南海晚第四紀氧碳同位素地層學及古海洋學研究

Late Quaternary Oxygen and Carbon Isotope Stratigraphy and Paleoceanography, South China Sea

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節要

本研究分析位於菲律賓巴拉望島西北部之 IMAGES-III岩心 MD972142（12°41.33'N, 119°27.90'E, 水深 1557 公尺）上部 20 公尺的浮游有孔蟲 *Globigerinoides ruber* 之氧同位素組成，建立了晚第四紀過去 35 萬年之氧同素地層。MD972142 的氧同位素架構大致與 SPECMAP stack 相符，但在上次間冰期與大洋的記錄差異甚大。MD972142 的氧同位素值亦低於鄰近蘇祿海的紀錄，而且在幾次的間冰期南海東南部與蘇祿海的氧同位素紀錄差值加大，可能顯示間冰期時中南半島、蘇門達臘、婆羅州附近的雨量增加，供給南海東南大量淡水來源，造成南海東南部與蘇祿海的鹽度差異。此外，MD972142 的碳同位素在每次冰消期時呈現低值，表示來自大陸棚的有機陸源物質供應量突增，反映了冰期、間冰期海水面變化對南海地區所造成的影響。MD972142 的氧同位素紀錄顯示作為西太平洋暖池的西緣地帶，南海東南部在過去 35 萬年中水文狀態變化頻繁，呈現放大的冰期—間冰期氣候旋迴效應。

關鍵詞：第四紀，氧同位素地層，古海洋，南海

Abstract

Oxygen isotope stratigraphy based on planktonic foraminifera *Globigerinoides ruber* in core MD972142 (12°41.33'N, 119°27.90'E, 1557m depth) was established for the past 350 kyrs. Core MD972142, located on the continental slope on the northwest side of Palawan Island, provides a unique sequence excellent for regional correlation because this long and continuous record contains well-preserved calcareous microfossils and numerous discrete tephra layers. The oxygen isotope variation pattern of MD972142 differs from that of SPECMAP stack in that it shows lighter $\delta^{18}O$ values than SPECMAP during the last interglacial and some glacial periods. The differences of $\delta^{18}O$ values between glacial and interglacial periods are much larger than that shown in Sulu Sea.

Furthermore, the oxygen isotope values of MD972142 were much more negative than those of cores in the Sulu Sea during interglacial periods. We interpret this phenomenon as caused by enhanced precipitation over the Indochina, Sumatra and Borneo areas during interglacial periods. Accompanied with each drastic deglaciation $\delta^{18}O$ transition, carbon isotopic composition also shows concomitant depletion, indicating major transport of terrestrial organic matters from continental shelf to the SCS during sea-level rise. The MD972142 planktic oxygen isotope profile attests that the western margin of the Western Pacific Warm Pool (WPWP) over the southeastern South China Sea region has been highly unstable over the past 350 thousand years.

Keywords: Quaternary, Oxygen Isotope Stratigraphy, Paleoceanography, South China Sea

Introduction

The South China Sea (SCS) is the largest marginal sea of western Pacific. The sediments of the SCS are very sensitive to monsoonal changes and this region plays an important role in the monsoon system (Wyrtki, 1961; Wang and Wang, 1990).

West Pacific Warm Pool (WPWP), the tropical region in Pacific with annul average temperature above 28℃, serves as an important source of heat and moisture for higher latitudes (Thunell and Miao, 1996). It is known that Sulu Sea and part of the southern South China Sea belong to the WPWP at present (Miao and Thunell, 1994). Core MD972142, located on the continental slope on the northwestern side of Palawan Island, sits just on the margin of WPWP, is likely to have recorded long-time paleoceanographic conditions of the southeastern South China Sea and therefore serves a good monitor of the stability of the WPWP.

The purpose of this study is to establish a long-term, continuous oxygen isotope stratigraphy of the past 350 kyrs for the South China Sea. Such a record can reveal for the first time the long-term paleoceanographic fluctuation of the South China Sea and provide a reference oxygen isotope stratigraphic profile to facilitate further chronostratigraphic correlation for the western Pacific region.

Results and Discussion

The oxygen isotope profile obtained can be correlated to the SPECMAP Stack (Imbrie et al., 1984; Prell et al., 1986) augmented with additional chronological delineators such as the five ^{14}C dating points and the LAD of pink *G. ruber*. The top 20 meters of MD972142 record a continuous sequence of oxygen isotope stages 1 - 10. The sedimentation rates of various intervals were calculated as follows: ~15.7cm/ky for the Holocene, ~18.9cm/ky for oxygen

isotope stage 2, 5.5~6.5cm/ky for stages 3 and 4, 4~5cm/ky for stages older than stage 4.

The oxygen isotopic values of MD972142 in the Holocene fluctuate from -3.5‰ to -3.0‰. These values are similar to those of an adjacent core, GGC-9, of which $\delta^{18}O$ data were based on *G. sacculifer* (Thunell and Miao, 1996), but the oxygen isotopic values of MD972142 depart from those of core ODP769 in the Sulu Sea of which $\delta^{18}O$ data were based on the same species, *G. ruber* (Linsley and Dunbar, 1994; Linsley, 1996). The differences in $\delta^{18}O$ between the two basins reach to 0.5~0.7‰. This suggests that the discrepancy in $\delta^{18}O$ does not mainly result from the vital effects of the two planktonic foraminifera species, *G. ruber* and *G. sacculifer*, but from different hydrological conditions between the South China Sea and Sulu Sea.

In contrast to the interglacial periods, the oxygen isotopic values during the glacials of MD972142 were closer to those of ODP769 (Sulu Sea). In other words, the difference in $\delta^{18}O$ between these two sites decreases during glacial periods but increases during interglacials. This result is somewhat counter-intuitive in that the two basins should be more isolated from each other during glacial periods when sea level dropped and therefore they show different values. On the other hand, there should be more water exchange between these two basins and resulted in a more mixed, homogeneous hydrography during interglacial times.

Given the fact that both sites (MD 972142 in the SCS and ODP 769 in the Sulu Sea) are located in the northwest margin of the West Pacific Warm Pool with similar latitudes, the oxygen isotopic values obtained from the same species of planktic foraminiferal tests are expected to be the same, or at least, similar. The observed differences in the oxygen isotopic values between the two sites ($\delta^{18}O_{MD142} - \delta^{18}O_{ODP769}$) are quite significant, ranging from –1.5‰~ 0.5‰. Such discrepancies must result from a significant difference in temperature or salinity, or a combination of both, of the surface waters of these two basins.

Summary and Conclusions

The planktic stable oxygen isotope stratigraphy at Site MD972142 provides a continuous climatic record from hemipelagic sediments of the southeastern South China Sea. The 350-kyr oxygen isotope profile can be correlated to the SPECMAP stack and hence serves as a reference stratigraphy for the western Pacific region. The amplitudes of $\delta^{18}O$ fluctuations during isotopic stage 5 is much larger than that shown in the SPECMAP, implying a local amplification of the signals due to changes in surface temperature and salinity. Significant lighter $\delta^{18}O$ values during the interglacial periods compared to the Sulu Sea ODP 769 record suggest

strongly that the South China Sea was under a different salt budget, probably caused by enhanced precipitation over the Indochina, Sumatra and Borneo areas. Accompanied with each drastic deglaciation $\delta^{18}O$ transition, carbon isotope composition also shows concomitant depletion, indicating major transport of terrestrial organic matters from continental shelf to the SCS during sea-level rise. The large variation of oxygen and carbon isotopic signals at this site is considered to be an amplification of the glacial-interglacial climatic variability. The fluctuation was manifested mainly by the expansion and shrinkage of the West Pacific Warm Pool over the southeastern SCS, and secondly by the corresponding changes in precipitation/runoff experienced by the surrounding land masses of the SCS.

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