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High-resolution Pliocene–Pleistocene calcareous nannofossil distribution and palaeoenvironmental changes in the northwest Nile Delta, Egypt

SHERIF FAROUK, SREEPAT JAIN, MOHAMMAD ABD-ELAZEZ, TAMER EL SHENNAWY AND FATMA SHAKER

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The Pliocene–Pleistocene sequences in the Nile Delta are of immense economic significance due to their hydrocarbon potential. Hence, a better understanding of the time-calibrated basinal palaeoenvironmental changes is essential to improve the hydrocarbon recovery. A total of 182 sub-surface samples from the Sapphire-DC well in the offshore north-western part of the Nile Delta were analysed to reveal changes in calcareous nannofossil assemblage composition and palaeoenvironments during the late Miocene–Pleistocene (5.44–0.43 Ma). Sixteen marker bioevents and nine biozones are identified for the first time. The absence of *Ceratolithus acutus* suggests a hiatus at the Messinian–Zanclean (Miocene–Pliocene) boundary. The studied interval is marked by the dominance of five species; *Pseudoemiliania lacunosa* (24%), small *Gephyrocapsa* sp. (20%), *Helicosphaera kamptneri* (11%), *Reticulofenestra minutula* (10%) and *Calcidiscus leptoporus* (6%). Based on their distribution patterns, six intervals (Intervals 0 to 5) are identified. Throughout the study interval, cooler waters (except during Interval 0; Messinian Salinity Crisis, MSC, 5.44–5.26 Ma) and eutrophic conditions persisted within a shallow hemipelagic and near-continental setting, marked by moderate-to-high terrigenous input (more for Intervals 4 and 5; ~2.73–0.42). Additionally, low species diversity and high species dominance are identified, suggesting a stressed environment. Species diversity shows a gradually declining trend, up section, whereas species dominance correspondingly increases. Interval 0 (MSC) is dominated by warm water species of *Sphenolithus abies* and *Helicosphaera kamptneri*. The cool water species, *Reticulofenestra pseudoumbilica*, and small *Gephyrocapsa* dominate in Interval 1; small *Gephyrocapsa* dominates in Interval 2. Interval 3 is marked by the deepening of the basin with a brief introduction of warm, somewhat oligotrophic and open-ocean waters. In the middle of this interval (at 3.73 Ma; the Early–Late Pliocene boundary), an abrupt decrease in species diversity with a corresponding increase in species dominance suggests deteriorating conditions. Interval 3 also encompasses the mid–late Pliocene warming period, which in the Nile Delta is marked by cooler waters. Intervals 3–5 are dominated by *P. lacunosa*, suggesting a continuation of cool waters and eutrophic conditions. Hence, throughout the study interval, cooler waters (except during the MSC) and eutrophic conditions within in a shallow hemipelagic and near-continental setting are inferred with moderate-to-high terrigenous input and low species diversity and higher species dominance, suggestive of stressed environmental conditions. □ *Diversity, Egypt, nannofossil, Nile Delta, Pleistocene, Pliocene.*

Sherif Farouk ✉ [geo.sherif@hotmail.com], Exploration Department, Egyptian Petroleum Research Institute, Nasr City Cairo 11727, Egypt; Sreepat Jain [sreepatjain@gmail.com], Department of Geology, Adama Science and Technology University, Adama 1888, Ethiopia; Mohammad Abd-Elazez [muhammad.abdelazez1979@gmail.com], Geology Department, Faculty of Science, Zagazig University, Zagazig 44519, Egypt; Tamer El Shennawy [exp864ff@gmail.com], Rashid Petroleum Company, New Maadi Cairo 11742, Egypt; Fatma Shaker [felkammar@gmail.com], Geology Department, Faculty of Science, Benha University, Benha 13518, Egypt; *manuscript received on 22/02/2021; manuscript accepted on 6/08/2021.*

The Miocene–Pleistocene sequences within the Nile Delta of Egypt is well known for its hydrocarbon potential (Abdel Aal *et al.* 2001; Mokhtar *et al.* 2016), particularly in the context of the Pliocene hydrocarbon pay zones (Kellner *et al.* 2018). Hence, a refined biostratigraphy (biozones and bioevents) coupled with the information on changes in water mass characteristics (such as surface water temperature, productivity and salinity), terrigenous input and palaeoenvironment are crucial for better understanding of basinal dynamics and sedimentation patterns. These, in turn, enable better pay zone recovery within these hydrocarbon-bearing successions. The calcareous nannofossils represent a major component of the

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