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Rewiew PhD dissertation MSc Michal Tomczak

Paleoenvironmental reconstructions in the north-western South China Sea over the last 140000 years: a multi-proxy approach

Short overview of the structure of the thesis

The thesis is a monograph consisting of 8 chapters, 1 – Introduction, 2 – Research area, 3 – Material and Methods, 4 – Results, 5 – Discussion, 6 – The north-western South China Sea during the last glacial/interglacial cycle (Summary), 7 – Conclusions and perspectives, 8 – References, and Appendices 1 - 8. Parts of results have already been published in two articles with M. Tomczak as second author and co-author respectively (Geological Society of London, Special Publication Series, v. 429).

Objectives of the thesis' research

Main objectives of the thesis are the analysis and interpretation of proxies for environmental variables aiming at the reconstruction and explanation of climate changes in the northwestern South China-Sea region during the last 140000 years. This goal should be achieved by estimating paleo-oceanographic conditions of surface waters such as temperature, salinity and primary productivity as well as sea-level changes and effects on the depositional environment. The multi-proxy approach is expected to allow the qualitative and quantitative reconstruction of climatic and oceanographic parameters with their variability in time and the identification of the driving forces for climatic and oceanic variability as well as to explain the interaction with the East Asian monsoon system, sea-level fluctuations, and solar radiation.

Summary and quality of main findings and scientific achievements

Sedimentological and analytical work was performed on sediment samples from piston cores PC83 and PC111 from the deeper Part of the South China Sea southeast of Hainan Island and from 88.3 m long drill core HDQ2 from the shelf west of Hainan Island and.

Backbones of the study are the age models of the three cores using radiocarbon and OSL dating, paleo-magnetic and SST data. Age models were developed separately for the long core HDQ2 (100000 years) and a composite profile of the two piston cores (140000 years). From the age models the records of the individual variables used for the multi-proxy estimates could be reconstructed with a resolution of 150 – 1500 years.

In his multi-proxy approach M. Tomczak analyzed diatom assemblages in great detail from water samples, surface sediments and sediment core 83PC. The composite profile 83PC and 111PC was analyzed for total organic carbon (TOC) and C/N ratios, C₃₇ alkenone concentrations and U^K₃₇ sea surface temperatures (SST), core 83PC for the stable isotopes ¹³C and ¹⁵N.

Concerning diatom studies, 47 genera and 116 species were identified in the plankton samples of the water column, which consist mainly of common and widespread marine, warm to temperate water species. Only five out of 24 surface sediment samples contained enough diatoms for a reliable analysis. Surface sediments are dominated by benthic and coastal-neritic species, water samples by planktonic tropical marine species. From a total of 61 species 40 species are present in both water and sediment samples. 53 diatom species were identified in the down-core record of core 83PC. A list of identified diatom species with photographic documentation can be found in Appendix 6 and 7. Five diatom zones (DAZ 5 to DAZ 1) along the core could be distinguished and are closely related to marine isotope stages MIS 1 to MIS 5.

TOC values vary according warmer and colder (inter)glacial stages along the 140000 years record. Highest values were reached at the end of MIS6, MIS 3 and MIS 2 and lowest values during MIS 5e and MIS 1, the Holocene. C/N values have been calculated only from measurements of core 83PC and show a similar trend for the last 100000 years. ¹³C and ¹⁵N stable isotopes were measured in core 83PC. ¹³C values reflect changes between colder and warmer climatic stages, while the variability in ¹⁵N values is relatively low.

U^K₃₇-based SST reconstructions from the composite profile span the last 140000 years and contain a good record of the last two deglaciations. Lowest SST's occurred in MIS 4 and late MIS 2 in the Oldest Dryas period. During the transition from MIS 6 to MIS 5e SST increase was higher compared to the transition from MIS2 to MIS 1. The SST reconstructions are generally in good agreement with published paleo-oceanographic records concerning general temperature trends but the SST's southeast of Hainan Island are lower than in the central and southern parts of the South China Sea, especially during glacial stages. The differences between northern and southern parts of the South China Sea are explained by higher intensity of the winter monsoon in the north. Reconstructed U^K₃₇ temperatures were compared to published Mg/Ca-based temperatures in core 83PC. Alkenone-based temperatures are considerably lower than Mg/Ca-based temperatures due to the assumption that alkenones derived from haptophytic algae reflect mean annual SST while Mg/Ca ratios from the foraminifer *Globigerinoides ruber* reflect summer temperatures.

$\delta^{18}\text{O}$ values of planktic foraminifera from core 83PC (not mentioned in the Methods and Results sections) were used to reconstruct sea surface salinity (SSS). The local SSS record does not follow climatic changes directly but seems to depend more on changes in evaporation, precipitation and river runoff.

The seismic architecture on the shelf west of Hainan Island together with core HDQ2 was interpreted in terms of local and global sea-level fluctuations. M. Tomczak describes six sedimentary units and seven reflectors from the interval MIS 5d up to now with a coarse-grained section at the base of each cycle. The author shows the relation of key-reflectors to sea-level minima in global sea-level curves (Fig. 36) but the boundaries of the sedimentary units do not always coincide with the positions of key-reflectors (unit 2, R4.1 within unit 4, R5 within unit 5). Unfortunately the quality of Fig. 14 showing the seismic section with the reflectors R1 to R 6/7 is too low to elucidate this problem.

Fig. 38 shows a strong disagreement between sea-level rise and SST rise during last deglaciation. The distinct phase of highly accelerated sea-level rise during meltwater pulse 1A around 14500 calendar years ago corresponds to the lowest SST values of MIS 2. A second phase of accelerated sea-level rise evidenced from the southern Vietnam Shelf between 9000 and 8200 calendar years ago corresponds to a phase of lowered SST's in the composite record.

A wide range of indicators (C_{37} , $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, TOC, C/N, diatom abundances) was used to reconstruct paleo-productivity from core 83PC. Productivity increased during glacial intervals and decreased during interglacial stages. $\delta^{13}\text{C}$ values indicate marine origin of organic matter with a higher tendency towards terrestrial sediment supply from MIS 4 to MIS 2. Changes in diatom productivity are also discussed with the conclusion that the significance of diatom abundance is limited due to the low preservation potential of siliceous diatom frustules and reinforced dissolution of biogenic opal during the glacial periods.

M. Tomczak summarized properly the new findings from his doctoral dissertation in terms of a strong paleo-climatic interpretation in chapter 6. This interpretation contributes to a better understanding of the Late Quaternary history of the northwestern South China Sea. In the conclusions (chapter 7) the most important results are highlighted and completed by an outlook of potential further research activities.

Core descriptions from cruise FENDOU5 (Beibu Gulf, 2009), detailed lithological description of core HDQ2, list of the recognized diatom species with photographic documentation of common species supplement the data used in the thesis.

M. Tomczak could improve the knowledge on the paleo-climatic and paleo-oceanographic evolution of the northwestern South China Sea region in the Late Quaternary by important new results of his PhD thesis. Despite of some shortcomings as mentioned above the good overall quality makes the thesis a valuable piece in geoscientific research of the hitherto poorly investigated region of the northwestern South China Sea.

Conclusion

In my opinion the reviewed dissertation justifies that its author, Mr. MSc Michal Tomczak

- has the knowledge and skills enabling independent research in the science field geosciences, discipline oceanology;

- is able to choose and formulate correctly a scientific research problem and consistently pursue its verification;
- knows how to find proper research methods and use them, and in particular the methods of paleo-oceanographic and paleo-climatic proxies;
- is able to draw conclusions, discuss and present them comprehensibly.

In consideration of the above I affirm that the reviewed work *Paleoenvironmental reconstructions in the north-western South China Sea over the last 140000 years: a multi-proxy approach* can be accepted as a doctoral dissertation in the science field geosciences, discipline oceanology and admitted to the public defense.



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