Global Compilation of Marine Varve Records

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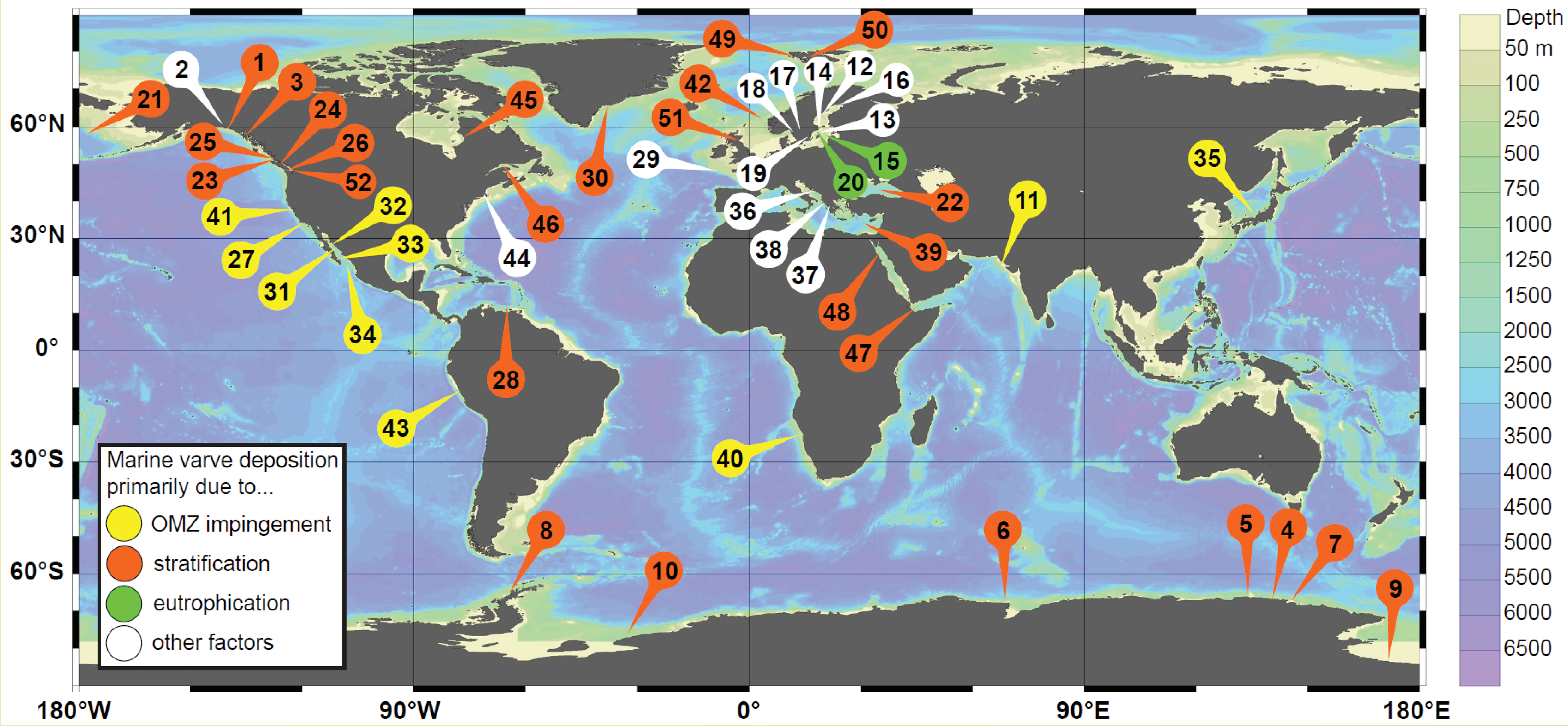
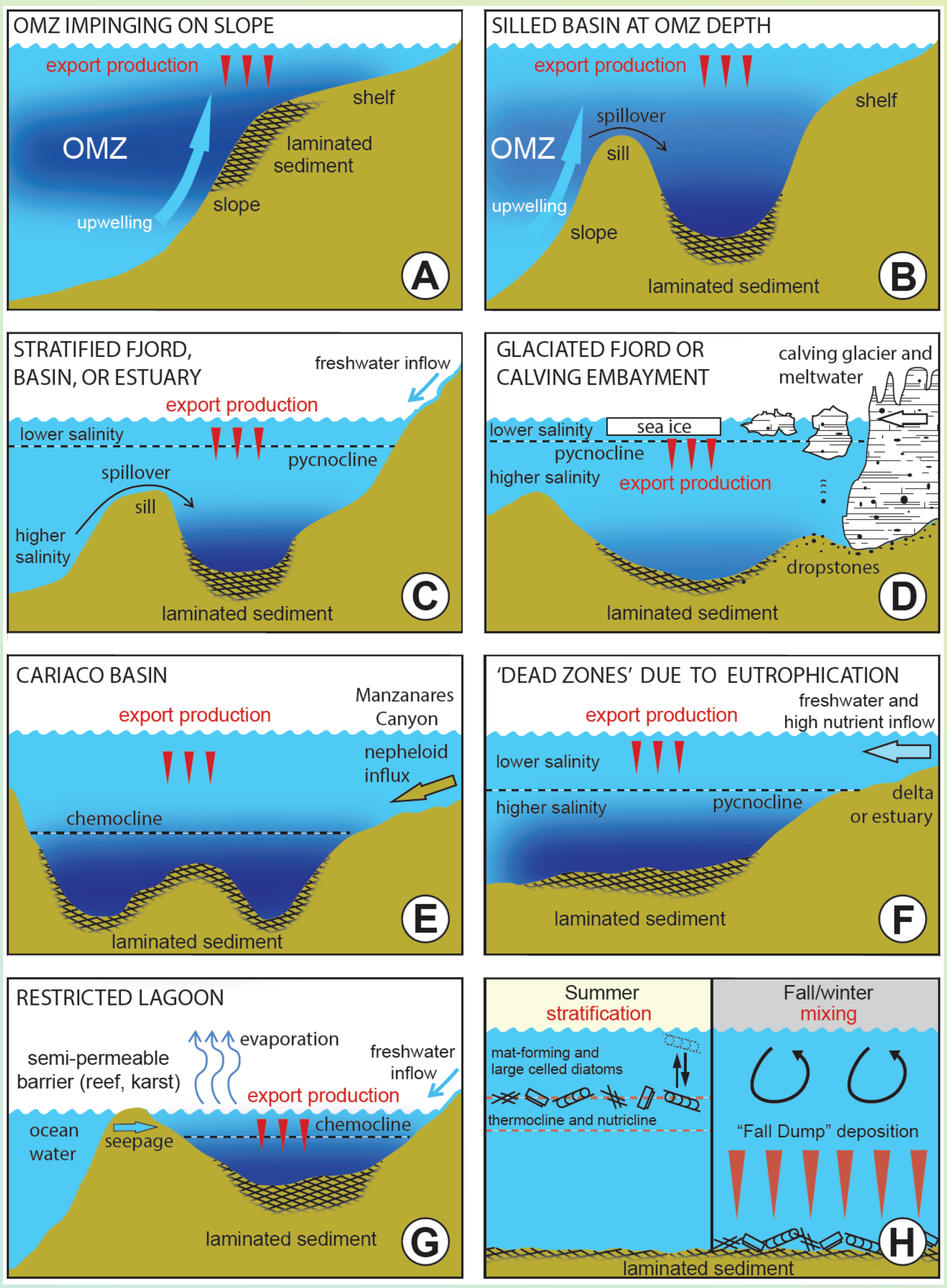
Marine varves are finely laminated sediments with seasonally alternating components that have been deposited from marine or brackish waters in connection with the global ocean. Varve sequences are natural archives of paleoenvironmental conditions that offer accurate internal time control in calendar years, exceptionally high temporal resolution, and the possibility to calculate flux rates. Varve records can typically provide longer-term perspectives on environmental dynamics, and can thus offer detailed information for the reconstruction of paleoenvironments and competent advice in the development of environmental policy. The global compilation of reported marine varved sedimentary records throughout the Quaternary contains 52 sites (*Earth-Science Reviews* 2016, v. 159, 215-246. http://dx.doi.org/10.1016/j.earscirev.2016.04.009)

1 Deep Inlet, Alaska, USA
2 Disenchantment Bay, Alaska, USA
3 Muir Inlet, Alaska, USA
4 Adélie Basin, Antarctic Margin
5 Dumont d'Urville Trough, Antarctic Margin
6 East Antarctic Margin: Iceberg Alley, Nielsen Basin, Svenner Channel
7 Mertz Ninnis Trough, Antarctic Margin
8 Palmer Deep, Antarctic Margin
9 Ross Sea, Antarctic Margin
10 Weddell Sea, Antarctic Margin
11 Arabian Sea off Pakistan
12 Ångermanälven estuary, Baltic Sea, Sweden
13 Baltic Sea south of Åland, Sweden
14 Edsviken Bay, Baltic Sea, Sweden
15 Gotland Deep, Gulf of Finland, Baltic Sea
16 Kalixälven estuary, Baltic Sea, Sweden
17 Middle-Swedish ice-marginal formation
18 Säveån valley, Sweden
19 South-central Swedish lowlands
20 St. Anna archipelago, Baltic Sea, Sweden
21 Bering Sea
22 Black Sea
23 Alison Sound, British Columbia, Canada
24 Effingham Inlet, British Columbia, Canada
25 Frederick Sound, British Columbia, Canada
26 Saanich Inlet, British Columbia, Canada
27 Santa Barbara Basin, California, USA
28 Cariaco Basin, Venezuela
29 Celtic-Armorican Margin, off France
30 Sermilik Fjord, Greenland
31 Alfonso Basin, Gulf of California, Mexico
32 Guaymas Basin, Gulf of California, Mexico
33 Carmen Basin, Gulf of California, Mexico
34 Pescadero Basin, Gulf of California, Mexico
35 Japan Sea
36 'Marine lakes' Veliko Jezero, Malo Jezero, Mediterranean, Croatia
37 Etoliko Lagoon, western Greece
38 'Marine' Lake Butrint, Albania
39 Mediterranean off Nile estuary, Egypt, and Napoli mud volcano, Italy
40 Benguela Current off Namibia
41 Northern-Central California Margin, USA
42 Norwegian Sea
43 Peruvian Margin
44 Pettaquamscutt River estuary, Rhode Island, USA
45 Rivière Nastapoka area, Québec, Canada
46 St. Lawrence estuary, Canada
47 Gulf of Aden, Red Sea area
48 Shaban Deep, Red Sea
49 Kongsfjorden, Svalbard Archipelago
50 Tempelfjorden, Svalbard Archipelago
51 Tay estuary, Scotland
52 Whidbey Island, Washington, USA

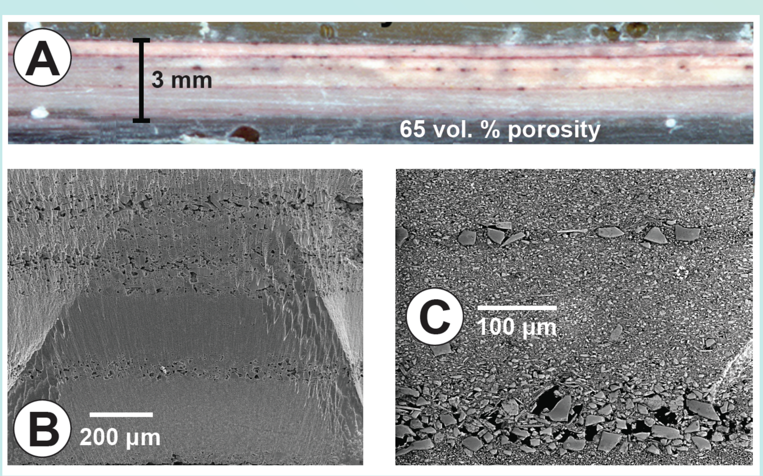


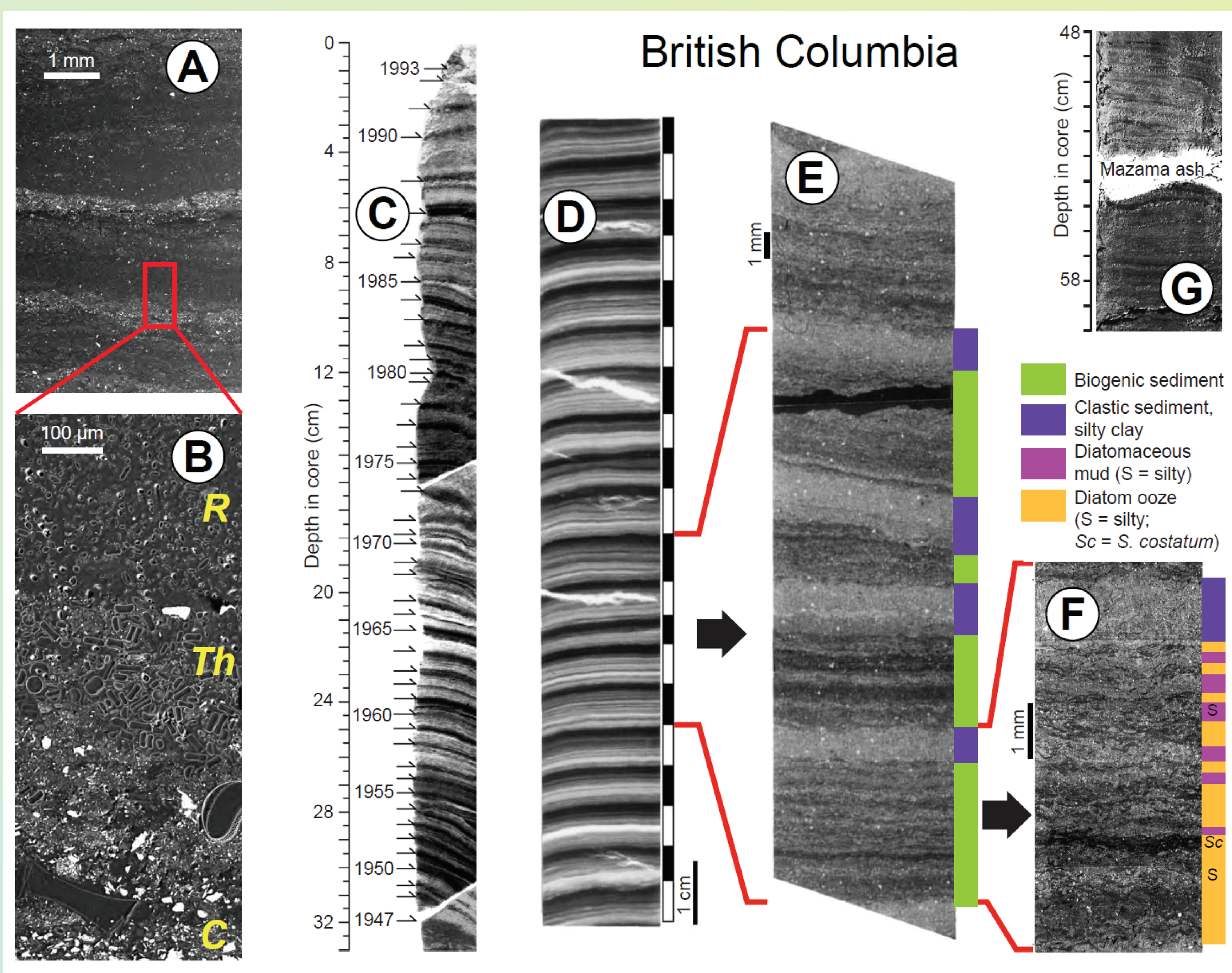
The close proximity of Quaternary varved sites to shore is caused by the need for sufficiently high sedimentation rates that is sometimes combined with the impingement of a mid-depth Oxygen Minimum Zone. In contrast, vast Mesozoic ocean basins transiently became suboxic or even anoxic and would likely have produced a wider-spread pattern of varve occurrence.



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 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. The sketches identify 8 types of idealized and simplified marine sedimentary environments and processes where modern deposition and preservation of laminated sediments have been observed.

Caution is advised when interpreting ancient laminated rocks. Laminations can also result from bedload transport. (**A**) Light-microscopic image of laminations resulting from sediment accumulation via migrating floccule ripples in a flume experiment. Red laminae are due to addition of spikes of powdered hematite to the flume current. (**B** and **C**) Scanning electron microscopic images of dried and ion-milled flume deposits from an experiment with a clay and silt mixture; laminae of coarse silt indicate the segregation of coarse silt from clay floccules during bedload transport.





Examples of marine varves from British Columbia. (**A**, **B**) Backscatter electron images (BSEI), Effingham Inlet (Chang et al., 2003); (**C**) X-radiograph, Effingham Inlet, varves AD 1947-1993 (Dallimore et al., 2005). (**D**) X-radiograph, Saanich Inlet, with (**E**, **F**) BSEI enlargements (Dean et al., 2001; Dean & Kemp, 2004). (**G**) Photograph of the 7645 cal BP Mazama tephra marker layer in ODP 169S-1033B-5H6 (Blais-Stevens et al., 2001).

Blais-Stevens et al., 2001. *Marine Geology* **174**, 3-20.
Chang et al., 2003. *Palaios* **18**, 477-494.
Dallimore et al., 2005. *Marine Geology* **219**, 47-69.
Dean & Kemp, 2004. *P3* **213**, 207-229
Dean et al., 2001. *Marine Geology* **174**, 139-158.