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THE GEOPHYSICAL LOG CORRELATIONS IN THE IEPER CLAY SECTIONS IN BELGIUM

by

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(with 1 figure and 8 plates under separate cover)

ABSTRACT

Rhythmic sedimentation during the Ypresian in West, Central and North Belgium could be established on the resistivity and natural radioactivity logs in about 60 boreholes. These rhythms are used for correlating the sections.

Key words: Tertiary, Ieper clay, geophysical logs, correlation, stratigraphy.

SAMENVATTING

Op basis van resistiviteitsmetingen en natuurlijke radioaktiviteitsmetingen in een zestigtal boorgaten in West, Centraal en Noord-België konden ritmen van verschillende grootte orden vastgesteld worden in de kleisedimentatie tijdens het Ieperiaan. Deze ritmen werden gebruikt voor de correlatie van de verschillende secties.

Sleutelwoorden: Tertiair, Klei van Ieper, geofysisch boorgatmetingen, korrelatie, stratigrafie.

RESUME

Des rythmes sédimentaires ont été établis par diagraphies de résistivité et de radioactivité naturelle dans une soixantaine de sections d'argile yprésienne, localisées dans l'Ouest, le Centre et le Nord de la Belgique. Les différentes sections ont été correlées sur base de ses rythmes.

Mots-clés: Tertiaire, l'Argile d'Ypres, diagraphie, corrélation, stratigraphie.

INTRODUCTION

An inspection of the natural radioctivity (GR) and resistivity (RES) borehole logs in about 60 wells distributed over west, central and north Belgium (fig. 1) showed systematic variations in the generally heavy Ieper clays. The natural radioactivity is expressed either in API units or in cps. The resistivity logs are mostly from short spaced normal resistivity tools (N) and in a few cases from induction (I) or spherically focussed logs (S). The logs could be correlated rather well in neighbouring wells whilst correlation in widely separated wells could become doubtfull. For the purpose of correlating the log sections, the wells are grouped in eight areas, for which the correlations are discussed. Probable correlation between areas is also discussed.

Existing biostratigraphical and lithostratigraphical data should be added to these log interpretation schemes in order to extract the full geological information contained in the logs. The present paper wants to create the frame for such further collective work.

A list of the wells, their Geological Survey number, and the plate number for the area in which they are grouped is given at the end of the paper.

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Plate 1: Antwerp Campine area.

Logs are available from the following wells: Meer, Heibaart, Brasschaat, Merksplas, Poederlee and Mol.

1. A major feature in the basal part of the Ieper Clay is a high GR response, together with a relatively normal to slightly higher RES value.
   This interval is about 15m thick. Its top is labeled level 1.
2. Above this basal unit a slightly negative graded bed, about 45m thick occurs.
   Its top is labeled level 2 and corresponds to a low GR reading being the sandy top of the negative rhythm.
   The unit between level 1 and 2 (unit 1-2) can be further subdivided based on GR-RES features common to several wells.
   An outspoken feature is the GR increase over about 5m at level 2.1, also reflected by a resistivity increase above level 2.1.
   Level 2.0 can be traced over at least some of the wells as a rather sharp GR maximum-RES minimum.
   Other detailed features might also be correlated such as the outspoken GR-low above level 1 (detail a) and the GR-increase just below level 2.
   It could be that these meters-order features are cycles superimposed on the tens of meter negative rhythm.
3. The next major rhythm is a steady increase of the GR reading, a positive fining upwards rhythm of about 30-40m thickness, till level 3.
   Apparently also this n x 10m rhythm (unit 2-3) is composed of several n x meter cycles; amongst the latter at least some are outspokenly asymmetrical with a slow fining upwards followed each time by a more rapid coarsening.
   Level 3 is put at the top of the last cycle and is followed by a rather constant and lower GR reading. Unit 2-3 can be further subdivided.
   Level 3.1 is located at the base of the uppermost small cycle, characterized by relatively high GR readings and a corresponding and characteristic RES low.
   Level 3.0 is only of local significance as it is not possible to correlate the different small cycles from one well to another and in particular not in the southern wells Poederlee-Mol. This difficulty is related to the thinning of unit 2-3.1 to the south.
4. Level 4 is characterized by a marked drop in GR reading and a corresponding rapid rise in RES reading.
   The striking similarity in the detailed variations of the RES curve between Heibaart-Merksplas-Brasschaat and even, but less clear, Poederlee suggests a stratigraphic value for the thin sand clay rhythms.
5. Above level 4, the Heibaart, Brasschaat, Merksplas and Meer wells can be well correlated. Apparently the new rhythm starts with a coarsening upwards sequence of about 10m thickness, followed by a pronounced GR increase, the top of which is labeled level 5.
   Above level 5 a new fining upwards rhythm starts.

Plate 2: East Brabant area.

The following wells are correlated: Onze-Lieve-Vrouw-Waver, Tildonk, Tremelo, Aarschot, Lubbeek and Meensel-Kiezegem.

1. Level 1, about 10 to 15m above the base of the formation, limits a lower high GR, high RES unit as in plate 1.
2. The top of the unit 1-2 negative rhythm can be located at the GR minimum in the Onze-Lieve-Vrouw-Waver well. The other wells have a much lower thickness of Ieper Clay. However this lower clay can be correlated well between the wells and with the lower part of the Onze-Lieve-Vrouw-Waver clay section. Indeed, level 2.1 corresponding to the top of a GR increase-RES low can be followed in all wells which have a sufficient thickness. The characteristic GR low just above level 1 (detail a) can be traced together with a characteristic GR increase just above it. Level 2.0, a sharp GR increase-RES low, is tentatively correlated between the wells.
3. The correlation of the Onze-Lieve-Vrouw-Waver well section above level 2 is achieved through a comparison particularly with the Poederlee and Brasschaat wells. The GR-RES response at the top of the unit 2-3 fining upwards sequence is characteristically similar. The interval 2-3.1 is very similar to the Poederlee section and level 3.0 can be traced.

Plate 3: West Brabant area.

The following wells are correlated: Nederbrakel, Roosdaal-Pamel, Ternat, Ukkel and Ninove.

1. On all wells level 1 can be traced, defining the lower high GR-high RES part. Above level one, on some logs, the characteristic GR-low is found. Level 2 can only be found on the Pamel-Roosdaal log, because the clay thickness is too low on the other logs.
2. Level 2.1 can be traced also on all logs, on top of a rather well defined GR-high.
   The RES-response below level 2.1 is over about 15m almost identical to the Lubbeek log (plate 2).

Plate 4: East coast area.

The following wells are correlated: Zandvoorde, De Haan, Knokke, Brugge and Gent.

1. The levels 1 and 2 can be correlated with the same levels in the wells of the other areas.
   Thickness of the basal unit is reduced to about 10m, whilst the RES readings are relatively lower along the coast.
   Level 2 limits the top of the first n x 10m negative rhythm.
   The increased GR at level 2.1 is also present beyond doubt, but not always clearly defined (e.g. Knokke).
   Besides, details on the resistivity logs apparently can also be correlated between logs (e.g. Zandvoorde, De Haan).
2. The most outspoken changes are as follows:
   - level 6: above which the GR reading drops and

a coarsening upwards rhythm starts which in the Knokke and Gent logs apparently gradually continues in the coarsening upwards cycle of the lower Panisel type sediments (Late Ypresian);

- level 4: characterized by a marked GR drop. At first glance level 4 could also be taken as the end of the second n x 10m, fining upwards, rhythm. However level 3 marks clearly the end of this rhythm in the Zandvoorde well and possibly the Knokke well. The GR between level 3 and 4 is rather constant.
  A fairly good correlation is possible at the level 2, 3, 4 interval between the Knokke well and the Heibaart well (plate 1).
  The resistivity logs of he Brugge and Knokke well confirm the GR based correlation.

3. The units 2-3 and 3-4.
   The fining upwards unit 2-3 is clearly made up by several n x meter scale rhythms, some of which are asymmetrical as observed on plate 1. Some can be correlated, some not.
   The level 3.1 has tentatively been put on all logs. It occurs in the top of the unit 2-3, a positive rhythm, namely at the base of the last cycle, displaying a characteristic RES curve.
   Our proposed correlation indicates that from the coastal area to the east the units between levels 2.1 and 4 are all present but gradually becoming thinner.
4. The units 4-5 and 5-6.
   The clay between level 4 and 6 can be subdivided on all logs based on RES variations. From bottom to top one finds two rhythms with upwards resistivity increase followed at the top by a rhythm of upwards decreasing resistivity. Based on a comparison with the Heibaart well level 5 of plate 1 is thought to correspond to the level 5 of this plate 4, positioned just above or slightly below the top of the second small rhythm.

Plate 5: West coast area.

The following wells have been correlated: Oostduinkerke, Steenkerke-Veurne, Leisele, Diksmuide BH6, Keiem BH3, Schore BH8, Zande BH5, Gistel BH7, Kortemark, Hooglede-Gits and Egem-Pittem.

1. The levels 1, 2.1 and 2 can easily be traced as defined in the plates 1, 2, 3, 4.
   Note that in unit 2-3 small details apparently can also be correlated, e.g. the RES reading in the lowermost meters in Oostduinkerke and Pittem, the resistivity curve in the interval 1 and 2.1 between Oostduinkerke and Zandvoorde, De Haan (plate 4).
2. Above level 2 three rhythms of about 10 to 20m thickness can be identified. The basal one is fining upwards ending in level 3.0. The second one is coarsening upwards ending in level 3.1 and the uppermost one is fining upwards again till level 4.
   Identification of the levels occurs through comparison of the GR logs of Oostduinkerke and Zandvoorde (plate 4) and Meer (plate 1) and using the 10-20m rhythms as clearly distinguishable on plate 5.
3. In the discussion of the former plates, one major fining upwards rhythm (unit 2-3) was identified and a rather stable GR-value unit 3-4 identified. In fact onto the 2-3 rhythm e.g. in plate 1, the three subrhythms discussed here can be found [e.g. Meer, Heibaart (plate 1)].
   Level 4 on plate 5 was identified by comparison of the Gent log (plate 4) and the Pittem log.
   Level 3 was identified at the base of the stable GR interval below level 4 and level 3.1 between the upper and middle subrythm, whilst level 3.0 corresponds to the limit between subrythm 1 and 2. These identifications are based on a comparison with plates 1 and 4.
   The Pittem log also shows a threefold division of the interval between level 4 and 6, as in plate 4. Level 5 in plate 4 was defined as the top of the second of these rhythms; this level was also labeled level 5 in plate 5.

Plate 6: South Flanders — area I.

The following wells are correlated: West-Outer, Nieuwkerke-Noordhoek, Nieuwkerke, Wervik-Noord, Wervik-Zuid, Rekkem-Zuid, Rollegem, Bellegem, Kooigem and Kooigem (Driehoven).

1. As in the other plates the identification of levels 1 and 2 poses no problem, neither does level 2.1. An additional level can be correlated in the interval 1-2.1, probably identical to a level identified in plate 5.
2. The West-Outer well can be correlated with Pittem (plate 4) and Onze-Lieve-Vrouw-Waver (plate 2).
   Using the criteria discussed in plate 5, levels 3.0, 3.1, 3, 4, 5 and probably even 6 can be confirmed.

Plate 7: South Flanders — area II.

The following wells are correlated: Sint-Eloois-Winkel, Gullegem, Bavikhove, Harelbeke, Ooigem and Vichte.

1. Levels 1, 2 and 2.1 are labeled according to the criteria discussed before. It should be noted however that clearly subrhythms can be distinguished in unit 1-2.
   In the Sint-Eloois-Winkel and Gullegem logs even the negative rhythm trend seems reversed below level 2.1.
2. The indication of the levels 3, 3.1 and 4 is based on a comparison of the Sint-Eloois-Winkel, and also Ooigem, logs with the Onze-Lieve-Vrouw-Waver log (plate 6) and the Pittem log (plate 5).

Plate 8: Limburg Campine area.

Different logs have been correlated (Mol, Koersel KS13, Hechtel KS40, Hechtel KS38, Houthalen KS12, Helchteren KS31, Helchteren KS28, Koersel KS10. Only level 1 and 2.1 can be identified because the Ieper sections are too thin.

CONCLUSIONS

1. Rhythms in the clay sedimentation can be identified. They are of different order. Rhythm wavelengths of several tens of meters down to some tens of centimeters have been identified.
2. Correlation between logs can be done both through comparing the evolution and the sequence of cycles and through important jumps in the log response.
3. Gamma ray and resistivity logs can be complementary for correlations.
4. Where the Ieper Clay becomes thin to the south and the east the basal rhythms (base level to level 1 and to level 2) are still present.
5. Rhythms can become thinner and sandier towards the east (lower part of the sections in plate 1, upper part of the sections in plate 4). It suggests that rhythms can be followed across facies changes and hence have an origin not related to the mechanism of these facies changes.

LIST OF WELLS*

Aarschot	75W 320	plate 2
Bavikhove (Harelbeke)	83E 440	plate 7
Bellegem (Kortrijk)	97E 865	plate 6
Brasschaat	15E 267	plate 1
Brugge	23W 375	plate 4
De Haan	22W 276	plate 4
Diksmuide (BH6)	51W 146	plate 5
Egem-Pittem (Pittem)	53W 73	plate 5
Gent	55W 978	plate 4
Gistel (BH7)	37W 199	plate 5
Gullegem (Wevelgem)	83W 472	plate 7
Harelbeke	83E 417	plate 7
Hechtel (KS38)	47W 261	plate 8
Hechtel (KS40)	47W 262	plate 8
Heibaart (Wuustwezel)	7E 200	plate 1
Helchteren (KS28) (Houthalen-Helchteren)	62E 273	plate 8
Helchteren (KS31) (Houthalen-Helchteren)	62 E275	plate 8
Hooglede-Gits (Hooglede)	67E 178	plate 5
Houthalen (KS12) (Houthalen-Helchteren)	62E 272	plate 8
Keiem (BH3) (Diksmuide)	36E 131	plate 5
Knokke (Knokke-Heist)	11E 138	plate 4
Koersel (KS10) (Beringen)	62W 302	plate 8
Koersel (KS13) (Beringen)	47W 260	plate 8
Kooigem (Kortrijk)	97E 864	plate 6
Kooigem-Driehoven (Kortrijk)	97E 863	plate 6
Kortemark	52W 154	plate 5
Leisele (Alveringem)	50E 214	plate 5
Lubbeek	90W 1158	plate 2
Meensel-Kiezegem (Tielt-Winge)	90E 748	plate 2
Meer (Hoogstraten)	7E 205	plate 1
Merksplas	17W 265	plate 1
Mol	31W 237	plate 1
Mol	31W 237	plate 8
Nederbrakel (Brakel)	99E 968	plate 3
Nieuwkerke (Heuvelland)	95W 152	plate 6
Nieuwkerke-Noordhoek (Heuveland)	95W 153	plate 6
Ninove	86E 250	plate 3
Onze-Lieve-Vrouw Waver (St. Kathelijne Waver)	59W 180	plate 2
Ooigem (Wielsbeke)	83E 407	plate 7
Oostduinkerke (Koksijde)	35E 142	plate 5
Poederlee (Lille)	30W 371	plate 1
Rekkem-Zuid (Menen)	97W 648	plate 6
Rollegem (Kortrijk)	97W 649	plate 6
Roosdaal-Pamel (Roosdaal)	86E 201	plate 3
Schore (BH8) (Middelkerke)	36E 137	plate 5
Sint-Eloois-Winkel (Ledegem)	83W 471	plate 7
Steenkerke-Veurne (Veurne)	50E 134	plate 5
Ternat	87W 409	plate 3
Tildonk (Haacht)	74W 152	plate 2
Tremelo	74E 128	plate 2
Ukkel	102W 847	plate 3
Vichte (Anzegem)	84W 1471	plate 7
Wervik-Noord	96E 75	plate 6
Wervik-Zuid	96E 74	plate 6
West-Outer (Heuvelland)	95W 154	plate 6
Zande (BH5) (Koekelare)	36E 136	plate 5
Zandvoorde (Oostende)	22W 279	plate 4

* Names between brackets are the administrative name of the locality.