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Global compilation of marine varve records

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Marine varves contain highly resolved records of geochemical and other paleoceanographic and paleoenvironmental proxies with annual to seasonal resolution. We present a global compilation of marine varved sedimentary records throughout the Holocene and Quaternary covering more than 50 sites worldwide. 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 may include the strength and depth range of the Oxygen Minimum Zone (OMZ) and regional anthropogenic eutrophication. Modern to 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. Marine varves have also been postulated in pre-Quaternary rocks. 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 transported and sorted silt-sized particles, clay floccules, and organic-mineral aggregates in the form of migrating bedload ripples.

Modern marine ecosystems on continental shelves and slopes, in coastal zones and in estuaries are susceptible to stress by anthropogenic pressures, for example in the form of eutrophication, enhanced OMZs, and expanding ranges of oxygen-depletion in bottom waters. Sensitive laminated sites may play the important role of a 'canary in the coal mine' where monitoring the character and geographical extent of laminations/varves serves as a diagnostic tool to judge the environmental conditions and longer-term trends of benthic ecosystems. Analyses of modern varve records will gain importance for simultaneously providing high-resolution and longer-term perspectives. Especially in regions with limited resources or at remote sites, the comparatively low cost of high-resolution sediment analyses for environmental monitoring is an essential advantage over continuous monitoring of oceanographic conditions in the water column.