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# Climate Change and Marine Geological Dynamics

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The tendency for climate to change has been one of the most surprising outcomes of the study of Earth history. Marine geosciences can record valuable information about past environment, climate, and biota just before, during and after each climate perturbation. Particularly, certain intervals of the geological record are windows to key episodes in the climate history of the earth-life system. In this regard, the detailed analyses of such time intervals are challenging and rewarding for environmental reconstruction and climate modeling, as they provide documentation and better understanding of a warmer than present world, and opportunities to test and refine the predictive ability of climate models, respectively. Marine geological dynamics such as sea-level changes, hydrographic parameters, water quality, sedimentary cyclicity, and (paleo)climate are strongly related through a direct exchange between the oceanographic and atmospheric systems. The increasing attention paid to this wide topic is also motivated by the interplay of these processes across a variety of settings (coastal to open marine) and timescales (early Cenozoic to modern). In order to realize the full predictive value of these warm (fresh)/cold (salty) intervals in Earth history, it is important to have reliable tools (e.g., integrated geochemical, paleontological and/or paleoceanographic proxies) through the application of multiple, independent, and novel techniques (e.g., $TEX_{86}$, $U^{K'}_{37}$, Mg/Ca, Na/Ca, Δ47, μCT) for providing reliable hydroclimate reconstructions at both local and global scales.

The book *Climate Change and Marine Geological Dynamics* includes nine contributions [1–9] to this Special Issue published during 2020–2021. Overall, the aim of this Special Issue is to collect studies that provide new views on marginal and open marine geological phenomena and processes by using different methodologies and approaches. The motivation to publish such a volume stems from the desire to contribute to the dissemination of knowledge about the marine environment, including the study of temporal and spatial paleoecological patterns of marine communities in the context of ranked changes in paleohydrology, paleogeography and paleoclimate. The scientific collection presented herein will be of great interest to scientists from various disciplines of Geosciences (Paleoceanography, Sedimentology, Stratigraphy, Paleontology, Paleoclimatology, Geochemistry, Marine and Petroleum Geology) and will promote a broader and more holistic integrated approach to marine geological margins. A brief overview of all the contributions, emphasizing the main investigation topic and the outcome of the analysis follows.

Kontakiotis et al. (2020) [1] investigate the Mesozoic-Paleogene depositional history and paleogeographic evolution of marine biogenic carbonates in the western segment of the southern Tethys (Ionian basin, Epirus, Greece). This integrated sedimentological, micropaleontological and stratigraphic study is based on lithostratigraphic characteristics, facies analysis and reservoir petrophysical behaviors of the carbonate successions, in conjunction with a synthetic paleogeographic reconstruction. Beyond the hydrocarbon prospectivity, this work has further implications for regional geology, since it contributes to describing the evolution of these carbonates and to a better understanding of the Ionian zone in western Greece, a region with crucial economic and strategic importance. The identified carbonate formations display various facies ranging in a full spectrum of depositional conditions, from shallow platforms (reefs) to slope (platform margin) environments, even to the open

marine settings, with different lithologies, sedimentary features, energy conditions, and diagenetic overprints. The results show that the Late Cretaceous (Senonian Limestones) and the Paleocene/Eocene carbonate units present the highest porosity values and therefore can be considered as the primary target for oil/gas exploration in the study area.

Giamali et al. (2020) [2] present a multi-proxy investigation of the environmental factors affecting the planktonic foraminiferal and pteropod communities of the south Aegean Sea. The combined micropaleontological (planktonic foraminiferal and pteropod distributions), multivariate statistical (principal component analysis), and geochemical (total organic carbon, stable isotopes) analyses provide evidence for the eastern Mediterranean hydroclimate evolution during the last 21 kyr, with particular emphasis on the most recent sapropel S1 deposition event. The obtained results highlight the dominant role of sea surface temperature in the distribution of the analyzed fauna, while further indicating that stratification of the water column, seasonality, and primary productivity also control their communities during the Late Quaternary.

Zarkogiannis et al. (2020) [3] report no major changes in plankton calcite production with the atmospheric $pCO_2$ variations of the Late Quaternary in the tropical Atlantic Ocean. This consistency in foraminifera calcification is attributed to the climatic and hydrological stability of the tropical regions over the geologic time. They further present $\delta^{18}O$, Mg/Ca, and μCT measurements of planktonic foraminifera shells for several samples, in order to elucidate the observed increase of shell weights midway through the penultimate deglaciation (Termination II). Compared with the lighter specimens, they found that tests of increased weight are internally contaminated by sediment infilling and that their masses respond to local surface seawater density changes.

Hermides et al. (2020) [4] focus on the hydrogeological conditions in the coastal (Thriassion plain) and submarine (Eleusis Gulf) environment of West Attica (Greece). The authors revise previously published hydrogeological conceptual models of the Thriassion Plain by evaluating the actual mechanism controlling the groundwater flow, the origin and distribution of saline water, and the existence of fresh groundwater in the submarine environment. Combined chemical water analyses and aquifer types as well as stratigraphic borehole data show that the groundwater of the Thriassion plain is partly discharged as an upwards leakage from deeper aquifers with the submarine fresh water possibly to exist in the deeper aquifers beneath the seafloor of the Eleusis Gulf.

Zarkogiannis et al. (2020) [5] present a systematic experimental application of a foraminiferal calcite cleaning protocol which can be used in micropaleontological and paleoclimatic or paleoceanographic studies. Thorough validation of the applied proxy is performed in unconsolidated Late Quaternary core sediments from the Aegean Sea, while the efficiency of each method in specimen cleaning was assessed using Scanning Electron Microscopy (SEM) and X-ray tomography. Based on the results of the visualization analyses and subsequent shell weight measurements, the authors conclude that a good compromise between time and cleaning efficiency is the simultaneous treatment of samples with a mixed hydrogen peroxide and Calgon solution, while the most effective way to decontaminate the calcareous components completely from undesirable sedimentary material is a two-step treatment—initially with hydrogen peroxide and subsequently with Calgon solutions. Overall, the proposed protocol (HyPerCal) minimizes discrepancies in foraminifera shell weight measurements and greatly facilitates microfossil X-ray imaging analyses for geochemical and paleoceanographic purposes.

Makri et al. (2020) [6] investigate the potential groundwater pollution from BTEX (benzene, toluene, ethylbenzene and xylenes) within the complex aquifer system of the Thriassion Plain (Attica, Greece). Benzene concentration values are generally much more elevated than those of the other BTEX compounds, indicating that the pollution originates mainly from permanent sources namely oil refinery and handling sources, located relatively close to the sampling points. The spatial distribution of BTEX in groundwaters further show that they were concentrated mainly in four, rather restricted locations. Three of them were in the close vicinity of evident pollution sources (a military airfield and two crude oil

refineries), whereas the other one corresponds to an abandoned site with no outstanding pollution sources, where wells exist, eventually used occasionally for illegal dumping of oily wastes. The fact that the town of Eleusis seems not to be polluted from BTEX could be attributed to impermeable strata working as water and pollution barriers. Therefore, the hydro-stratigraphic particularities, along with general hydrogeochemical conditions play an important role to the BTEX fate and attenuation rate in the study area.

Zarkogiannis (2021) [7], using species-specific planktonic foraminifera shell weights succeeds in obtaining a first-order approximation of the horizontal density gradient of the eastern Atlantic during the last 200,000 years and reports two instances of disruption of the Atlantic Ocean Meridional Circulation. Published records of *Globigerina bulloides* shells from the North and Tropical eastern Atlantic were complemented by the analysis of a South Atlantic core. Same species shell weights from three different dissolution-assessed sediment cores along the eastern Atlantic Ocean were converted to seawater density values using a calibration equation. By using planktonic foraminifera shell weight as an upper ocean density proxy, two intervals of convergence of the shell masses were identified during cold intervals of the last two deglaciations that were interpreted as weak ocean density gradients, indicating nearly, or eliminated meridional circulation. He also reports that interhemispheric Atlantic density differences appear to alleviate with the onset of the last interglacial. Overall, the results confirm the significance of variations in the density of Atlantic surface waters for meridional circulation changes.

Kontakiotis et al. (2021) [8] present new data on the spatial distribution and size of modern planktonic foraminifera from the central Mediterranean. The authors document a latitudinal differentiation with species-specific distributional patterns and size variability deduced by the study of 17 core-top sediments collected from a north-south transect along the Adriatic and Ionian sub-basins. The quantitative analysis reveals that *Globigerina bulloides* and *Globigerinoides ruber* (w) were the most abundant species, presenting an antagonistic behavior and an overall decreasing trend in their average size values from the north to the south. The rest of the species occur in minor percentages and show, on average, an 11% increase with decreasing latitude characterized by distinct species-specific size variations along the transect. Overall, central Mediterranean assemblages' size mainly relates to nutrient availability, while the relationship between planktonic foraminifera shell size and abundance or sea surface temperature is either absent or weaker than previously reported for other regions. Finally, besides the environmental parameters, the authors further report the possible hidden cryptic diversity to give a better understanding of the geographic and morphological differentiation within the Mediterranean planktonic populations.

Shu et al. (2021) [9] examine the response of the physicochemical properties of sediment lixivium to changes in the sedimentary environment, as well as the feasibility of using these properties to reflect changes in coastal environment. They employ the physicochemical property indexes TDS, SAL, and EC of sediment lixiviums in Gangxi and Caoyankou sections of the sea-land interaction zone in the eastern margin of the Subei Basin (China). The authors introduce a multi-parameter water quality meter to the field of paleo-coastal environmental change research. The comparison between the physicochemical property indexes of sediment lixiviums with geochemical elements and diatom indicators revealed characteristics of the entire transgression process with significant advantages over other relevant approaches.

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## References


1. Kontakiotis, G.; Moforis, L.; Karakitsios, V.; Antonarakou, A. Sedimentary Facies Analysis, Reservoir Characteristics and Paleogeography Significance of the Early Jurassic to Eocene Carbonates in Epirus (Ionian Zone, Western Greece). *J. Mar. Sci. Eng.* **2020**, *8*, 706. [CrossRef]
2. Giamali, C.; Kontakiotis, G.; Koskeridou, E.; Ioakim, C.; Antonarakou, A. Key Environmental Factors Controlling Planktonic Foraminiferal and Pteropod Community's Response to Late Quaternary Hydroclimate Changes in the South Aegean Sea (Eastern Mediterranean). *J. Mar. Sci. Eng.* **2020**, *8*, 709. [CrossRef]
3. Zarkogiannis, S.D.; Antonarakou, A.; Fernandez, V.; Mortyn, P.G.; Kontakiotis, G.; Drinia, H.; Greaves, M. Evidence of Stable Foraminifera Biomineralization during the Last Two Climate Cycles in the Tropical Atlantic Ocean. *J. Mar. Sci. Eng.* **2020**, *8*, 737. [CrossRef]
4. Hermides, D.; Makri, P.; Kontakiotis, G.; Antonarakou, A. Advances in the Coastal and Submarine Groundwater Processes: Controls and Environmental Impact on the Thriassion Plain and Eleusis Gulf (Attica, Greece). *J. Mar. Sci. Eng.* **2020**, *8*, 944. [CrossRef]
5. Zarkogiannis, S.D.; Kontakiotis, G.; Gkaniatsa, G.; Kuppili, V.S.C.; Marathe, S.; Wanelik, K.; Lianou, V.; Besiou, E.; Makri, P.; Antonarakou, A. An Improved Cleaning Protocol for Foraminiferal Calcite from Unconsolidated Core Sediments: HyPerCal—A New Practice for Micropaleontological and Paleoclimatic Proxies. *J. Mar. Sci. Eng.* **2020**, *8*, 998. [CrossRef]
6. Makri, P.; Stathopoulou, E.; Hermides, D.; Kontakiotis, G.; Zarkogiannis, S.D.; Skilodimou, H.D.; Bathrellos, G.D.; Antonarakou, A.; Scoullos, M. The Environmental Impact of a Complex Hydrogeological System on Hydrocarbon-Pollutants' Natural Attenuation: The Case of the Coastal Aquifers in Eleusis, West Attica, Greece. *J. Mar. Sci. Eng.* **2020**, *8*, 1018. [CrossRef]
7. Zarkogiannis, S.D. Disruption of the Atlantic Meridional Circulation during Deglacial Climates Inferred from Planktonic Foraminiferal Shell Weights. *J. Mar. Sci. Eng.* **2021**, *9*, 519. [CrossRef]
8. Kontakiotis, G.; Efstathiou, E.; Zarkogiannis, S.D.; Besiou, E.; Antonarakou, A. Latitudinal Differentiation among Modern Planktonic Foraminiferal Populations of Central Mediterranean: Species–Specific Distribution Patterns and Size Variability. *J. Mar. Sci. Eng.* **2021**, *9*, 551. [CrossRef]
9. Shu, Q.; Zhang, S.; Chen, Y. Physicochemical Property Indexes of Sediment Lixiviums in Sea–Land Interaction Zone of Subei Basin and Their Significance to Transgression. *J. Mar. Sci. Eng.* **2021**, *9*, 719. [CrossRef]