The ocean-sediment system and stratigraphic modeling in the North Atlantic

Bernd Joachim Haupt and Karl Stattegger

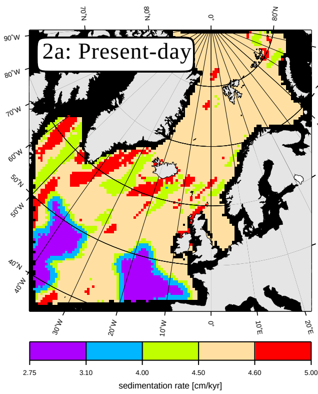
Sonderforschungsbereich 313,Univ. Kiel, Germany
E-mail: bjhaupt@essc.psu.edu
WWW: http://essc.psu.edu/~bjhaupt

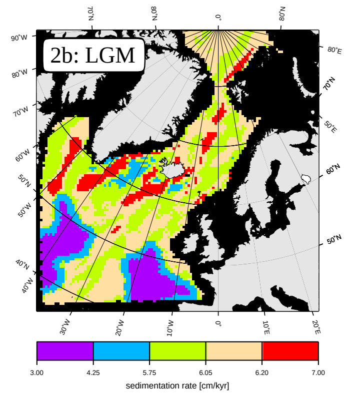
Geologisch–Paläontontologisches Institut,
Universität Kiel, Germany
E-mail: kstattegger@gpi.uni-kiel.de

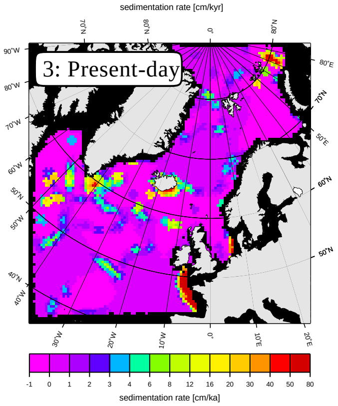
The 3–D forward sedimentation model SEDLOB (SEDimentation in Large Ocean Basins) is used to simulate the climatically driven Quaternary sedimentation history of the North Atlantic (Haupt et al., 1994, 1995, 1998). This model is driven by the thermohaline oceanic circulation and coupled to an ocean general circulation model.

Sedimentation processes including erosion, transport and deposition in large ocean basins depend strongly on sediment input from various sources and on ocean circulation patterns. Sedimentation and ocean thermohaline circulation are controlled to a large extent by the morphology of a basin and by climate, and are subject to long term tectonic and short term climatic changes. Process–oriented 3–D modeling of sedimentation in the North Atlantic should be performed on the basis of (a) an adequate geologic/oceanographic data base; (b) efficient algorithms and parameterization for the simulation of sedimentation processes; (c) accurate model initialization with respect to the external forcing of sedimentation and (d) reproducible model validation in comparison to the modern state of the investigated system.

We use SEDLOB to generate basin–wide glacial and interglacial sedimentation patterns of the North Atlantic. Sediment accumulation is integrated over time spans covering succeeding cold and warm periods as defined by the high–resolution Plio/Pleistocene sedimentary record. Synthetic stratigraphic sections are obtained from this climatically forced basin fill. Examples with maps and synthetic cross sections are presented for the North Atlantic using stratigraphic data from sediment cores covering the last 2.62 million years.







(FIG 2a) Present–day and (FIG 2b) LGM sedimentation rate (centimeters/1000 years). Only the eolian sediment input from the atmosphere (1x10**-13g/cm**2 s) is considered (Miller et al., 1977; Honjo, 1990). The critical velocities for starting of bed load and for beginning of suspension load are set to 0.05 cm s^{-1}.

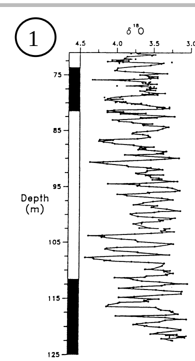
(FIG 3) Present–day sedimentation rate (cm/1000 years). In comparison to experiment HM1 (FIG 4a) additional lateral sediment sources from rivers and coastal melting icebergs are applied (Haupt, 1995; Haupt et al., 1997). Furthermore, the critical velocities for starting of bed load and for beginning of suspension load are set to 0.002 cm s^{-1} respectively 0.02 cm s^{-1} to initiate higher transports.

Climatic period	age in ka	duration in ka
warm	0–16	16
cold	16–113	97
warm	113–143	30
cold	143–194	51
warm	194–223	29
cold	223–294	71
warm	294 –327	33
cold	327–374	47
warm	374–421	47
cold	421–477	56
warm	477–497	20
cold	497–516	19
warm	516–589	73
cold	589–662	73
warm	662–697	35
cold	697–790	93
warm	790–817	27
cold	817–853	36
warm	853–950	97
cold	950–983	33
warm	983–1052	69
cold	1052–1072	20
warm	1072–1128	56

Climatic period	age in ka	duration in ka
cold	1128–1159	31
warm	1159–1185	26
cold	1185–1242	57
warm	1242–1259	17
cold	1259–1290	31
warm	1290–1319	29
cold	1319–1336	17
warm	1336–1359	23
cold	1359–1377	18
warm	1377–1396	19
cold	1396–1420	24
warm	1420–1445	25
cold	1445–1468	23
warm	1468–1483	15
cold	1483–1518	35
warm	1518–1538	20
cold	1538–1575	37
warm	1575–1624	49
cold	1624–1655	31
warm	1655–1679	24
cold	1679–1695	16
warm	1695–1729	34
cold	1729–1754	25

Climatic period	age in ka	duration in ka
warm	1754–1775	21
cold	1775–1801	26
warm	1801–1917	116
cold	1917–1960	43
warm	1960–1985	25
cold	1985–2006	21
warm	2006–2022	16
cold	2022–2037	15
warm	2037–2092	55
cold	2092–2131	39
warm	2131–2166	35
cold	2166–2191	25
warm	2191–2278	87
cold	2278–2296	18
warm	2296–2424	128
cold	2424–2454	30
warm	2454–2471	17
cold	2471–2525	54
warm	2525–2576	51
cold	2576–2595	19
warm	2595–2620	25

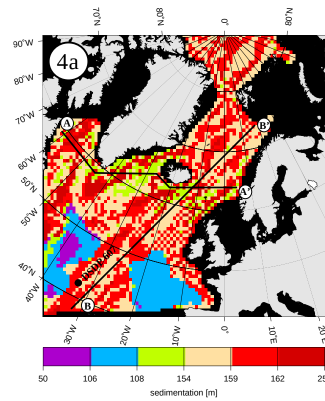
(Table 1) North Atlantic site DSDP 607 (Raymo et al., 1989; Ruddiman et al. 1989), following the oxygen isotope timescale of Shackleton et al. (1990), was used for stratigraphic calibration of glacial and interglacial stages. From the astronomically tuned and globally correlated oxygen isotope record (cf. Tiedemann et al., 1994) stages 1 to 104 close to the Matuyama/Gauss magnetic boundary were used, covering the last 2.62 Ma. Cold and warm periods were distinguished based on the oxygen isotope curve. A continuous time sequence of 33 cold and 34 warm periods was elaborated taking into account shifts in the time dependent mean of oxygen isotope values (Mudelsee & Stattegger, 1997) and a minimum duration of 15000 years per period to contribute noticeably to the build–up of the sediment column. This glacial/interglacial sequence provides the time frame for the basin fill stacking succeeding cold/warm sedimentation patterns.

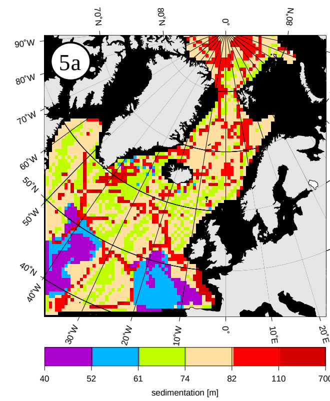


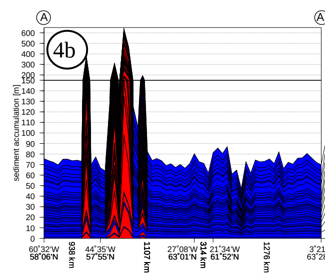
(FIG 1) Site 607 $\delta^{18}O$ record to composite depth, with magnetic polarity of sediments indicated at left (Raymo et al. 1989).

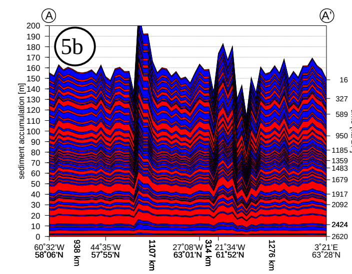
scenario 1

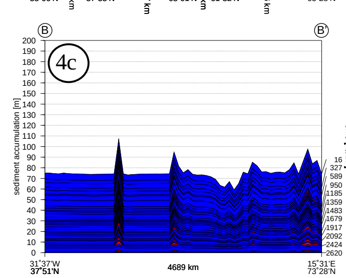
scenario 2

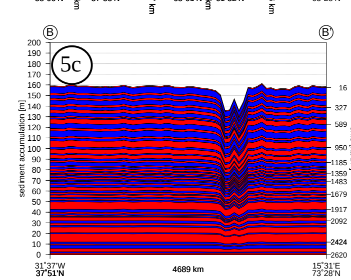












(FIG 4a) Scenario 1: Time–integration and stacking of glacial and interglacial sediment patterns. This scenario uses the sedimentation pattern shown in FIG 2a for the interglacial and that shown in FIG 2b for the glacial state. Additionally, the location of the cross–sections A–A' and B–B' (see FIG 4b, 4c), and the location of the North Atlantic site DSDP 607 (TABLE 1) are shown.
(FIG 4b) Synthetic stratigraphy along the Greenland–Iceland–Faeroer–Scotland Ridge and (FIG 4c) from the Mid–Atlantic Ridge to the border of the Barents shelf in scenario 1 (FIG 4a).
(FIG 5a) Scenario 2: Time–integration and stacking of glacial and interglacial sediment patterns, scenario 1. This scenario uses the sedimentation pattern shown in FIG 3 for the interglacial and that shown in FIG 2b for the glacial state.