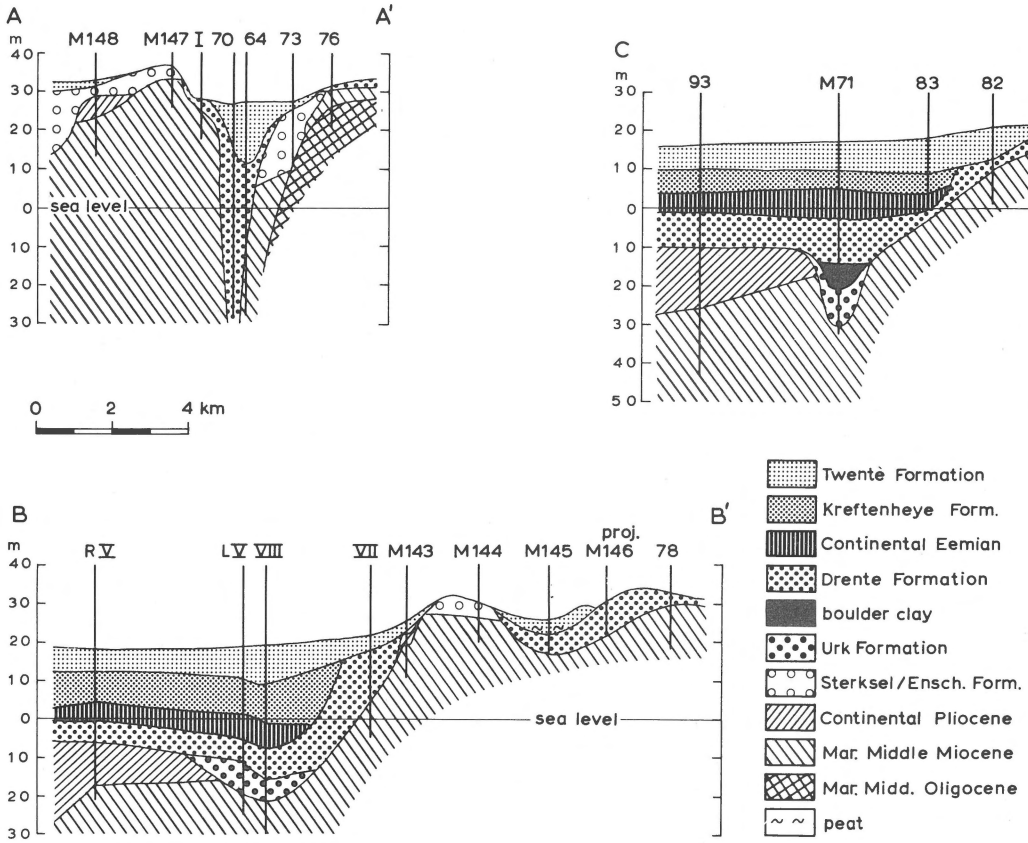

Fig. 3 Geologic cross-sections A-A′, B-B′, C-C′.

The first indications of this buried valley system were obtained from some borings near the villages of Haarlo and Beltrum (fig. 2). Here very coarse gravel-bearing sands, with a very high content of volcanic heavy minerals (sometimes 80% to 90% augite), are directly overlying the Miocene deposits or occur in narrow channels incised into these deposits. These augite bearing sands, varying in thickness from 1 to 10 meters, are overlain by fluvioglacial deposits of the Drente Fromation of which the augite content is considerably lower. These augite sands were later also found in some borings near Lichtenvoorde and near Dinxperlo (fig. 4). It is remarkable that the augite-rich deposits seem to occur in a narrow zone only, extending from Dinxperlo in the south via Varsseveld and Lichtenvoorde to Haarlo in the north.

Elsewhere in the Netherlands, for instance in the Northeastpolder (in the former Zuiderzee), augite-bearing sands have been found in the subsurface by W i g g e r s (1955). These sands are overlain by clayey deposits of the Holstein Interglacial and belong to the Urk Formation.

Other deposits of the Rhine with high contents of augite have been found at various sites in the west and north of the Netherlands (Z o n n e v e l d, 1958). These sediments probably belong to the Vianen Formation which was deposited during the Holstein Interglacial and the early Saalian Ice Age (see fig. 5). Investigations of T e r W e e (1966) have made clear that a division of the various augite-bearing deposits is not yet possible, so for the time being we will regard the augite-rich deposits, as belonging to the Urk Formation.

In East Gelderland clayey deposits overlying the augite sands are only found in one boring (M 71 near Beltrum, fig. 3, section C-C′ and fig. 4). Here several meters of boulder clay (Z a g w i j n, 1961) overly the augite-bearing layers filling a narrow channel, cut into the underlying marine Miocene.

From the obtained evidence it can be taken that this valley system was filled before the deposition of the Saalien fluvioglacial material. So the deposits in

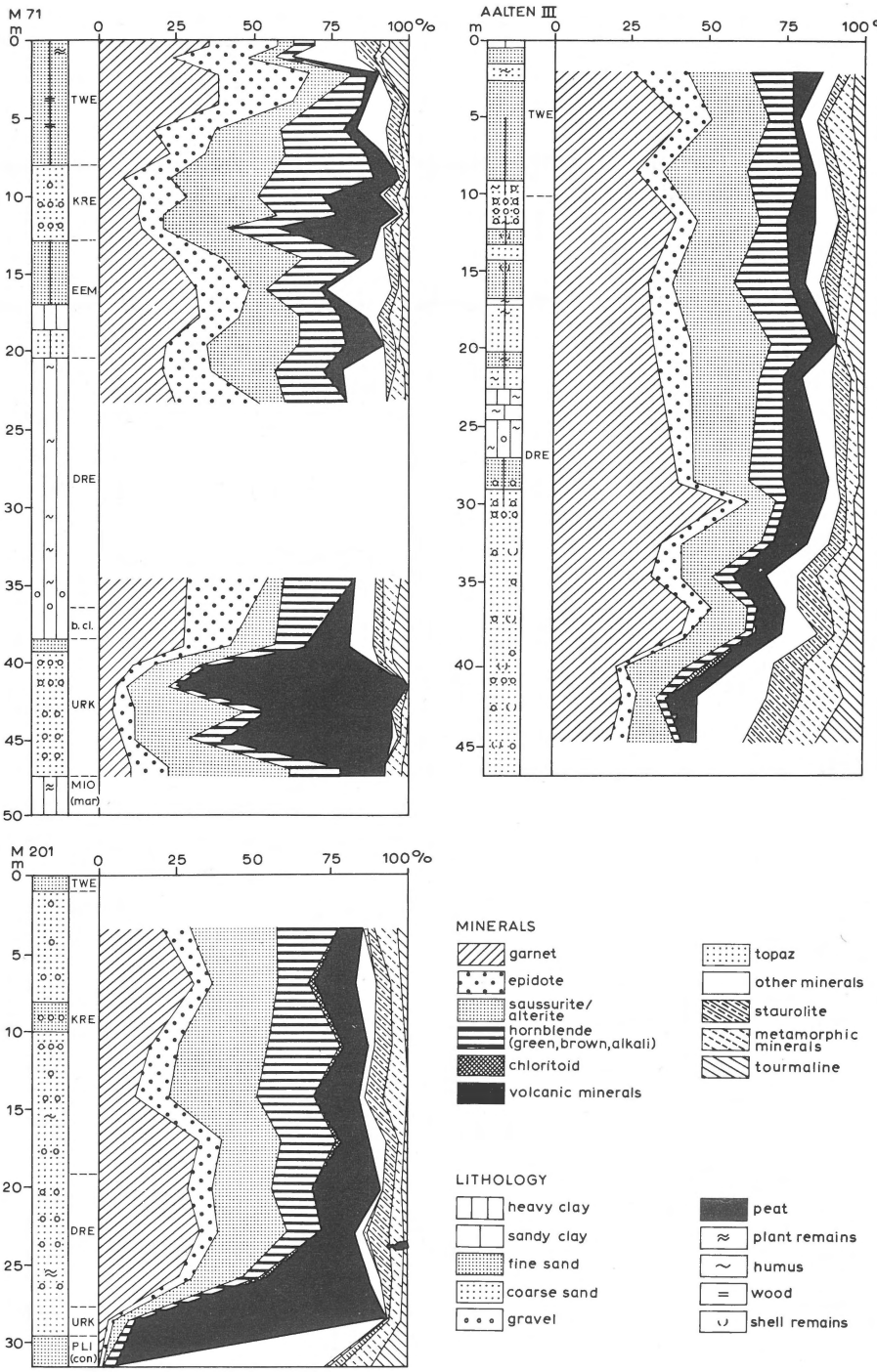

Fig. 4
Heavy mineral analysis of the borings M 71, M 201, Aalten III. For location see fig. 2 (for M 71, also fig. 3 section C-C′).
TWE: Twente Formation; KRE: Kreftenheye Formation; DRE: Drente Formation; URK: Urk Formation; CON PLI: Continental Pliocene; MAR MIO: Marine Miocene.

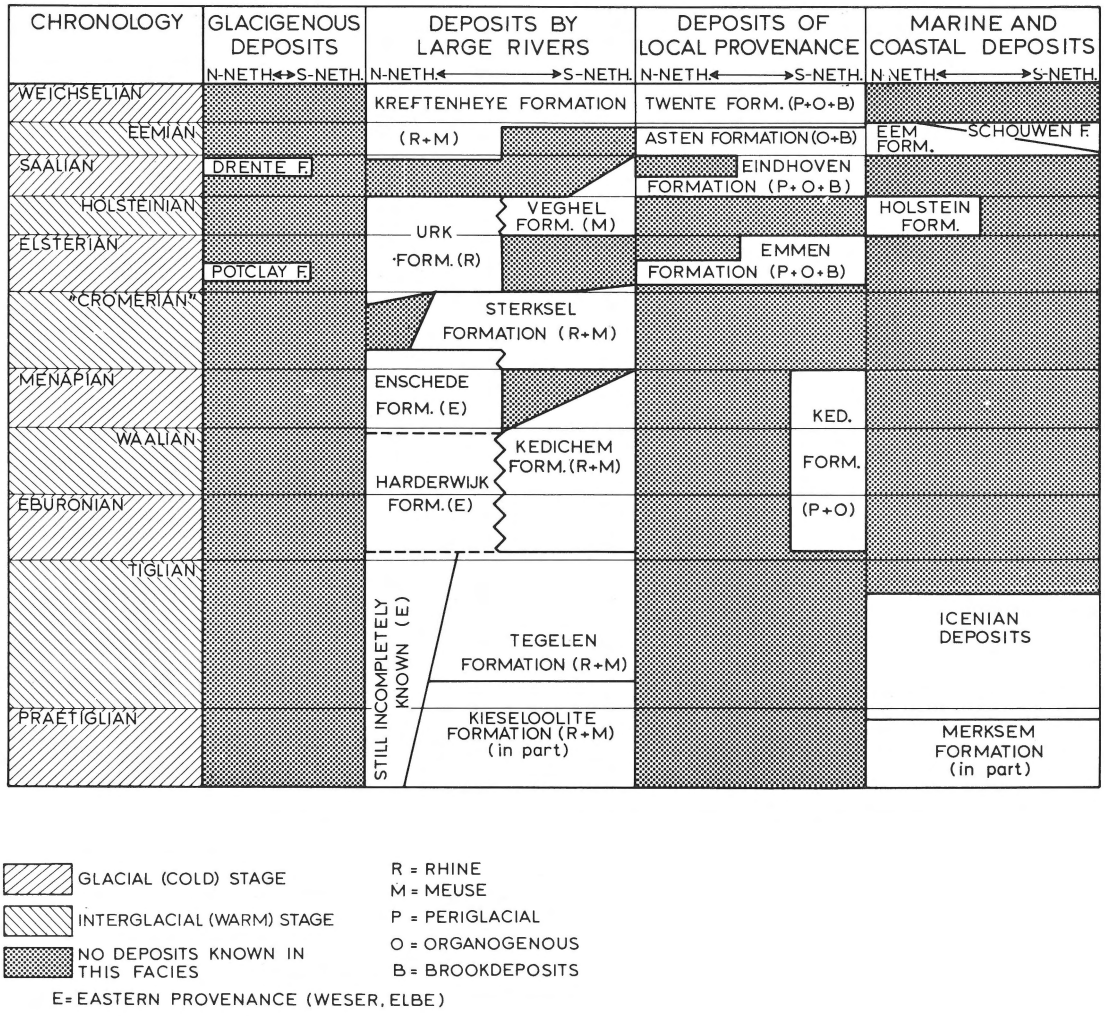

Fig. 5 Stratigraphic division after Zagwijn, 1967.

the fill are older than those found in the valley system on the East Netherlands plateau which have a melt water origin. An early Saalien age of these deposits is therefore likely.

THE OLD AND PRESENT STREAM SYSTEMS

After the Saalian Glacial the preglacial valley system west of the terrace escarpment was overlain by fluvioglacial deposits (Drente Formation), partly by Eemian sediments and by layers of fluvial origin (Kreftenheye Formation). The Drente and Kreftenheye Formations consist of coarse sands, the latter deposited by braided rivers. Therefore the present stream system need not have any relation to the old valley system; being tributaries of the river IJssel they are running almost perpendicular to the old valley system.

On the East Netherlands plateau the course of the buried valley system is traceable as depressions in the present land surface and the channels of this system still be considered as a natural subsurface drainage system. It is remarkable, however, that the main streams (Slingebeek, Groenlosche Slinge and Berkel) are almost perpendicular to the old channel system. This difference in stream direction may be explained by the following processes.

A. Tectonic movements

The geological structure of the East Netherlands plateau is governed by the high elevation of the Trias. South of Winterswijk several Cretaceous and Jurassic blocks are thrusted against these formations and crop out (fault of Plantengaarde). Aside from the complicated situation south and southeast of Winterswijk, the graben of Corle, Groenlo and Eibergen are the main tectonic structures on this plateau (fig. 2). These graben are characterised by the presence of Cretaceous and Jurassic rock below the Tertiary deposits while in the horsts in between them, the Tertiary deposits are directly underlain by Trias (Harsveldt, 1963).

Comparing the present drainage system with the tectonic structure, it can be seen that these features are partly related: the Slingebeek, the Groenlosche Slinge and the Berkel are flowing in the tectonic graben (fig. 2).

An example of a more recent change in stream direction by tectonic influence is present southeast of Winterswijk. Here, as mentioned by F a b e r (1948) the Slingebeek has captured part of the Groenlosche Slinge. It is noteworthy that this event may be associated with the location of the Plantengaarde fault.

The Schaarsbeek, the Wissinkbeek and the Beurserbeek can be considered as the relics of the former drainage system of glacial channels captured by the Groenlosche Slinge (fig. 2). A cross section of the valley of the Groenlosche Slinge (see fig. 3 section B-B′) shows how a rather shallow depression is filled with fluvioglacial deposits. Possibly an incision was already present at the end of the Saalian glaciation, made by a tributary of the river scouring the deep preglacial channel indicated on the map.

b. Shift of the Rhine Valley

The preglacial Rhine running from southeast to northwest flowed approximately perpendicular to the Pleistocene valley system. At the retreating of the land ice the Rhine shifted its main course to an area south of the ice-pushed hills of Montferland (some 15 km west of Dinxperlo) to a region where it now flows. An important branch, however, flowed to the western part of East Gelderland and deposited the coarse sands of the Kreftenheye Formation (P o n s, 1957). The downstream part of the river Oude IJssel can be considered as a relic of this former stream system.

At the end of the Weichselian glaciation the Rhine abandoned this branch. Later on the present river IJssel running southwest to northeast some 10 to 20 km east of the area considered became a branch of the Rhine. The present drainage system of East Gelderland then became tributary to the river IJssel. This would explain the southeast to northwest direction of the present streams in the western part of East Gelderland. They probably captured the drainage system on the Tertiary plateau by headward migrating erosion, a drainage system which probably already had a southwest to northwest course determined by the tectonic structure of that region.

In the adjacent German area present streams are still tributaries to the rivers Rhine and Oude IJssel, and also follow old drainage system (B o l s e n k ö t t e r and H i l d e n, 1969).

c. The deposition of wind-blown sands

Towards the end of the Weichselian glaciation and after the deposition of the Kreftenheye Formation, the wind was the principal depositing agent. In the western Pleistocene basin the fluvial coarse sands were overlain by a thick layer of fine wind-blown sands, the Twente Formation. On the East Netherlands plateau, however, only in the old channels and other depressions some meters of this material was laid down. Considering the depth of the valleys before they were filled with wind-blown sands, they must have been acting as drainage courses. The filling of these valleys with eolian deposits may have initiated the change in stream direction. The development of peat in some of the old valleys (Korenburger Veen and Meddosche Veen, see fig. 2) is an indication of a stagnating drainage.

SUMMARY AND CONCLUSIONS

Relics of buried channels occur in many places in the eastern part of the province of Gelderland. On the East Netherlands plateau the depth of one buried channel is locally at least 100 meters and its course if from the north and northeast towards the southwest. In the Pleistocene basin the depth of one buried channel is at least 80 meters and its course runs from south to north.

The former valley system have been filled with fluvioglacial deposits and seem to have developed along the boundaries of the geological formations. The filling of the system in the Pleistocene basin consists of fluvial coarse and gravel-bearing sands wich are very rich in volcanic minerals.

Both buried channel systems have a course which is almost perpendicular to the present drainage system. For the valley system of the Pleistocene basin the cause of the change in stream direction has been the postglacial replacement of the glacial river Rhine by the present IJssel as the main drainage channel of the area. On the East Netherlands plateau the change in stream direction is most probably the result of tectonic movements, capture of the older system by the tributaries of the river IJssel and the filling of the old channels by wind-blown sands.

REFERENCES

Bolsenkötter, H. and H.D. Hilden (1969) – Ein Beitrag zur Talgeschichte der Stever und der Unteren Lippe. Forthr. Geol. Rheinld. u. Westf. 17, 47-54.

Csonka, J. (1967) – Rapport inzake geo-elektrisch onderzoek in de Gelderse Achterhoek oostelijk van de lijn Ulft – Zelhem – Ruurlo – Lochem. Werkgroep Geo-elektrisch Onderzoek TNO. Rapp. XXXVI, 53 p. and 27 append.

Ernst, L.F., N.A. de Ridder and J.J. de Vries (1970) – Geohydrologic study of East Gelderland (Netherlands). Geol. en Mijnbouw 48, p. 457-488.

Faber, F.J. (1948) – Geologie van Nederland I, Algemene Geologie, 3rd edition, Gorinchem.
(1960) – Geologie van Nederland IV, Aanvullende Hoofdstukken, Gorinchem.

Harsveldt, H.M. (1963) – Older conceptions and present view regarding the Mesosoic of the Achterhoek, with special mention of the Triassic limestones. Verh. Kon. Nederl. Geol. Mijnbouwk. Genootsch., Geol. Serie 21, 2, p. 109-130.

Heide, S. van der and W.H. Zagwijn (1967) – Stratigraphical Nomenclature of Quaternary deposits in The Netherlands. Meded. Geol. Stichting. N. Ser. 18, p. 23-29.

Pons, L.J. (1957) – De geologie, de bodemvorming en de waterstaatkundige ontwikkeling van het Land van Maas en Waal en een gedeelte van het Rijk van Nijmegen. Thesis Wageningen, 156 p.

Ridder, N.A. de (1966a) – De geohydrologische gesteldheid van de Gelderse Achterhoek (interim rapport). Inst. Land and Water Manag. Res. Nota 344.
(1966b) – Hydrogeologie van het stroomgebied van de Leerinkbeek. Inst. Land and Water Manag. Res. Nota 337, 22 p.

Romein, B.J. (1967) – Stratigrafische interpretatie van enige Mesozoische kernmonsters van Proefboring T van de R.O.V.D. Rapp. 9, Micropal. Lab. afd. Mesozoicum, Geol. Dienst, 3 p.

Thome, K.N. (1959) – Eisvorstoss und Flussregime an Niederrhein und Zuiderzee im Jung-pleistozän. Pliozän und Pleistozän am Mittel- und Niederrhein. Geol. Landesamt Nordrhein-Westfalen, Band 4, p. 197-247.

Walter, F. (1965) – Rapport inzake een geo-elektrisch onderzoek in de omgeving van Ruurlo, Lichtenvoorde en Aalten in de Gelderse Achterhoek. Werkgroep Geo-elektrisch Onderzoek TNO, 25 p.

Wee, M.W. ter (1966) – Toelichting op de Geologische kaart van Nederland. Blad Steenwijk Oost (16 0), Geol Stichting, afd. Geol. Dienst, Haarlem.

Wiggers, A.J. (1955) – De wording van het Noordoostpoldergebied. Thesis Amsterdam, 216 p.

Zagwijn, W.H. (1961) – Pollenanalytisch onderzoek van boringen bij Eibergen. Rapp. 296, Palaeobot. Lab., Geol. Dienst.

Zonneveld, J.I.S. (1958) – Litho-stratigrafische eenheden in het Nederlandse Pleistoceen. Meded. Geol. Stichting. N. Ser. 12, p. 31-64.