

Exam paleoceanography November 4.

1

- a) What are the three most important biogenic components on a global scale that form in the surface waters of the ocean?
- b). Indicate the approximate global average ratios for these three components at formation in the surface waters
- c) Indicate approximate ratios for the same three components for the global average bottom arriving material
- d) Indicate and explain the most important differences between one of these three, carbonate (CaCO_3), and the other two (mention one or more of the following words if applicable: primary production, alkalinity, acidity, degradation/dissolution occurring ... (where/when)..., deep water, distinct areas of production, exposure time to ..., distinct areas of preservation, global similar production rate.

(20 pt)

2.

If we assume a simple global circulation pattern as it is today, with deepwater formation in the north Atlantic, then explain general patterns for the following dissolved compounds, starting in the North Atlantic, mentioning their relative contents in the deep water mass for North Pacific, N. Indian Ocean, South Pacific, South Atlantic, and North Atlantic: motivate your answers

- a. Oxygen (O_2)
- b. Barium (Ba)
- c. Silica (Si of H_4SiO_4 or ' SiO_2 ')
- d. Nitrate (NO_3)
- e. Phosphate (PO_4)
- f. Sodium (Na)
- g. Sulphate (SO_4)

(12 pt)

3.

If during a certain period in the past the same Global circulation pattern would have been two times slower, how would this influence the parameters under question 2 ? Motivate your answer (8pt)

4. Give in your own words a definition for Burial Efficiency and Export Productivity (no formula but description !)

(5 pt)

5.

Wide spread dysoxic conditions in the water column developed several times in Earth's history. Within the water column the developing anoxia mostly follows a similar pattern.

- a) At what depth in the water column would you expect low oxygen concentrations to occur first? Explain why.
- b) Give two proxies for water column dysoxia and explain the processes involved in the proxy recording, discussing potential pitfalls.

- c) Burn down of organic matter after reoxygenation critically relies on which two factors?
 d) Large scale changes in denitrification have been invoked to explain differences in $p\text{CO}_2$ on a sub-Milankovitch time scale (Altabet et al., 2002). Explain how according to Altabet's theory mid depth dysoxia is influencing global $p\text{CO}_2$.
 (20 pt)

6.

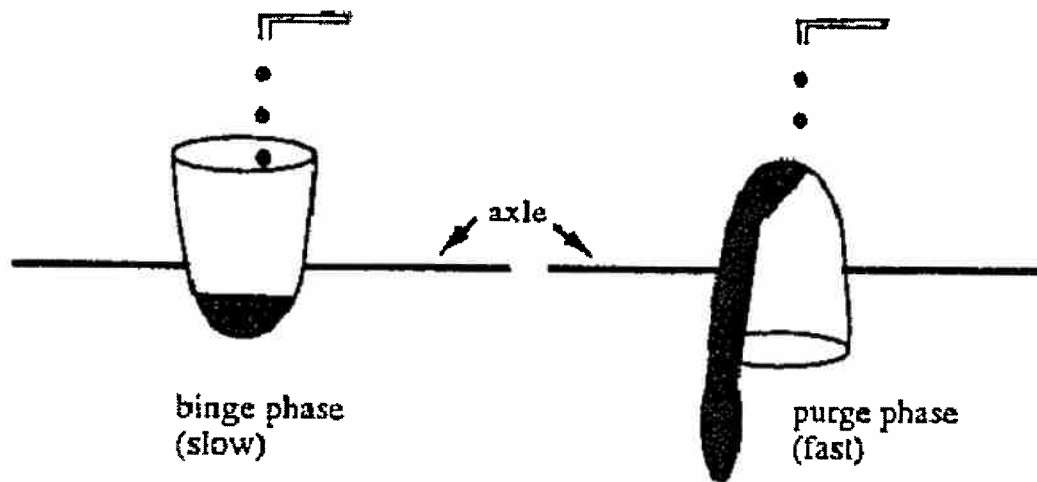


Fig. 1 Schematic illustration of the Bing-Purge principle

MacAyeal (1993) proposed that *Dansgaard-Oeschger* events cannot be caused by external forcing, such as for instance Milankovitch cycles. Instead she proposed the so-called Binge-Purge model, in which a slowly growing ice sheet regularly (e.g. every 7 kyr) suddenly collapses.

- a) What process is responsible for the sudden collapse of the ice sheets in the MacAyeal model?
 b) How would you investigate whether changes in solar activity were involved in rapid climate change?

Since later it was found that these sudden collapses indeed correlate with changes in solar activity the original Binge-Purge theory was revised.

- c) What kind of mechanism was suggested by *Hulbe et al.* to link the collapse of ice sheets to solar activity?
 (15 pt)

7.

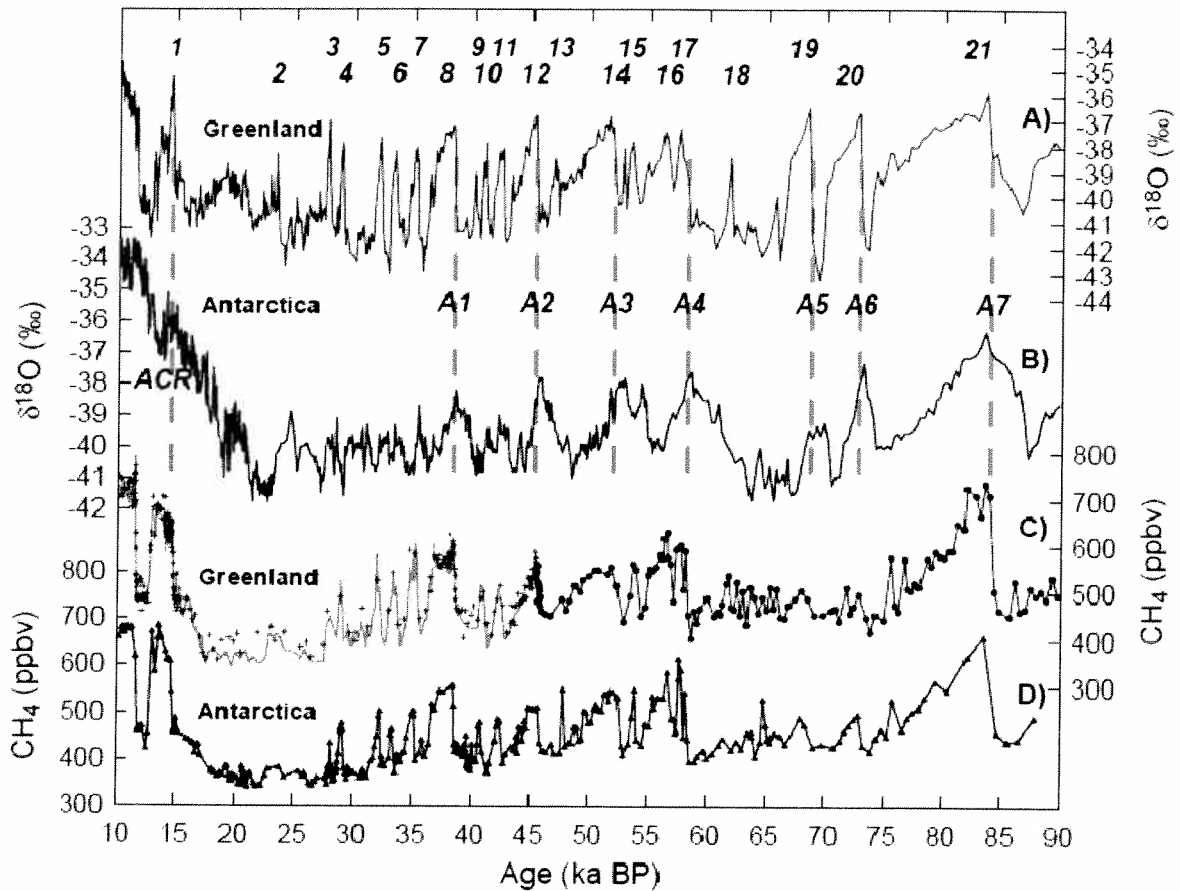


Fig. 2.

Isotopic and CH₄ data from Greenland and Antarctica on the GISP2 time scale. Dashed lines indicate the onset of major D-O events. (A) δ¹⁸O ice from GISP2, Greenland. (B) δ¹⁸O ice from Byrd station, West Antarctica (23). (C) CH₄ data from GISP2 and GRIP. Crosses and dots are from GISP2; the solid gray line is from GRIP. The solid line runs through the data used for the synchronization: GISP2 (black line) up to 45.5 ka and GRIP data (gray line) from 45.5 ka to the Holocene. (D) CH₄ data from Byrd station.

- Figure 2 shows how the northern and southern hemisphere ice records were synchronized using the methane (CH₄) analyzed in gas trapped in the ice. Why was methane used for synchronization?
- The upper two graphs show the oxygen isotopic composition of the ice itself. For which environmental factor is this a proxy?
- The Arctic and Antarctic oxygen isotopic records seem anti-phased. Which mechanism could be responsible for this negative correlation? Explain the sequence of events responsible.
- How could such a sequence of events result in a regular switching from one climatic mode to another?

(20 pt)