Some features in Clay with Tuff-beds from Lower Eocene on Røsnæs, Danmark

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In a clay pit SW of Ulstrup on Røsnæs, Danmark, part of the formation Clay with Tuff of Lower Eocene age is demonstrated. Sedimentological and diagenetic circumstances are treated.

I en lergrav SW for Ulstrup på Røsnæs er der i en nedre eocæn lagserie blevet påvist ler med lag af vulkansk aske, som omfatter øvre del af den negative og nedre del af den positive serie. Sedimentologiske og diagenetiske forhold gennemgåes. En hiatus omfattende den øvre del af det fra andre lokaliteter kendte askeførende ler påpeges.

The investigated locality is situated 800 m WSW of the church in the village Ulstrup on Røsnæs. Here A/S Leca has been exploiting plastic clay from 1960–68 in a E-W orientated hill covering an area of 24 000 m². The Clay with Tuff not exploited is left as a ridge through the pit, text-fig. 1.

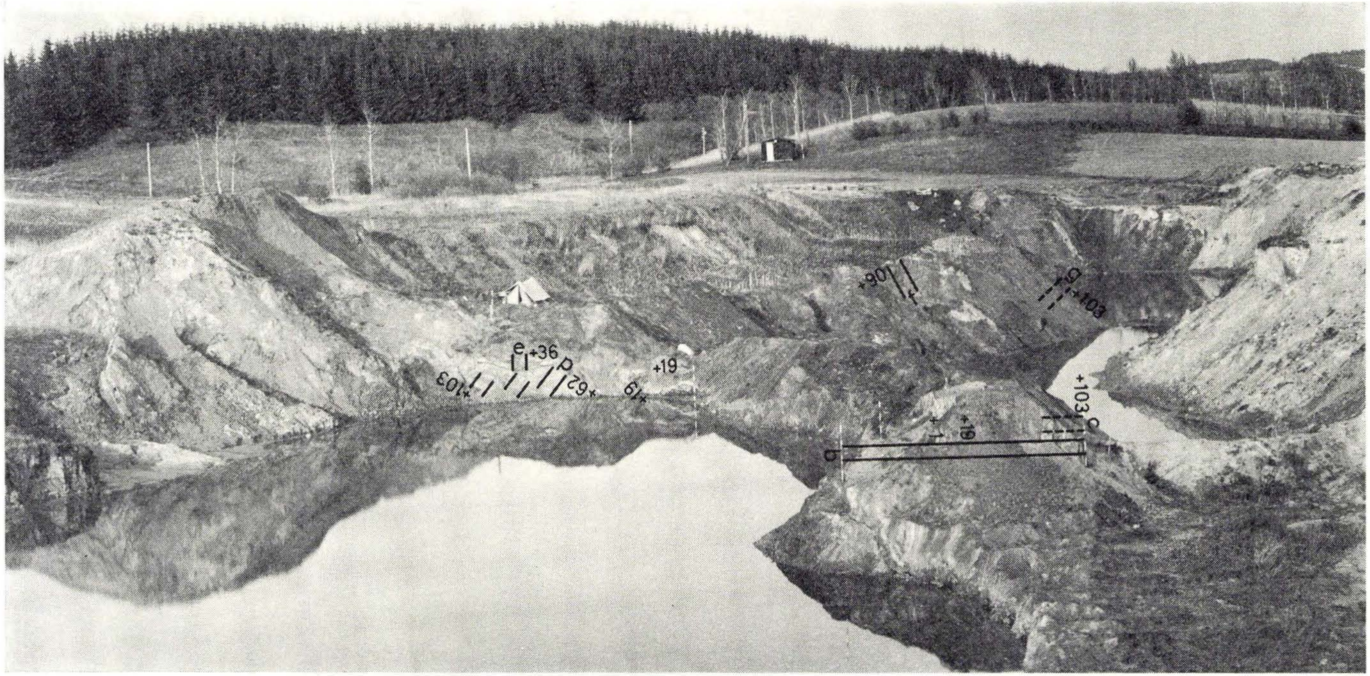
The southern coast of Røsnæs is outstanding with many Lower Eocene outcrops. The plastic clay from this locality has been known to geologists since the beginning of the last century. It occurs as floes in the drift. From borings outside the hilly part of the peninsula it is possible to judge the surface of the Tertiary deposits as being at a depth of 40 m below sealevel.

Clay with Tuff was recognized on Røsnæs in 1913 at Snogekjærgaard by the seashore. In 1937 a description of Volcanic tuff layers outside the Mo Clay area was published by Andersen (1937a). From this paper profile (a), text-fig. 2 has been taken, supplemented by recognized concretionary horizons.

Characteristic tuff beds and strata are used for correlation between the Slettenshage clay pit and the Snogekjærgaard profile 3 km to the west.

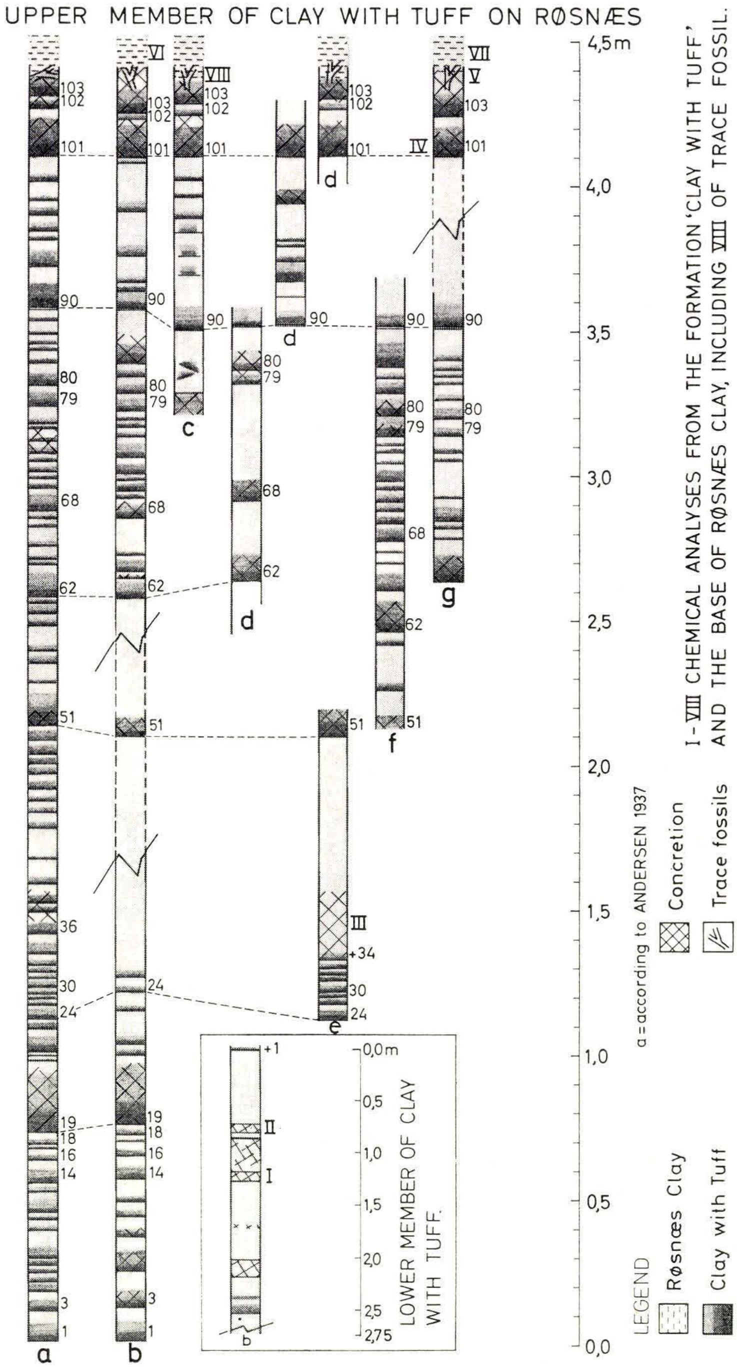
Part of the series is smeared by movement between the layers. This movement is part of the Pleistocene dislocating process which appears from the individual movement of the different parts of the ash ridge (Petersen 1973).

It has been impossible to trace all of the ashlayers from the corresponding part of the ash series in the Mo Clay area (Bøggild 1918). Thus the

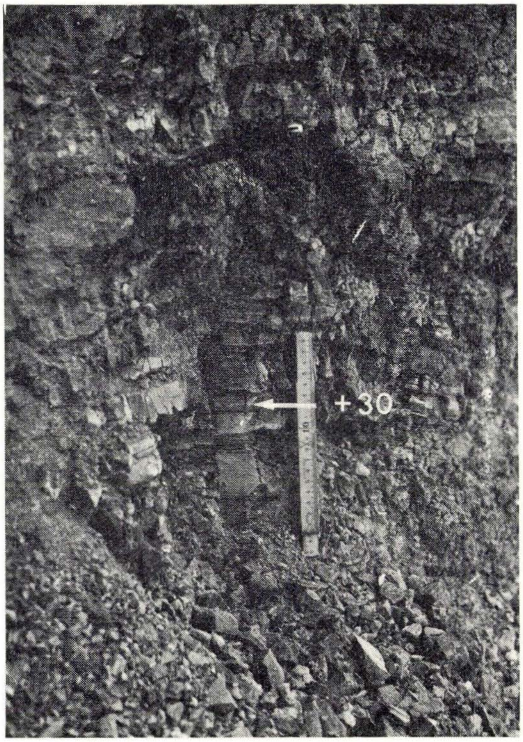


Fext-fig. 1. The folded strata of Clay with Tuff beds, seen from the west in the Slettenshage clay pit, Røsnæs.

Phot. K.S.P., 2.5.1968.



Text-fig. 2. Profiles in Clay with Tuff beds and base of Røsnæs Clay from Røsnæs. Chemical analyses I–VIII are rendered on text-fig. 6.



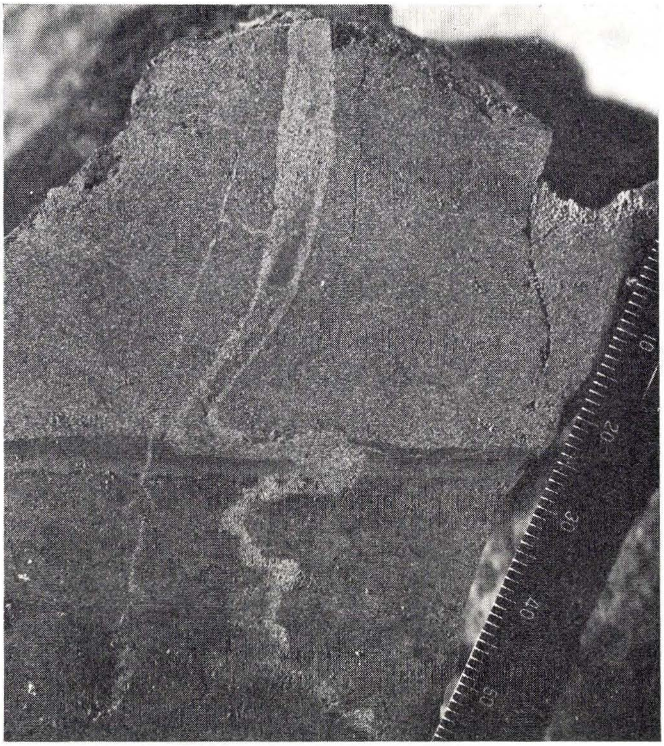
Text-fig. 3. Profile with the ash-beds +24 – +34. By the knife, a horizon of lensshaped concretions around + 36.
Phot. K.S.P. 1968.

numbering of the less characteristic and less distinct ash layers is subject to doubt.

Below the ashlayer +1 in profile b, text-fig. 2, 275 cm of dark, blue to black clay with blurred ash layers and few hardened horizons were found. This is clearly different from the more particoloured clay with closely packed ash layers in the positive series, the upper member of Clay with Tuff. Such a difference is known from other localities (Andersen, 1937a, p. 46).

The hardened horizons of the blue-black, light weathering, lime-free clay are of varying thickness and chemical composition (I & II text-fig. 6). Under the influence of the atmosphere they crumble into irregular bits.

From 232–249 cm below +1, a marked lamination of light-coloured layers < 1 mm was found, partly in a hardened horizon. This lamination has a certain resemblance to the closely packed, very small ashlayers in



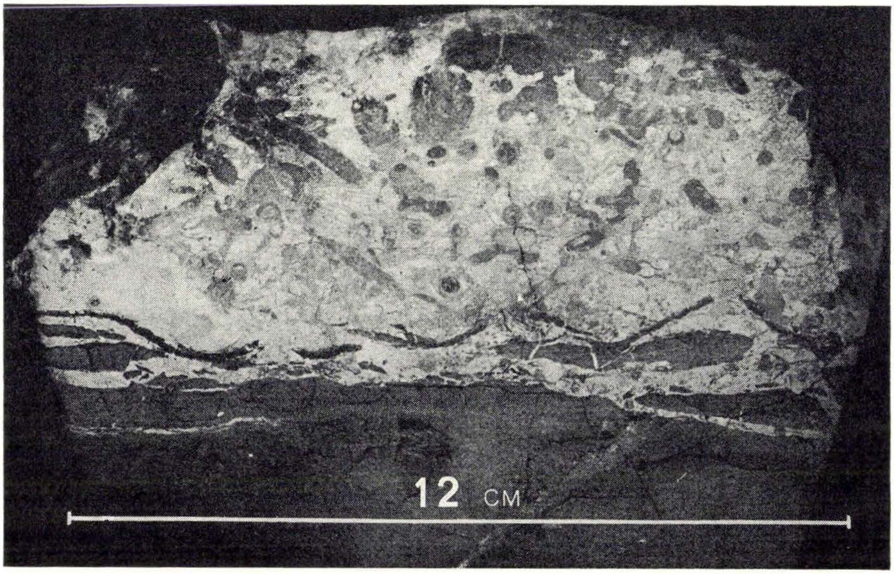
Text-fig. 4. Ptygmatic folding of an ashfilled fissure in the clay below + 90. A thin layer of clayey sediment is seen between the two components of the double-layer.

Phot. K.S.P.

the striated cementstone 2700 cm below +1 in the Mo Clay area (Pedersen 1960 p. 284). It was stated by Andersen (1937 b) that in the Mo Clay area the greatest depositional rate of diatomite was reached during the sedimentation of the upper part of the negative series of ashlayers, more than 15 times the rate of sedimentation of clay (outside the Mo Clay area). From this it is seen that the marked lamination 232–249 cm below +1 might be synchronous with the striated cementstone 2700 cm under +1 in the area of diatomite.

The ashlayer +1 is about 7,5 cm thick with graded bedding coarser in 1 cm of the bottom part. The exact thickness can not be measured, as the smaller grain-size higher in the layer makes it impossible to draw the limit ash/clay in the field. This feature, which affects most measurements outside the Mo Clay area, determines the presentation on text-fig. 2.

The layers +14, +16 and +18 were found, but not appearing as double layers as at Snogekjærgaard. +19 with its thickness (20 cm), compactness



Text-fig. 5. Intraformational sharpstone conglomerate at the top of + 103.
Phot. O. Neergaard Rasmussen.

and scraped appearance gives a firm base for the measurement. The layer is rusty where it is exposed but blue inside.

The closely packed, graded ashlayers between +24–+34 are found in a flaky, light, green clay. +30 has the appearance of a double-layer with a 0,3 cm lower layer. The cementstone known from +24–+30 is not found, but a layer of lens – shaped sideritic concretions (chemical analysis III, text-fig.6) occur around the ashlayer +36, text-fig. 3. +79 is separated from +80 by 0,5 cm of clay in the profiles b and g. In the profiles c and d the layers +79 and +80 occur in one cementstone, this having a total thickness of 10–12 cm. In the profiles f and g, ash and clay were found between +80 and +90, but in the profile d, 5,5–6,0 cm of green clay with smears of coarser ash-like particles occur between these layers. The clay series between +80 and +90 in profile c is 20 cm thick, containing broken ash-beds and fossiliferous clay at the base (Petersen, Hoch and Bonde 1973). The fossils might have gathered in a little basin; the layers were disturbed by sliding shortly after deposition.

An ash-filled fissure through +90 down into the underlying clay reflects by its ptygmatic folding the settling of the clay after the consolidation of the ash, text-fig. 4. +90 is a double layer with a thin layer of clayey sediment between the two components.

The cementstone with the ashlayers +101, +102, and +103 occurs

No.	I	II	III	IV	V	VI	VII	VIII
Percentage by weight of dry matter:								
Insoluble + SiO_2	42,7	80,9	14,4	68,9	15,5	66,8	46,6	7,8
Fe_2O_3	2,5	3,37	33,0	7,52	15,2	7,89	9,67	6,3
Al_2O_3	2,6	5,0	2,4	9,9	2,0	10,0	9,7	1,7
P_2O_5	15,7	0,09	0,05	0,10	0,12	0,08	0,14	0,05
CaO	23,2	0,34	5,85	0,90	20,8	1,20	11,0	19,0
MgO	0,63	1,19	4,64	3,12	2,77	3,50	1,64	3,1
MnO	0,21	0,04	5,73	0,03	6,87	0,16	0,60	24,8
Na_2O	0,63	0,36	0,31	0,79	0,45	0,84	0,79	0,30
K_2O	0,61	0,95	0,43	0,32	0,43	0,49	1,19	0,29
Loss on ignition 1000°C	6,95	6,13	28,8	6,18	31,9	7,17	15,8	33,3
% CO_2 by absorption	2,1	0,1	31,0	0,3	31,8	0,1	9,5	35,7
% S-total	1,2	0,79	0,96	0/tr.	0/tr.	1,1	0/tr.	0/tr.
- S in SO_4	0,52	0,39	0,14			0,87		
Estimated carbonate composition:								
% $CaCO_3$	4,8		11,0		37,0		19,0	33,9
- $MgCO_3$	0		9,7		5,9		1,7	6,5
- $MnCO_3$	0		9,2		11,0		0	40,2
- $FeCo_3$	0		47,0		22,0		0	5,3
- FeO (excess)								2,4

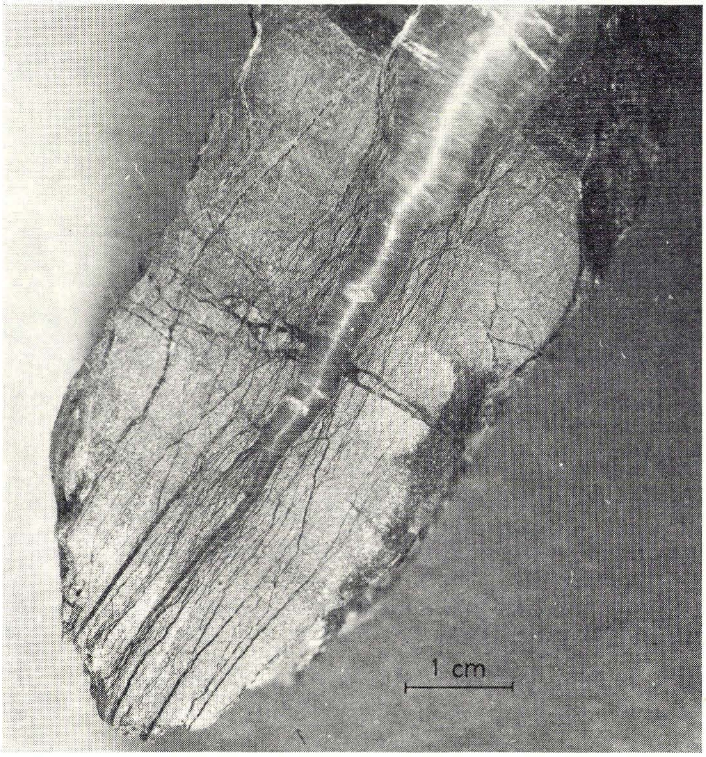
Text-fig. 6. Chemical analyses render the composition of respectively:

I–III concretions up to + 36
IV ash-bed + 101
V concretion above + 101
VI–VII Røsnæs Clay
VIII trace fossil from the base of Røsnæs Clay

The analyses have been made on components soluble after 2 hrs' boiling with aqua regia (1/3 HNO_3 + 2/3 HCL).

in all the profiles. +101 has a thickness of 10–12 cm. The thickness of +103 of 7,5 cm is outstanding for Røsnæs, as mentioned by Andersen (1973a), compared with the thickness of this layer at other localities. Plastic clay overlies this ashbed in the Snogekjærgaard profile. (On pl. VI fig. 20 Andersen 1937a, +110 is mentioned from Røgle-Røsnæs. This is a misprint; the numbers belong to Albækhoved-Røgle).

A sectional view of the concretion normal to the beding, text-fig. 5, shows the top of +103 broken up, forming an intraformational sharpstone conglomerate. Furthermore, the upper limit of an ashfilled crack at the top of



Text-fig. 7. Plates of calcite in fissures. A sectional view normal to the bedding. Notice plate-like growth of calcite parallel to the bedding. Phot. K.S.P.

+103 shows this level to be an erosional surface. However, because of the extraordinary thickness of "+103", this layer might be regarded as a "Tuffite" (Illies 1949, p. 14). The cementstone above "+103" in profile g is 12 cm thick without ash-beds. The ash-layer +104 was to be expected here as it is found within this distance at localities west of Røsnæs.

Together with the above-mentioned features, the occurrence of Røsnæs Clay above the concretion at the two localities might lead to the conclusion that there is a hiatus above "+103". This hiatus could hardly represent a tectonic break.

The presence of concretions is a conspicuous feature of the formation Clay with Tuff. Their occurrence in the profiles has been marked on text-fig. 2. Few of them are found at the same level within the peninsula, and only one (+101–+103) represents a horizon traceable to other localities outside Røsnæs.

In order to figure the concretionary composition, chemical anaylses, text-fig. 6, have been made by the DGU laboratory staff, with the following

Text-fig. 8. Gypsum. "Swallow-tail" twins are found in lower member of Clay with Tuff on Røsnæs. This one is derived from a concretionary horizon in the Snogekjærgaard profile. Phot. O. Neergaard Rasmussen.

comment by senior-geologist H. Kristiansen: "Three of the samples (III, V and VIII) show equivalent excess of CO_2 in relation to CaO and MgO. In two oft hese samples the excess of CO_2 was equivalent to the sum of FeO and MnO, while there was a small excess of FeO or MnO in the sample VIII. From these analyses an estimated carbonate composition has been calculated. Normally the reduced loss on ignition (loss on ignition $\div CO_2$) is equal to the content of organic matter + chemically bound water. If the samples contain $FeCO_3$ and $MnCO_3$, the reduced loss on ignition will be lower or negative owing to the fact that $2FeO + O \rightarrow FE_2O_3$".

Trace fossils (chem,an. VIII) are a special case owing to their high content of MnO. This does not merely reflect the higher porosity caused by bioturbation but is more probably an effect of cementation of the burrow walls made by the Callianassa-like animal (Petersen, K. Strand: Trace fossils from Lower Eocene of Denmark – in preparation). The organic component of the cement of the walls may have trapped/attached the manganese (Blatt *et al.* 1972). The existence of penecontemporaneous feeding tracks in the walls supports the presumption of the occurrence of organic matter.

Plate-like, fibrous masses of calcite ($CaCO_3$) are found anastomosing more or less parallel to the bedding, especially in the horizon +101–+103. In one case calcite is found cutting the ash-beds vertically through more than one meter having a max. thickness of 2–3 cm and at the base splitting into thin plates that fill up fissures < 1 mm, text-fig. 6.

Gypsum ($CaSO.2H_2O$) is commonly found as described by Bøggild (1943) but twinning does occur as shown in text-fig. 7.

Pyrite (FeS_2) is found in the central part of the burrows. Pyritic fillings in vertebrate bones and wood material occur but are not found in extensive masses as is the case at other localities of Lower Eocene age, viz: Katharinenhof on Insel Fehmarn and Trelde Næs near Lillebælt.

The poverty of lime-shelled fossils of this formation must be seen as a result of diagenesis. Syngenetic cementation as seen in the hardened horizon around +36 preserved the fossils (bivalves) from destruction to some extent, as reported by Illies (1949).

The hardened trace fossils met with in this formation were made by animals burrowing in a soft sediment: the trace fossils have not suffered from pressure but expose shearing at the outer side; this shearing reflects the settling in the sediment. Sedimentological investigations published by Oertel, G. and Curtis, C. (1972) and Nielsen (1973) support the abovementioned idea of syngenetic cementation.

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