Introduction

Laminae Formation in Long- and Short-Term Perspectives

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When assessing the different causes of laminae formation there appears to be a need to summarize those factors which are considered characteristic or indicative of laminated sediments. The source of the material and the depositional environment, together with hydrographic and climatic conditions are all important. In addition, both natural events and human activities can cause variations and changes in the composition and formation of laminae.

Laminated sediments have proved to be excellent archives of environmental history and human impact. They have a high chronostratigraphical value. The undisturbed laminae have recorded, among other things, the start of, and changes in, human activities, i.e. deforestation, land use and settlement.

Air pollution, acidification as a result of acid rain, eutrophication due to the extensive use of fertilizers, or in connection with big animal farms and centres of dense population, polluted waters and an increasing load of heavy metals are just some of the recent environmental problems recorded in sediments. Power plants, both nuclear and those based on fossil fuels, and refineries, are also sources of man made compounds and particles which are present in modern sediments.

An evaluation of the degree of human (including industrial) impact and the tracing of major events by absolute dating are among the possibilities offered by laminated sediment studies.

In order to estimate the degree of human impact it is necessary to study laminated sediments deposited in recent environments which are not

directly influenced by man, such as the lakes of polar regions. For long-term perspectives comparisons have to be made with interglacial and interstadial lakes, particularly deep ones in kettle holes and volcanic craters which have long sequences of annually laminated sediments.

A joint evaluation of our present knowledge of the existing and expected applications of laminated sediments in interdisciplinary research would be highly appreciated by many disciplines.

Formation of laminae age and environment

Laminations are already known from the Early Proterozoic sedimentary rocks, that is they are more than 2.2 billion years old. In Cretaceous and Tertiary rocks and sediments laminations occur in deposits of lagoonal and shallow water littoral environments, e.g. the huge diatomite deposits in California and Denmark. During the Pleistocene laminated sediments were formed as varved clays in connection with deglaciation or were deposited in deep lakes (kettle holes and volcanic craters), big lakes and lagoonal waters. During the Holocene laminae formation has been common in brackish water and lagoonal environments. Annually laminated sediments are known from subarctic-boreal-subboreal regions where they have been particularly significant in illucidating the type of human interference with the environment.

Causes of laminae formation

Laminae formation can be :

Seasonal – annual or even daily and composed of light and dark laminae of mainly minerogenic and organic material, respectively. The cyclicity can depend on icecover and ice-free seasons or dry and wet seasons.

Occasional – caused by erosion, eutrophication and vegetational changes. Very often connected with human activities such as deforestation, land use, building construction, industrial waste water and cooling water. There are also naturally occurring occasional varves caused by land slides and the deposition of eolian sand, loess and volcanic ash.

Lagoonal laminations – are formed at the start of the isolation of the lagoon basin, when the threshold is emerging above the water level and the lagoon is only temporarily connected with the sea. Periods with higher and lower sea level or ice-covered and ice-free conditions usually result in the formation of annual, but sometimes also occasional laminae.

Brackish sea laminations – in the deep basins of the Baltic Sea often seem to be connected with transitions between the different Baltic stages such as Late Weichselian Baltic Ice Lake/Yoldia Sea (varved glacial clay),

Ancylus Lake/Litorina Sea (laminated gyttja clay/clay gyttja), recent Baltic (laminated clay gyttja).

The youngest laminae formation in the Baltic is easily explained as the result of accelerating eutrophication and oxygen deficiency, caused by the activities of man. The question is : are these laminae annual ?

The lateglacial varved clays were formed by meltwater in connection with the last deglaciation and are definitely not influenced by man.

What is the reason for the laminae formation at the transition of the Ancylus Lake/Litorina Sea ? It may be the result of cyclic oxygen deficiency caused by high bioproduction or it may depend on the change from a freshwater environment to marine conditions.

The examples given above show the breadth of the laminated sediments field of study, covering many geological eras and different depositional environments. What laminated sediments have in common is their chronological and palaeoecological value, and their applicability in interdisciplinary research. In each individual case, however, it is crucial to first prove that the laminations are annual. Laminated sediments are not only excellent archives of environmental history and human impact, but also the key to the future prospects of the depositional environment.

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