2015-2016 GEO4-1415 Paleoceanography and climate variability - Exam

Please add your name and a page number to each sheet that you are using.
Good luck!

Question 1

Stacks of deep-sea foraminiferal benthic oxygen isotope records provide the backbone of paleoceanography. They are important tuning targets, based on which age models are developed for marine sediment cores.

1a) Explain the rationale behind the construction of the SPECMAP oxygen isotope stack and name the main assumptions that are made in the construction of SPECMAP. **(8 Points)**

1b) Describe the most important features and changes of the benthic oxygen isotope record over the last 1.2 million years (trends, frequencies, amplitudes etc.) and briefly discuss the major associated changes in the Earth's climate system. **(8 Points)**

Question 2

Organic-rich sediments are important recorders of past climate variability. Prominent examples are Cretaceous black shale deposits.

2a) Name 3 factors that enhance organic carbon preservation in marine sediments. **(3 Points)**

2b) Describe a possible sequence of events that leads to oceanic anoxic events and the formation of black shales during the Cretaceous starting with globally enhanced volcanic activity. Name proxy records that support your sequence of events. **(10 Points)**

Question 3

Sea surface temperature (SST) reconstructions

3a) Choose one geochemical SST proxy (inorganic or organic) and describe briefly its underlying scientific rationale and its major limitations and main assumptions. **(6 Points)**

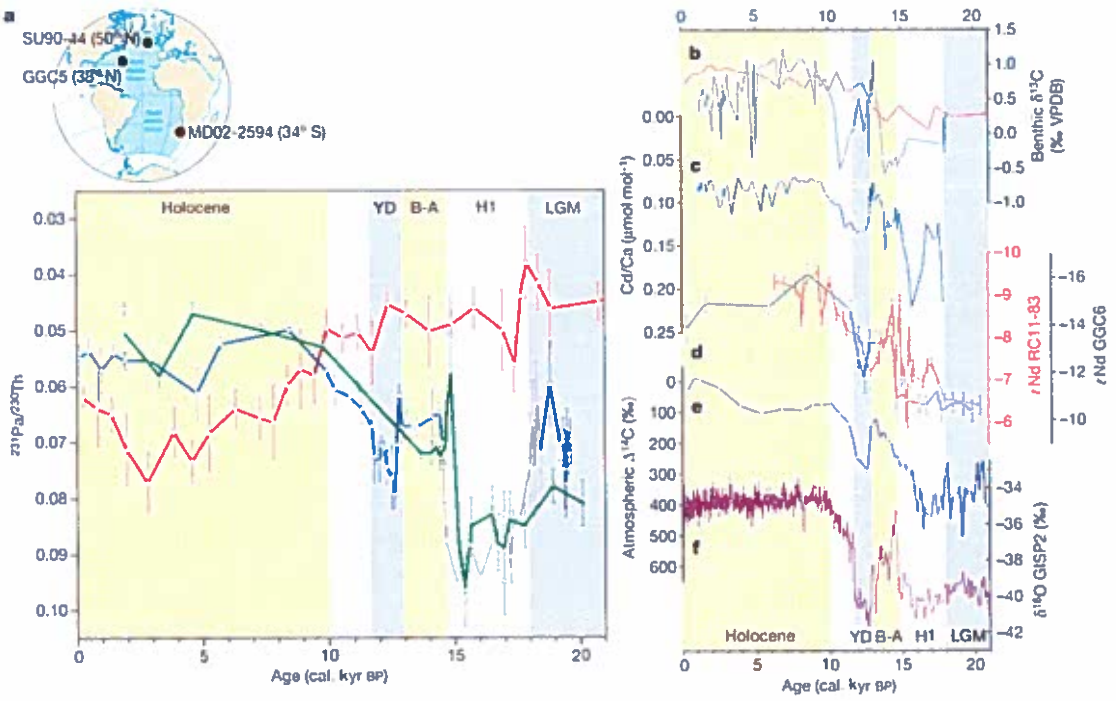
Question 4

Past ocean circulation

4a) The following figure is from a recent *nature* paper. The new dataset from this study is shown in panel a (red line), a Pa/Th record from the South Atlantic over the last 20,000 years. Come up with a short title for this paper and write a short Nature style abstract that could accompany the study **(max. 200 words). (15 Points)**

Try to follow the typical structure of a *nature* style abstract.

- basic introduction with some background (2-3 sentences)
- general problem (1 sentence)
- one sentence with a summary of the results (starting with : "Here we show…")
- main results, and how they add to previous knowledge (2-3 sentences)
- broader perspective (1 sentence)



a, Top, core locations. Bottom, sedimentary $^{231}Pa/^{230}Th$ ratios from Cape Basin (MD02-2594; red; this study), eastern North Atlantic (SU90-44; green)[13] and Bermuda Rise (OCE326-GGC5; blue)[5]. The section 18.6–14.5kyr BP of the OCE326-GGC5 record is influenced by opal scavenging[23] and is drawn in light grey. b, *F. wuellerstorfi* $\delta^{13}C$ measured in Cape Basin (MD02-2594; red; this study) and Bermuda Rise (EN120-GGC1, 33° 40′ N, 57° 37′ W, 4,450 m; blue)[25] corrected for mean-ocean changes[29]. c, Benthic Cd/Ca from EN120-GGC1[25]; d, Nd isotope ratios (εNd) in the Southeast Atlantic (RC11-83, 40° 36′ S, 9° 48′ E, 4,718m; red)[27] and Bermuda Rise (OCE326-GGC6, 33° 41′ N, 57° 35′ W, 4,541m; blue)[6]. e, Atmospheric $\Delta^{14}C$ profile from ODP Site 1002, Cariaco basin[28]. f, $\delta^{18}O$ record from GISP2, Greenland, indicating atmospheric temperature variations[30]. Error bars give analytical s.d. Vertical shading as Fig. 1, with Younger Dryas (YD, 11.5–12.8kyr BP), Bølling–Allerød (B-A; 12.8–14.5kyr BP) and H1 (~16.8kyr BP).

Question 5

Carbon-14 dating

5a) How and where does ^{14}C form? **(4 Points)**

5b) Explain the oceans' reservoir effect on ^{14}C **(6 points)**

5C) explain the impact of solar activity on ^{14}C activity (5 points)

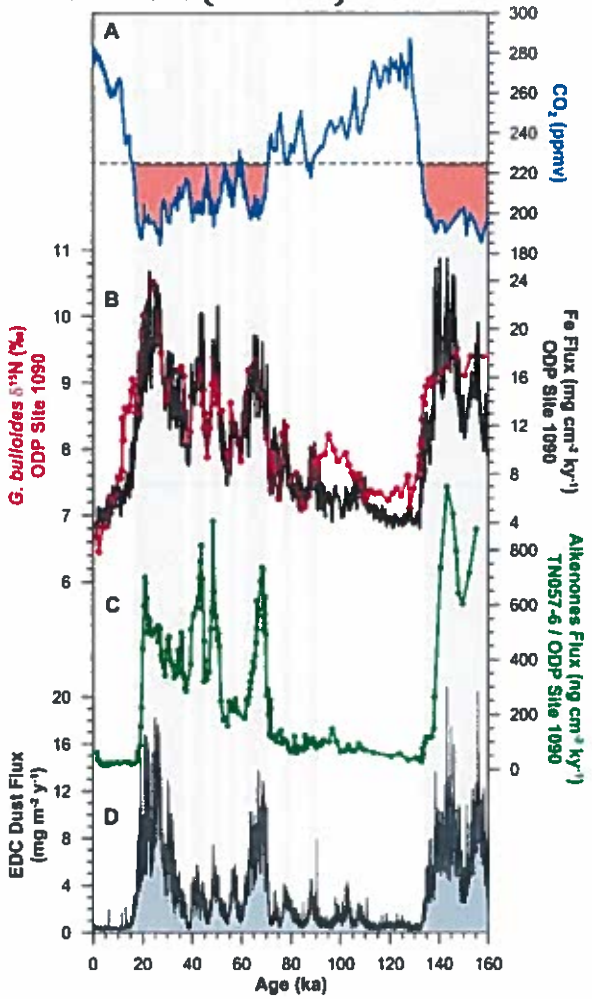
Question 6

Biological productivity in the oceans plays a major role in the global carbon cycle.

6a) Give the Redfield ratio between C, N and P **(2 Points)**

6b) Explain why the precipitation of calcium carbonate enhances pCO_2 **(10 Points)**

6c) The graphs below are from a core in the Atlantic part of the Southern Ocean. Explain how these records show evidence for the role of dust in lowering pCO_2 during glacial conditions **(8 Points)**



Question 7

Past episodes with lower bottom water oxygen concentration played an important role in climate change. To reconstruct past bottom water conditions the distribution of redox sensitive elements is often used.

7a) Name 2 elements enriched commonly under oxic conditions and 2 elements known to be enriched primarily under anoxic conditions **(2 points).**

7b) Trace elements associated with anoxic conditions are potentially remobilized during reoxygenation of the bottom water. Which factors influence the depth into the sediment where trace elements are remobilized during reoxygenation, and explain why? **(5 points).**

7c) Explain why denitrification could affect global productivity and thereby global pCO_2. How could you trace past changes in denitrification? **(8 points)**