Examination Quaternary Geology and Climate Change GEO3-4303

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Carefully read the questions and provide concise but complete answers (with explanation)!

1. Definitions

Briefly indicate the meaning of *5 out of the following* 6 items:

a) Isostatic compensation
b) Equilibrium line of a glacier
c) OSL dating
d) Lysocline
e) Heinrich event
f) Global Warming Potential of a greenhouse gas / aerosol

2. Time control

a. The ^{14}C method has been widely applied in dating materials containing carbon. What is the approximate half-life of ^{14}C?
b. Explain why a ^{14}C age is different from a calendar age. What will be the effect of anthropogenic emissions of CO_2 resulting from fuel combustion on the apparent ^{14}C age of recent samples?
c. Explain how to establish a ^{14}C calibration curve; mention at least tree types of information that can be used, and indicate the approximate time ranges covered by these methods.
d. Which methods are used to date $\delta^{18}O$ curves in ocean cores covering the entire Quaternary?
e. Give at least three methods that can be used for chronological correlation between different ice cores.

3. Climate forcing and control

a. Orbital variations are a major cause of climate change during the Quaternary. Which are the characteristic periods of the Obliquity, Precession and Eccentricity, and explain for each of these whether or not their variations have the same radiation effect on both hemispheres at the same time.
b. Which are the driving factors of the Global Ocean Circulation?
c. Which mechanism causes the Deep Water formation in the Northern Atlantic; how has this mechanism been affected during the past 100 ka; and what were the climatologic consequences?
d. At a certain point in time the following trends in orbital parameters are occurring: Obliquity is decreasing, Precession is shifting such that the Earth is at the perihelion in January, and Eccentricity is high. What are the consequences of this situation for a) growth or decay of the N-hemisphere ice sheets, and for b) the intensity of monsoons in Africa? Explain your answer.

4. Ice cores and ocean records

a. Draw the shape of the $\delta^{18}O$ curve for the past 150.000 years in the Summit (GISP2/GRIP) ice record from Greenland; indicate (schematically) glacial and interglacial periods, Younger Dryas, Dansgaard-Oeschger events and Bond cycles.

b. $\delta^{18}O$ curves can be obtained from ice cores, and from planktonic forams and benthic forams in ocean cores. What is the approximate value range of each of these during glacial and interglacial times?

c. Explain how variations in SST and Ice sheet volume are determined using the $\delta^{18}O$ of the three sources mentioned in b.

d. Explain why ^{13}C isotope records ($\delta^{13}C$) from forams in Pacific Ocean cores indicate the strength of the "Ocean Carbon Pump".

5. Climate forcing and global warming

Although the climate during the Holocene interglacial period can be considered relatively stable when compared at glacial-interglacial time scale, there have been still variations in the global climate, with very different time scales of these variations.

a. Mention at least 4 external climate forcings that have determined the Holocene climate. Indicate for each forcing over which time scale it has determined the climate and how the strength of the forcing can be determined.

b. Which external climate forcings will determine the global climate in the future? Indicate over which time scales these forcing apply, and whether their strength can be predicted in advance.

c. The figure below shows 4 graphs, each indicating a different trend in global mean temperature over the period 1880 – 2000. Graph A is the observed temperature. The other graphs were obtained using GCM experiments driven by different (combinations of) climate forcings. Explain which forcing is reflected by the curves B, C and D.