LATE TERTIARY WEATHERING OF FLUVIAL DEPOSITS AT LÅSBY, DENMARK

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A section of uppermost Tertiary fluvial deposits in which a less resistant heavy-mineral association overlies a more resistant one is presented. The character of the succession is discussed in relation to weathering processes and it is concluded that weathering of the uppermost Tertiary fluvial deposits took place shortly after deposition.

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Three heavy-mineral associations are found in the Upper Tertiary deposits of Denmark. One of these, the amphibole-epidote association, is characteristic of marine deposits, whereas the others, the epidote association and the metamorphic association (dominated by kyanite, sillimanite and staurolite), are found in non-marine deposits (Larsen & Dinesen, 1959; Johannesen, 1971; Larsen & Friis, 1973; Friis, 1974). Similar associations are found in Holland and Schleswig-Holstein displaying the same distribution of sedimentary facies (Edelman, 1938; Weyl, 1952). It has been shown (Friis, 1974) that the three heavy-mineral associations have originated from one single association by successive weathering of amphibole and epidote, and it was demonstrated, that the weathering took place after deposition of the sediments. Heavy-mineral analyses of fluvial deposits at Låsby (fig. 1) are the basis of further discussion of the weathering conditions.

The heavy-mineral analysis

The analyses have been carried out on the 63–250 μm fraction. After separation in bromoform (sp. gr. = 2.89) the heavy-minerals were mounted in clearax (R. I. = 1.666). By ribbon-counting, the mutual percentages of non-opaque heavy-minerals (exept mica) were estimated counting 200 grains from each sample. Typical compositions are shown in table 1.

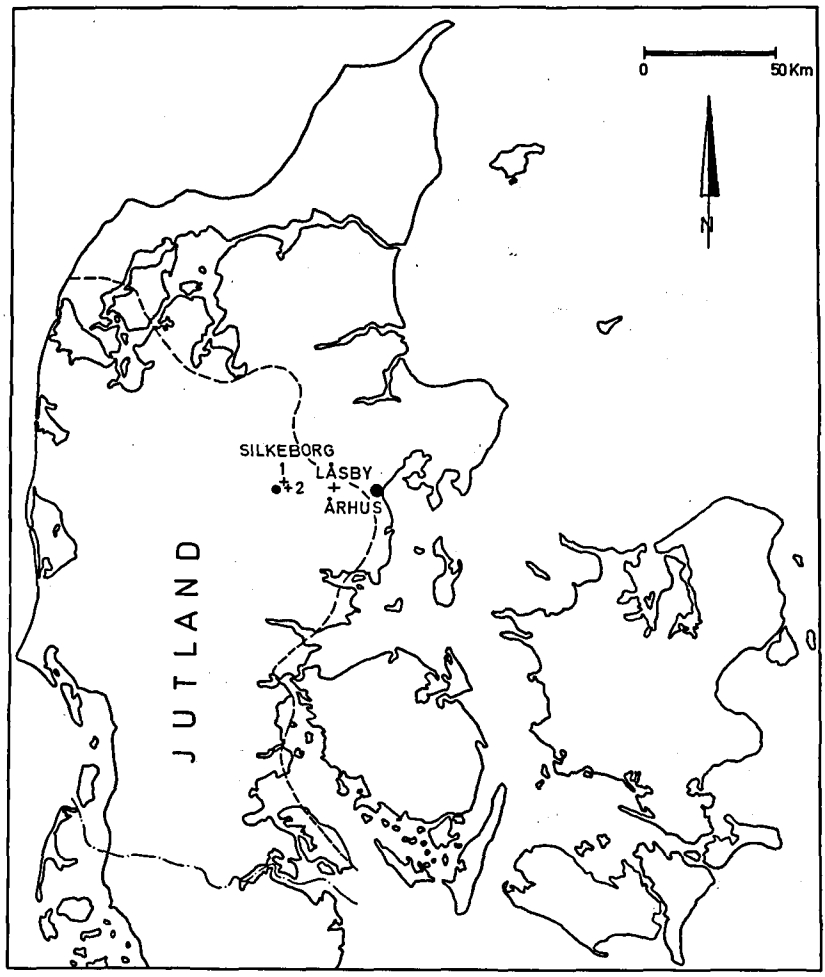

Fig. 1. Location map. Dotted line indicates approximate limit of Miocene deposits (from Rasmussen, 1961).

Låsby sand pit

The sand pit is situated about 20 km west of Aarhus (fig. 1). It is 200 m long and 75 m wide. The maximal height of the profile is 26 m of which almost 25 m are Tertiary fluvial sand, covered by Quatenary sand and gravel. The Teriary deposits are, from bottom to top, 12 m of coarse cross-bedded sand with intercalations of fine, laminated sand, followed by laminated sand with lenses of cross-bedded sand.

Samples have been taken at short intervals through-out the section to reflect changes in the distribution of heavy-minerals. It was found that all

samples were readily referred to either the metamorphic association or the epidote association (table 1). The metamorphic association was found in samples from the lowermost part of the section (0–9.25 m), and the epidote association in samples from the uppermost part (9.25–24.80 m). There are no samples transitional between the two associations, and the boundary between the mineralogical units defined by heavy-mineral associations is erosional and marked by a thin gravel-layer (fig. 2). Studies of sedimentary structures have shown that this layer is also the boundary between two units of a cyclic sedimentation (Johannesen, 1971).

Discussion

As the less resistant epidote association overlies the more resistant metamorphic association, weathering of the lowermost unit must have been completed before deposition of the uppermost unit. This weathering may have taken place in the source-area, or the sediments may have been submitted to post-depositional weathering. During investigations of the Danish Upper Tertiary deposits it has been impossible to find evidence that the heavily weathered materials were transported separately. Furthermore, as mentioned, an in-situ weathering has been intensive enough to dissolve epidote, thus changing the epidote association into the metamorphic association. In fig. 3 the epidote percentages from a part of the Låsby profile and from three profiles at Silkeborg (fig. 1) have been compiled. The Silkeborg profiles show a gradually increasing content of epidote downwards in the profiles. Samples from the upper part contain the metamorphic association while samples from the

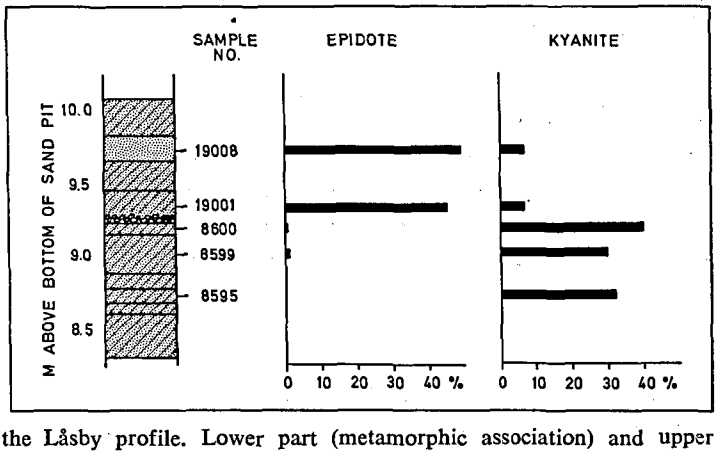

Fig. 2. Part of the Låsby profile. Lower part (metamorphic association) and upper part (epidote association) are separated by an erosional gravel-layer.

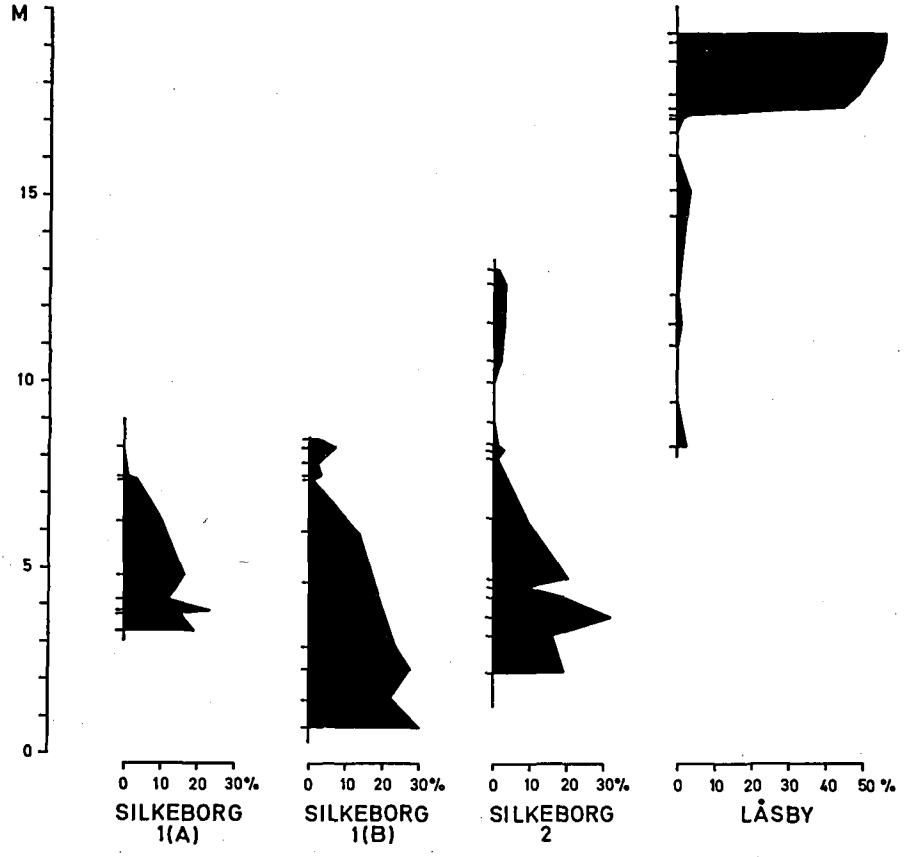

Fig. 3. Epidote percentages of four Upper Tertiary profiles in central Jylland (fig. 1). The profiles have been correlated only by means of the epidote percentages to illustrate the model of "cyclic weathering".

lower part contain an almost typical epidote association. The profiles thus demonstrate an in-situ weathering of the epidote association, the metamorphic association being the weathering residue. Quaternary erosion has reduced the sections and it is not possible to prove whether the weathering was Tertiary or Quaternary. However, the Låsby profile shows that the weathering must have taken place during deposition of these fluvial sediments.

Conclusion

The four profiles of fig. 3 indicate a model of "cyclic weathering" paralleling the cyclicity of sedimentation. After deposition the fluvial sediments may be exposed to weathering dependant on subsidence and depositional rates.

Table 1. Typical heavy-mineral distributions.
Samples 8599 and 8600 represent the metamorphic association.
Samples 19050 and 19061 represent the epidote association.

Sample no.	8599 %	8600 %	19050 %	19061 %
Zircon	22	4	14	7
Rutile	16	10	15	7
Tourmaline	6	9	3	7
Staurolite	6	11	2	5
Andalusite	1	0	0	0
Kyanite	30	44	8	17
Sillimanite	7	16	0	4
Garnet	7	0	3	2
Epidote	1	3	54	45
Amphibole	0	0	0	1
Other minerals	10	3	1	5

The deposits are generally highly permeable which facilitates a deep penetration of the weathering. So a dissolution of the most unstable heavy-minerals takes place, and pyroxenes and amphiboles are rarely found. Somewhere as seen in the profiles from Silkeborg the weathering has been intensive enough to dissolve epidote in the upper parts of the deposits. With increasing depth the intensity of the weathering decreases and epidote is counted among the heavy-minerals with larger percentages until it is totally uneffected by the weathering. When a new fluvial cycle has been deposited upon the old one the weathering surface is moved, and the dissolution of heavy-minerals is initiated from the new surface. The "weathering cycle" is initiated with the epidote association which is upwards transitional to the metamorphic association. Lying abruptly upon the metamorphic association the epidote association of a new cycle is found (the Låsby profile).

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Dansk sammendrag

I danske ung-Tertiære aflejringer findes tre tungmineralselskaber, hvis oprindelse kan forklares ved postsedimentær forvitring af først amfibol, dernæst epidot. I en sandgrav ved Låsby (fig. 1) findes et profil af fluviatilt sand, hvori et mindre forvitrings-stabilt tungmineralselskab (epidot selskabet) findes over et mere forvitrings-stabilt selskab (det metamorfe selskab). Dette forhold underbygger den antagelse, at

forvitringen af tungmineralselskaberne er sket i ung-Tertiæret og placerer den meget nær tidspunktet for aflejringen. Ved hjælp af fig. 3 antydes en "rytmisk forvitring", der afspejler en rytme i sedimentationen.

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