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The following paragraphs were adopted from several Nature articles (Orr et al., 2012; Phrampus and Hornback, 2012; Svensen, 2012), please read carefully the text and answer the questions listed after.

**(1) Bubble from deep: (30%)**

Gas released from sedimentary basins has been proposed to be a key player in many of the rapid climate changes that occurred in the past 250 million years. The types and sources of the released gases are still debated, but they probably included gases formed by the heating of organic matter around hot magma, and gases released by the dissociation of gas hydrates (solid compounds that trap gas molecules) found in deep-ocean sediments. The influence of hydrates is greater in a warming world because higher ocean temperatures can melt methane-bearing gas hydrates, releasing the gas. The methane can then be oxidized to carbon dioxide, causing ocean acidification, and can contribute to global warming because both methane and carbon dioxide are greenhouse gases. Writing in *Geophysical Research Letters*, Kroeger and Funnell suggest another way in which global warming can lead to increased gas emissions from the sea floor.

Sedimentary basins have large accumulations of biological, inorganic and clastic deposits (which consist of fragments of pre-existing rocks), and are host to more than 99.9% of the organic carbon in Earth's crust. This amounts to a staggering 15,000,000 gigatonnes (Gt) of carbon; for comparison, 3,300 Gt of carbon are stored in all known hydrocarbon and coal reserves. Any viable mechanism for transferring significant quantities of sediment-bound carbon to the atmosphere on a short timescale may thus perturb the global carbon cycle and lead to global warming.

A series of such perturbations has been suggested to have happened in the Eocene epoch (which ran from 55.8 million to 33.9 million years ago) to explain several short-lived climatic anomalies that occurred during a period of otherwise steady warming from 58 to 50 Myr ago. The most prominent of these events was the Palaeocene–Eocene thermal maximum (PETM), which was characterized by global warming of 5–10 °C and subtropical conditions in the Arctic. One cause of the PETM is commonly assumed to have been methane release to the atmosphere that was triggered either by the melting of gas hydrates or by the heating of rocks rich in organic material in sedimentary basins (caused by widespread volcanic activity in the northeast Atlantic region).

(背面仍有題目,請繼續作答)

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**Please briefly answer the following questions: (6% each)**

Q1, What is the "gas hydrate" mentioned in the text?

Q2, Why the influence of hydrate is greater in a warming world?

Q3, What are green house gases and how were these gases affecting the average global air temperature in PETM period?

Q4, What is PETM event and what are the possible causes?

Q5, Is there any useful resource reported offshore southwestern Taiwan?

**(2) Please translate the following paragraphs into Chinese (8% each)**

a), Today's surface ocean is saturated with respect to calcium carbonate, but increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations, and thus the level of calcium carbonate saturation.

b), Recent predictions of future changes in surface ocean pH and carbonate chemistry have primarily focused on global average conditions or on low latitude regions, where reef-building corals are abundant.

c), In our projections, Southern Ocean surface waters will begin to become undersaturated with respect to aragonite, a metastable form of calcium carbonate, by the year 2050. By 2100, this undersaturation could extend throughout the entire Southern Ocean and into the subarctic Pacific Ocean.

d), Methane hydrate, a solid consisting of methane and water, is stable at high pressures and low temperatures. Owing to a positive thermal gradient in the Earth, methane hydrate exists only within the first few hundred meters of sediments in deep marine settings, below which methane gas and liquid water are stable.

e), A growing concern among scientists is that ocean acidification, driven by climate change, will reduce the abundance of calcium carbonate in the seas, making it difficult for algae to form their microscopic plating, essential for their survival.

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**(3), The following report is adopted from Phrampus and Hornback (2012) article on "recent changes to the Gulf Stream causing widespread gas hydrate destabilization". Please read carefully the text and fill in appropriate words in the designated (marked in the parentheses) space. (30%)**

The Gulf Stream is an ocean current that modulates climate **(1)** the Northern Hemisphere by transporting warm waters **(2)** the Gulf of Mexico into the North Atlantic and Arctic oceans. A changing Gulf Stream has the potential to thaw and convert hundreds of gigatonnes of frozen methane hydrate trapped **(3)** the sea floor into methane gas, increasing the risk of slope failure and methane release. How the Gulf Stream changes **(4)** time and what effect these changes have on methane hydrate stability is unclear. Here, using seismic data combined with thermal models, we show that recent changes in intermediate-depth ocean temperature associated **(5)** the Gulf Stream are rapidly destabilizing methane hydrate **(6)** a broad swathe of the North American margin. The area of active hydrate destabilization covers **(7)** least 10,000 square kilometres of the United States eastern margin, and occurs in a region prone to kilometre-scale slope failures. Previous hypothetical studies postulated that an increase of five degrees Celsius in intermediate-depth ocean temperatures could release enough methane to explain extreme global warming events **(8)** the Palaeocene–Eocene thermal maximum (PETM) and trigger widespread ocean acidification. Our analysis suggests that changes in Gulf Stream flow or temperature **(9)** the past 5,000 years or so are warming the western North Atlantic margin by up to eight degrees Celsius and are now triggering the destabilization of 2.5 gigatonnes of methane hydrate (about 0.2 per cent of that required to cause the PETM). This destabilization extends along hundreds of kilometres of the margin and may continue **(10)** centuries. It is unlikely that the western North Atlantic margin is the only area experiencing changing ocean currents; our estimate of 2.5 gigatonnes of destabilizing methane hydrate may therefore represent only a fraction of the methane hydrate currently destabilizing globally. The transport from ocean to atmosphere of any methane released—and thus its impact on climate—remains uncertain.