BISS Biodiversity Information Science and Standards

Biodiversity Information Science and Standards 8: e138673
doi: 10.3897/biss.8.138673

OPEN ACCESS

Conference Abstract

Automatic Detection and Identification of Calcareous Nannofossils in Chalk Using Deep Learning: A Proof-of-Concept Study for Biostratigraphy and Climate Research

Sanson T. S. Poon[‡], Avellina M.Y. Leong[§,‡], Thomas Fogerty[‡], Richard Twitchett[‡], Arianna Salili-James [‡], Stephen Stukins[‡], Ben Scott[‡], Vincent S. Smith[‡]

‡ Natural History Museum, London, United Kingdom
§ University College London, London, United Kingdom

Corresponding author: Sanson T. S. Poon (sanson.poon@nhm.ac.uk)

Received: 05 Oct 2024 | Published: 07 Oct 2024

Citation: Poon STS, Leong AMY, Fogerty T, Twitchett R, Salili-James A, Stukins S, Scott B, Smith VS (2024) Automatic Detection and Identification of Calcareous Nannofossils in Chalk Using Deep Learning: A Proof-of-Concept Study for Biostratigraphy and Climate Research. Biodiversity Information Science and Standards 8: e138673. https://doi.org/10.3897/biss.8.138673

Abstract

Calcareous nannofossils serve as crucial indicators for establishing the biostratigraphic age of chalk macrofossil specimens in natural science collections. Better age control of specimens collected several hundred years ago enables us to uncover the dark data hidden within these collections and incorporate these data into current research projects, examining ecosystem response to past climate change. However, the manual identification of these microscopic organisms is laborious and subjective, and so we are harnessing deep learning techniques for automatic nannofossil detection and identification.

This approach required the construction of a robust dataset, currently comprising over 100,000 labelled images, complemented by the development of multiple specialised deep learning models. While some models focus on detecting target species, others are dedicated to species classification.

Evaluation on an independent test set showcases the efficacy of our methodology, with the current detection model achieving a balanced accuracy of 93%. Similarly, the classification model demonstrates robust performance, attaining an average balanced accuracy of 96%.

Furthermore, as well as assisting with our biostratigraphic studies, the dataset of accurately labelled images has enabled us to test other aspects of ecosystem response. For example, examining morphometric changes in nannofossils over geological time can provide valuable insights into the potential impact of current global warming on modern phytoplankton assemblages (Mancini et al. 2021). This is particularly important for coccolithophores (Young et al. 2005), which play a critical role as primary producers in the global carbon cycle. A decrease in their size could lead to bottom-up ecosystem impacts and reduced carbon sequestration (Poulton et al. 2007, Krumhardt et al. 2017).

Using our dataset, we conducted a deep-learning-enhanced automatic morphometric analysis focusing on the nannofossil species, *Tranolithus orionatus*. Our analysis revealed that two key morphometric parameters, minor axis and area size, showed statistically significant differences between the Cenomanian stage (approximately 100.5 to 93.9 million years ago) and the post-Cenomanian stages of the Late Cretaceous (approximately 93.9 to 66.0 million years ago). Kolmogorov-Smirnov tests (Massey 1951) between the two samples yielded p-values of 0.039 for the minor axis and 0.031 for the area size.

Understanding these morphometric changes is crucial due to the close parallels between current climate projections and the warming and greenhouse climate of the Late Cretaceous, particularly the Cenomanian-Turonian boundary event (Arthur et al. 1990). Insights into how organisms changed morphologically during past periods of environmental stress can help us more effectively predict future responses of organisms under similar conditions (Razmjooei et al. 2020).

These findings underscore the effectiveness of our approach in automating the identification and recognition of chalk nannofossils, helping to unlock natural science collections and to address key questions related to marine response to past climate change.

Keywords

Natural History Museum London, AI nannofossils, nannofossil morphometrics, ecosystem response, climate change, *Tranolithus orionatus*

Presenting author

Sanson T. S. Poon

Presented at

SPNHC-TDWG 2024

Hosting institution

This project was conducted at the Natural History Museum (NHM) and was selected as part of the NHM AI Lab Programme (Poon et al. 2024).

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Arthur MA, Brumsack HJ, Jenkyns HC, Schlanger SO (1990) Stratigraphy, Geochemistry, and Paleoceanography of Organic Carbon-Rich Cretaceous Sequences. Springer eBooks https://doi.org/10.1007/978-94-015-6861-6_6
- Krumhardt KM, Lovenduski NS, Iglesias-Rodriguez MD, Kleypas JA (2017) Coccolithophore growth and calcification in a changing ocean. Progress in Oceanography 159: 276-295. https://doi.org/10.1016/j.pocean.2017.10.007
- Mancini AM, Grelaud M, Ziveri P, Nallino E, Lozar F (2021) Calcareous Nannofossil Size and Abundance Response to the Messinian Salinity Crisis Onset and Paleoenvironmental Dynamics. Paleoceanography and Paleoclimatology 36 (9). https://doi.org/10.1029/2020pa004155
- Massey F (1951) The Kolmogorov-Smirnov Test for Goodness of Fit. Journal of the American Statistical Association 46 (253): 68-78. https://doi.org/10.1080/01621459.1951.10500769
- Poon S, Scott B, Salili-James A, Smith V (2024) Accelerating Museum AI Research and Application at the UK Natural History Museum: The NHM AI Lab Programme. Biodiversity Information Science and Standards 8 https://doi.org/10.3897/biss.8.138147
- Poulton AJ, Adey TR, Balch WM, Holligan PM (2007) Relating coccolithophore calcification rates to phytoplankton community dynamics: Regional differences and implications for carbon export. Deep Sea Research Part II: Topical Studies in Oceanography 54 (5-7): 538-557. https://doi.org/10.1016/j.dsr2.2006.12.003
- Razmjooei MJ, Thibault N, Kani A, Dinares-Turell J, Puceat E, Chin S (2020) Calcareous nannofossil response to Late Cretaceous climate change in the eastern Tethys (Zagros Basin, Iran). Palaeogeography, Palaeoclimatology, Palaeoecology 538: 109418. https://doi.org/10.1016/j.palaeo.2019.109418
- Young JR, Geisen M, Probert I (2005) A review of selected aspects of coccolithophore biology with implications for paleobiodiversity estimation. Micropaleontology 51 (4): 267-288. https://doi.org/10.2113/gsmicropal.51.4.267