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Problems of lithostratigraphic classification of Holocene deposits in the perimarine area of The Netherlands

Comment

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Introduction

Lithostratigraphic mapping always faces the problem of to what detail separate units should be distinguished. It is quite clear, for instance, that a rough first mapping requires other standards than a highly specialized investigation. Consequently, the choice of lithostratigraphic units should be based on flexible criteria (cf. Hedberg 1976). In practice the rules applied seem to be strongly influenced by national and historical developments. In the USA, for instance, hard-rock formations tend to be several hundreds of metres thick; in The Netherlands, in contrast, the Quaternary succession has been subdivided in formations and members which often have a local or even regional thickness of less than one metre.

Berendsen (1984b), in an elegant analytical paper, recently argued that the detailed 'lithostratigraphic' subdivision of (sub)recent deposits in The Netherlands, as applied by the Dutch Geological Survey, gives rise to serious problems since various concepts are mixed and used simultaneously in an unacceptable way. In fact, he underlined rather similar views published earlier in a special issue of this journal on Quaternary geology (Van Loon 1981).

A main problem is the term 'Westland Formation', formally introduced by Doppert et al. (1975) in an explanation to the new geological maps (Zagwijn & Van Staalduinen 1975). Berendsen (1984b) once more demonstrate that both the theoretical definition and the practical mapping of the Westland Formation are based on illogical concepts.

Terminologies presently used

The Dutch Geological Survey in practice still adheres to the original definition of the Westland Formation as given by Doppert et al. (1975). Consequently, the unit is supposed to contain a large number of full-marine, coastal, estuarine, lagoonal, fluvial, limnic and even fresh-water marsh deposits. The main similarity of all those sediments is that they occur in the marine or perimarine part of The Netherlands; moreover, this lithostratigraphic unit seems restricted to sediments with a Holocene age.

Other authors (Roeleveld 1974; Van Loon & Wiggers 1975, 1977; Griede 1978; Van Loon, 1981) distinguished a marine to brackish clastic unit (Groningen Formation) and a brackish to fresh-water organic unit (Wold Formation). Many problems were solved in that way (though some other remained) and lithostratigraphic correlations became much clearer. Unfortunately, Doppert et al. (1975) of the Dutch Geological Survey introduced the illogical and impractical Westland Formation after Roeleveld's (1974) work. The Survey has not (yet?) adopted the earlier and better terminology of Roeleveld. As a result, even in the relatively small Dutch area two stratigraphic terminologies for the (sub)recent deposits exist simultaneously.

The approach by Berendsen (1984b), though fundamentally correct, might add to the confusion, since he adheres to a third lithostratigraphic terminology, firstly used in his Ph.D. thesis (Berendsen 1982). Roughly speaking, he reserves the term 'Westland Formation' for the marine sediments formed during and after the sea level rise that followed the last glacial. The equivalent perimarine and fluvial sediments are attributed to the Betuwe Formation and the peats, in his terminology, form the Broek Formation.

Objections against Berendsen's terminology

Lithostratigraphic terminology is meant to facilitate both mapping and scientific communication. Though Berendsen's terminology is by far superior to that used by the Dutch Geological Survey, there are, in my opinion, serious objections against some specific proposals.

(1) Berendsen uses the term 'Westland Formation' in a sense that is distinctly different from the original meaning. As such, new confusion will arise if in future papers it is not indicated whether the term is used *sensu* Berendsen or *sensu* Dutch Geological Survey. As history shows, such additions are doomed to be rejected as unpractical.

(2) The same objection applies to the term 'Betuwe Formation'. Moreover, from the context it is clear that Berendsen does not include any peat in this formation; when, however, peat is eroded by waves or currents and redeposited in a perimarine, fluvial or lacustrine environment, the resulting organoclastic deposit should be attributed to this formation on the basis of genetic and environmental similarity. This possibility also solves the problem raised by Van Loon (1981) with respect to reworked peat in the Zuiderzee area (Flevomeer Member).

(3) The relatively new term 'Broek Formation' meets no formal objections, except that it is only another name for Roeleveld's (1974) Wold Formation. For reasons of priority (cf. Hedberg 1976) one therefore should name the peat 'Wold Formation'. Besides, it should be emphasized that this only refers to peat *in situ* as stated by Berendsen (1982) in his thesis.

Suggestions

The above mentioned objections do not imply that Berendsen's proposals should be fully rejected. In contrary, they form a fine analysis that will be most valuable for more precise future communication. The objections, however, cannot be neglected; for that reason I propose the following solutions.

(1) The term 'Westland Formation' should be deleted in both Berendsen's and the Survey's sense. For the marine and brackish deposits as described by Berendsen, the earlier proposed term 'Groningen Formation' should be used.

(2) Instead of 'Betuwe Formation' *sensu* Berendsen, another name should be used. To avoid unnecessary confusion, a suggestion for another name is not made here; Berendsen should do so, choosing a name in accordance with formal prescriptions (cf. Hedberg 1976). In his definition he should mention the occurrence of reworked peat.

(3) For peat *in situ* (as far as considered in this context) the term 'Broek Formation' should be rejected as an unnecessary synonym for Wold Formation; the latter term should be adapted as long as no internationally accepted name is available for the same deposit in a wider geographical area.

Conclusions

The stratigraphy of the (sub)recent deposits in The Netherlands has gone into such detail, that an unambiguous nomenclature cannot be missed. The lithostratigraphic units should be well defined, allow easy mapping and correlation, and fulfill the formal stratigraphic requirements. For that reason the term 'Westland Formation', used mainly by the Dutch Geological Survey, should be rejected. The sediments should be grouped into three formations that are defined by both lithological and genetic characteristics.

Reply

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Introduction

The Geological Survey of the Netherlands assigns all Holocene mineral deposits and peat in the marine as well as the perimarine area to the Westland Formation (Zagwijn & Van Staalduinen 1975). The Westland Formation is subdivided into members on the basis of the alternation of clastic sediments and peat. The clastic marine deposits comprise essentially the lower Calais Deposits and the upper Dunkirk Deposits. The clastic perimarine deposits comprise the lower Gorkum Deposits and the upper Tiel Deposits. In both areas peat layers are included in the Holland peat (member). Both the definition and subdivision of the Westland Formation have met with serious practical and theoretical objections from many authors (Roeleveld 1974; Brouwer 1976; Griede 1978; Van der Woude 1981; Van Loon 1981; Berendsen 1982). As pointed out in my paper (Berendsen 1984b), these objections result from the mingling of the concepts of lithostratigraphy, chronostratigraphy and genesis. In mapping the perimarine area, I felt that a new system of lithostratigraphical classification was needed, in which lithostratigraphy is disconnected from the genetic concept of a perimarine area, and in which no confusion arises between lithostratigraphic and chronostratigraphic terminology. However, since many of the recently introduced stratigraphic names are already commonly used, alterations to the existing nomenclature should be restricted to a neccessary minimum.

Possible solutions to the problems and some complications

To overcome the main problems of lithostratigraphic classification in the perimarine area, it would certainly be possible to follow Van Loon's suggestions and adopt Roeleveld's (1974) scheme of lithostratigraphic classification that was designed for the marine area in the northern Netherlands. In this system the term Groningen Formation comprises all clastic sediments of the northern marine district, while peat in situ is assigned to the Wold Formation. In his comment on my paper, Van Loon correctly points out that this system is very similar to the system I proposed in my thesis (Berendsen 1982). For reasons of priority, he argues, Roeleveld's (1974) names should be adopted.

I do not have any objections against Roeleveld's (1974) names nor against his classification system. Still, there are some problems that explain why I did not use Roeleveld's (1974) names, and which Van Loon did not consider in his comment.

a. The Groningen Formation and Wold Formation have never been formally defined in the way it should be done according to Hedberg (1976). Although definition, boundaries, regional extent, geologic age etc. may partly be inferred from Roeleveld's (1974) work, no *holostratotype* is given, at least not explicitly specified.
b. The terms Groningen Formation and Wold Formation were clearly meant for use in the northern Netherlands, and the terms have never been used outside that area. The Wold Formation for example, certainly was not meant to incorporate peat in the fluvial district. To do so now, would require the definition of a *hypostratotype*, in which the orginal meaning of Roeleveld's terms is extended. Clearly, prior to the introduction of a *hypostratotype* the *holostratotype* should be well established. At the time, I did consider it too far-fetched to define both a *holostratotype* for the northern marine district and a *hypostratotype* for the fluvial district in

order to be able to use Roeleveld's (1974) names.

c. In fact, for reasons of priority, the Geological Survey of The Netherlands should have adopted Roeleveld's (1974) terminology, which is not only better but which was also published even before the introduction of the Westland Formation by Zagwijn & Van Staalduinen (1975). Now, the Westland Formation (although its definition and subdivision is fundamentally incorrect) is better known than the Groningen Formation.

Considering these problems I decided to maintain the now familiar names of formations introduced by the Geological Survey as much as possible, but to modify their definitions instead of Roeleveld's. In my opinion, this meets both the theoretical classification purposes and practical purposes as well as possible. Therefore the Westland Formation and Betuwe Formation were slightly modified, and only one new formation (the Broek Formation) was introduced. In this new system of classification (Berendsen 1982) all clastic sediments in the marine area are included in the Westland Formation; all clastic sediments in the perimarine and fluviatile area are included in the Betuwe Formation. Reworked peat in the fluvial district also belongs to the Betuwe Formation (as suggested by Van Loon in his comment). Peat *in situ* in both areas is included in a new lithostratigraphic unit, the Broek Formation. The Broek Formation has been defined in such a way that it comprises the peat that formerly was included in the Holland Peat Member of the Westland Formation (Zagwijn & Van Staalduinen 1975), as well as peat of the Wold Formation (Roeleveld 1974) and peat of the Betuwe Formation (Verbraeck 1984).

The advantage is that these formations are now well defined and described, and any mixing of lithostratigraphic, chronostratigraphic and genetic concepts can be avoided. In the marine district the subdivision of the Westland Formation requires some extra attention. Following Roeleveld (1974), the terms 'Calais' and 'Dunkirk' should be used to indicate periods of transgression and new names should be used for the lithostratigraphic subdivision into members.

A disadvantage of the redefinition of formations is – and here I agree with Van Loon – that confusion may arise if the same terms continue to be used with different meanings. In that case entirely new names would be better. However, since the term 'Betuwe Formation' has hardly been used so far, the proposed extension will most likely confuse nobody, and a new name in my opinion would be unnecessary. Throughout the history of lithostratigraphic classification in The Netherlands, the 'content' of formations has been changed slightly many times, as illustrated by Zagwijn & Van Staalduinen (1975). No appreciable confusion has ever arisen from these re-definitions.

Although Hageman's (1969) misleading concept of synchronous sedimentation in the marine and perimarine area (cf. Berendsen 1984a) is now abandoned by Verbraeck (1984), the Geological Survey of The Netherlands still adheres to the original definition of the Westland Formation. The reasons for doing so – although understandable in some respects – are not at all convincing. The lithostratigraphic classification unfortunately still is tied to the genetic concept of a perimarine area. The boundary of this 'perimarine area' (i.e. the boundary of the Westland Formation *sensu* Zagwijn & Van Staalduinen 1975) certainly cannot be mapped more accurately than the boundary between salt water and fresh water deposits (i.e. the boundary of the Westland Formation *sensu* Berendsen 1982). It is time for the Geological Survey to enter the discussion. The practical purposes of mapping have led to the very fine system of the profile-type legend of the new geological map scale 1:50 000, that certainly should not (and needs not to) be abandoned. The classification system, however, is not in accordance with international standards. It is better to change definitions now than to continue with wrong concepts.

Conclusions

I do fully agree with Van Loon that an unambiguous nomenclature is necessary. Since most of the geological mapping is carried out by the Geological

Survey of The Netherlands, they should enter the discussion and modify their existing classification system in such a way that both theoretical and practical purposes are best served. Whether this is done by re-defining the Groningen Formation and Wold Formation and adopting these names, or by modifying the Westland Formation and Betuwe Formation and adopting the Broek Formation is in my opinion a matter of subordinate importance. If agreement can be reached on the definitions there will be no confusion in the future.

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