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PhD Dissertation Assessment
(Recenzja pracy doktorskiej)

Author: **Jinpeng Zhang**

Title: '*Diatoms in the Northwestern South China Sea continental margin sediments: reconstruction of Late Pleistocene and Holocene paleoenvironments*'

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1. Introduction

Palaeoceanography is one of the rapidly growing, modern branches of Earth sciences, that requires an interdisciplinary multiproxy approach. Palaeoceanographic findings often provide vital information about past climate and environmental changes on our planet. However, the indicators used in these studies require careful and in-depth analysis, as many of them may give contradictory interpretations. Therefore, there is a special need for research documenting both the record of the contemporary oceanographic situation in the investigated proxies, as well as the proxies (e.g. foraminifera, diatoms, biomarkers) application in the interpretation of sediments representing the records of past changes.

The PhD dissertation, submitted by Jinpeng Zhang for evaluation, fits perfectly into the above research trend. It is a reliable study based on analysis of modern conditions and their reflection in proxies (mainly diatoms) as well as interpretation of palaeoceanographic conditions from sedimentary record of northern part of South China Sea. The study area is also of particular international interest as it is located in the zone affected by monsoon circulation, which is correlated to major climatic systems of our planet.

The thesis is an effect of Polish-Chinese scientific cooperation financially supported from various sources, both Chinese and Polish (the NCN). The core of the work consists of introduction, three peer-reviewed papers and one submitted paper. All the publications are first-authored by the PhD-candidate and published in good international journals (*Marine Geology* and *Journal of Asian Earth Sciences*).

2. General description of the thesis

The thesis is composed of three general chapters (Introduction, Regional Geographic and Geological Setting, and Material and Methods), three publications, and of one submitted manuscript presented in Appendix 1. It is also supplemented by extensive appendixes with valuable documentation (e.g. diatom images).

In the introduction are presented the main drivers important for the study region, namely climate, sea-level changes, oceanographic circulation, and shoreline configuration. The presented overview of a relatively well-studied region revealed a gap in the application of potentially very useful proxies – mainly diatoms, which are the main focus of the research presented in the reviewed thesis. The author presented his good knowledge of the previous palaeoceanographic works in the region and build on that the goal of his own study. The main generally stated aim is ‘to analyze the fossil diatom assemblages recovered from the shelf and adjacent slope sediments of the northwest South China Sea’. This very general goal is subdivided into four (partly overlapping) secondary aims:

- reconstruction of the changes in diatom assemblages in the East Asian tropical shelf and adjacent slope during the late Quaternary;
- reconstruction of diatom response to environmental and climatic forcings (e.g., sea level, salinity, water temperature, and monsoon activity);
- reconstruction of the relationship between changes in diatom assemblages of the superficial sediments and environmental proxies: salinity (SSS), temperature (SST), nutrients and water depth;
- reconstruction of the environmental changes based on the succession of diatom assemblages from core samples, and improvement of the application of diatoms as proxies for past environmental changes.

The presentation of the goals is followed by the research hypothesis, which partly repeats the previously stated aims of the study.

The following chapter presents detailed information about the study area, including data on study site geography, geomorphology, hydrology, oceanography, climate tectonics and geological background. Although, the chapter is in general well presented. Some parts about monsoon climate and geological setting are a bit unclear, and not necessary (e.g., about the evolution of depositional basins in Cenozoic). This chapter is also well illustrated. However, some maps are unclear (e.g., Fig. 2.4. – the legend is not readable; Fig. 2.5. – the sedimentary logs are too small).

The chapter three: ‘Material and methods’ presents the impressive study material analysed in the study (surface samples and sediment cores) and variable methods applied for the analysis. The study material included:

- 66 surface samples collected with box corer from eastern Baibu Gulf;
- 32 m long sediment core BBW-ZK4BH from coastal site (11 m water depth) – over 100 samples were collected for the analyses from the upper 15 m of the core;
- 101 m long core ZBW from water depth of 100 m (Hainan Delta);
- 8.6 m long piston core 111PC collected from water depth of 2253 m.

The main method applied was diatom analysis of almost 800 samples (!). It was supplemented with grain size analysis, ¹⁴C and OSL dating, geochemical analyses of total carbon, nitrogen, as well as stable isotopes of carbon and oxygen. The results were analysed using various statistical methods.

The first publication presents a diatom-based reconstruction of the Holocene environmental changes within the Beibu Gulf, NW South China Sea:

Zhang, J-P., Tomczak, M., Witkowski, A., Liang, K., Harff, J., Li, Ch., Wang, B. 2021. A diatom-based Holocene record of sedimentary and oceanographic environmental changes within the Beibu Gulf, NW South China Sea. *Marine Geology*, 432, 106395.

The author assessed own contribution to be 64 %. He took part in subsampling campaigns, sample preparation, and constructing an age model. He did microfossil analyses, made data interpretations, designed the figures and wrote the first draft of manuscript, as well as served as corresponding author. The paper is based on detail analysis of core BBW-ZK4BH and presents the history of c 10ka. The documented changes in diatom assemblages and other proxies were interpreted mainly in context of sea-level changes, climate induced circulation and river discharge variability, as well as human impact (for the last c. 1400 years).

The second paper documents paleoecology and sedimentary evolution of the buried, Pleistocene Delta, located towards the South of Hainan Island.

Zhang, J-P., Tomczak, M., Li, Ch., Witkowski, A., Li, Sh., Zhou, Y., Miluch, J. 2021. Paleoeological changes and sedimentary evolution of the Hainan Delta, NW South China Sea. *Journal of Asian Earth Sciences*, 209, 104685.

The author assessed its contribution to the paper as 64%. He subsampled the core, performed microfossil analyses, took part in constructing an age model, analyzed the data, designed the figures and wrote the manuscript draft, as well as served as corresponding author. This paper presents sedimentary record from ZBW core from recently identified, so-called Hainan Delta. The authors identified several stages of the delta evolution between c. 65 ka and 55 ka, which were characterized by fluctuations in dominating terrigenous sediment supply.

In the third publication, is presented the response of marine diatoms to environmental changes in the NW South China Sea during the late Pleistocene and Holocene.

Zhang, J-P., Tomczak, M., Witkowski, A., Li, Ch., Chen, Ch-X., McCartney, K. 2020. Marine diatom response to oceanographic and climatic changes in the NW South China Sea since the penultimate glacial interval. *Journal of Asian Earth Sciences*, 204, 104553.

The own contribution to this publication is assessed to be 65%. He participated in subsampling, sample preparations, performed microfossil counts and selected geochemical analyses, he also took part in constructing an age model. He interpreted the data, designed the figures and wrote the manuscript draft. He also served as corresponding author during the review process. The paper is based on the core 111PC from continental margin. The sedimentary record covers the last 160 ka. Thus it covers the full glacial – interglacial cycle and provides record of the related changes in deep water environment, driven by sea-level variability, changes in sediment supply and climate variability.

In the last paper, presented in Appendix 1 by Zhang et al. (submitted in PeerJ Journal), the distribution of subfossil diatom assemblages in the NW SCS and an impact of environmental factors as key drivers of their distribution is presented:

Zhang, J-P., Witkowski, A., Tomczak, M., Li, Ch., McCartney, K., Xia, Z. (submitted). The sub-fossil diatom distribution in the Beibu Gulf (NW South China Sea) and related environmental interpretation. *PeerJ*



The contribution of the first author is assessed as 68%. He designed the research, subsampled sediments, performed sub-fossil analyses, conducted statistical analyses, designed the figures, and wrote the manuscript draft. The draft is based on extensive sample set of surface sediments from Beibu Gulf. The diatom analyses were compared to the modern environmental data and allowed to identify particularly clear relations to water temperature, salinity and trophic state of the ecosystems.

The following appendixes include: SEM images of selected diatom taxa, LM images of selected diatom taxa and the complete list of identified diatom taxa. The final part of the thesis consists of abstract in Polish and English.

3. Assessment and specific comments

My opinion about the presented doctoral dissertation is very high. The author presented a work based on high-quality analyzes of very rich and unique research material. The number of analyzed samples, subjected to time-consuming analyzes, is really impressive. The author showed a very good knowledge of the current palaeoceanographic literature in the studied area, and also presented an excellent understanding of the studied system. He proved that he can identify the problem and choose ways to falsify the working hypothesis. He became an expert in the analysis of NW sea diatoms of the South China Sea. He also has the ability to apply and interpret various important paleoceanographic indicators (stable isotopes, etc.). Finally, he has a very important ability to present the obtained results in the form of high-quality scientific papers. His publishing achievements are outstanding, taking into account the existing standards for doctoral dissertation. I would like also to stress that the approach used in the study is complementary and includes analysis of the modern composition of sediments in relation to modern environmental factors, then analyses including various time scales and environments – from shallow coastal sites to deep-sea continental slope environments. The obtained data are compared with other records from the study area as well as with representative records from the same time periods.

Without diminishing the very high evaluation of the doctoral dissertation presented above, it is also necessary to pay attention to some shortcomings and to some emerging questions. In the context of the structure of the work, it would be valuable to place the last work (submitted for review) as the first article, as it is, in a way, a key to the interpretation of fossil associations of diatoms. The work also lacks a chapter that would summarize the results achieved and directly refer to the goals



set out in the introduction. The introductory chapters are somewhat lengthy and some figures need to be corrected before their possible use in subsequent publications. The author carefully indicated his own contribution to subsequent articles, he is their first and corresponding author, however, including appropriate statements of co-authors or providing authors contribution in the article should be a good practice.

Palaeoceanographic proxies usually leave some room for alternative interpretations. The presented, well-documented data presented by Jinpeng Zhang inspired me to ask several selected questions about possible alternative interpretations that could contribute to discussions during the PhD exam and in further research. Out of several threads, I have chosen three that particularly intrigued me:

- in the paper by Zhang et al. 2021 published in Marine Geology, a 'condensed section' was interpreted at a sediment depth of c. 6m. In this section, however, we do not observe a higher abundance of diatoms (Fig. 4), which could be expected in the case of a decrease in the accumulation rate of terrigenous sediments. So, I wonder if this 'condensed section' is a hiatus instead? I am also interested in the author's opinion on the interpretation of diatoms abundance - to what extent can the effect of a change in productivity be distinguished from a change in the rate of sediment accumulation?
- the next question refers to foraminiferal isotopic data (oxygen stable isotopes) presented in the article by Zhang et al. 2021 (Journal of Asian Earth Sciences). This high-resolution record was compared, inter alia, with the isotope record from ice cores, where it is interpreted mainly in the context of temperature changes. The interpretation of the sedimentary environment presented in the article suggests that the core sediment formed a part of the delta that was significantly influenced by river waters. Thus, an important question arises - to what extent is the isotopic composition of foraminifera tests a record of temperature changes, and to what extent it is a record of salinity fluctuations?
- the last discussion point is related to a very important problem of early diagenetic changes and preservation potential. The paper by Zhang et al. 2021 (Journal of Asian Earth Sciences) mentioned sections with absence or very low abundances of diatoms in the sediments. The authors discussed several possible explanations, however, they have not considered the dissolution of diatoms remains. The later process is well known from various coastal settings. Moreover, the potential dissolution is



discussed by the authors in the following paper (Zhang et al. 2020, Journal of Asian Earth Sciences) related to deep-sea sediments. So, I am curious why the dissolution was not considered in the case of Hainan Delta deposits. It leads also to the more general question – how much of the modern record is preserved in the fossil record in the context of diatoms.

4. Conclusion

This thesis represent a great deal of work. The results are well presented and their interpretation is at high scientific level. I really appreciate the candidate expertise in the field of application of diatoms in regional palaeoceanographic analyses. In my opinion, the **dissertation by Mr Jinpeng Zhang fully complies both with Polish and international standards for PhD dissertations in the field of geosciences.**

Wniosek końcowy

Z głębokim przekonaniem stwierdzam więc, że **przedstawiona do recenzji praca spełnia wszystkie wymagania stawiane rozprawom doktorskim i zasługuje na wyróżnienie stosowną do rangi nagrodą.** Stanowi ona istotny, nowy wkład do dotychczasowej wiedzy i dowodzi, że Pan Jinpeng Zhang w pełni opanował umiejętność prowadzenia badań naukowych. Recenzowana praca spełnia zatem wymagania określone w "Ustawie o stopniach naukowych i tytule naukowym oraz o stopniach i tytule w zakresie sztuki" z dnia 14 marca 2003 r. (Dz. U. z 2017r. poz. 1789 i ze zm.). Tym samym wnioskuję o dopuszczenie Pana Jinpenga Zhanga do dalszych etapów przewodu doktorskiego.

Witold Szczuciński