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TITLE: Varves in marine sediments: A review

AUTHOR: ['Arndt Schimmelmann', 'Carina B. Lange', 'Jüergen Schieber', 'Pierre Francus', 'Antti Ojala', 'Bernd Zolitschka']

ABSTRACT:

The global compilation of reported marine varved sedimentary records throughout the Quaternary contains 52 sites. Marine varve deposition and preservation typically depend on environmental and sedimentological conditions, such as a sufficiently high sedimentation rate, severe depletion of dissolved oxygen in bottom water to exclude bioturbation by macrobenthos, and a seasonally varying sedimentary input to yield a recognizable rhythmic varve pattern. Additional oceanographic factors include the strength and depth range of the Oxygen Minimum Zone (OMZ) and regional anthropogenic eutrophication from point sources such as large polluted rivers. Quaternary marine varves are not only found in those parts of the open ocean that comply with these conditions, but also in fjords, embayments and estuaries with thermohaline density stratification, and nearshore 'marine lakes' with strong hydrologic connections to ocean water. This review critically describes settings and sedimentological characteristics of marine sites where varves have been reported. Broader applications of marine varve records are discussed, for example in terms of radiocarbon calibration on high-resolution time scales, constraining paleoceanographic variability and global change teleconnections, diagnosing factors affecting modern fish population dynamics based on past performance, detailing biogeochemical cycles, and deciphering complex factors influencing marine productivity. Varves in saline water bodies without hydrologic connection to the global ocean are not included in this review and instead pertain to the companion review on lacustrine varves where also general and fundamental principles of varve deposition, classification, and dating are covered (Zolitschka et al., 2015). The postulated occurrence of varves in pre-Quaternary rocks is critically discussed in this review with representative examples. In the case of non-evaporitic laminations in fine-grained ancient marine rocks, such as banded iron formations and black shales, laminations may not be varves but instead may have multiple alternative origins such as event beds or formation via bottom currents that transport and sort silt-sized particles, clay floccules, and organic-mineral aggregates in the form of migrating bedload ripples.

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