Microfossil as proxy for paleoclimate and paleoceanography

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ABSTRACT

Recent global warming has been addressed due to human activity that causes increased greenhouse gases. However, there are inherent uncertainties in the statement, one of them is the level of natural variability inherent in the climate system. Climate data from measuring instruments are not long enough to evaluate climate variability and current climate evolution. Therefore, we need climate data that has a long back span. To get adequate past climate data, we need natural phenomena which are climate dependent. This natural phenomenon provides a proxy record of the climate. This study of proxy data is the foundation of paleoclimatology and paleoceanography. Microfossils (i.e., foraminifera, palynomorphs, nannofossils) which in geology are used as a standard tool in biostratigraphy for both age determination and paleoenvironment and correlation, can also be used as a proxy for obtaining paleoclimate and paleoceanography data. Using microfossil as a proxy to study past climate and paleoceanography, we need an understanding of the type of proxy data available and methods used in their analysis.

In addition to the dating method (biostratigraphy), there are many climate and oceanography parameters that can be obtained from microfossil proxies such as: sea surface temperature (SST), sea surface salinity, (SST) climate (warm, cold, dry, wet), precipitation, productivity, oxygen content and organic carbon level, deep sea current and ventilation/upwelling, thermocline and mixed layer, variability deep water properties, CCD, bathymetry, sea level change and dissolution.

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The methods to obtain data fall into some categories e.g., faunal/floral displacement, morphology changes, transfer function/modern analog and isotopic content. Another method that can be used is observing microfossil assemblages and link them to ecological changes associated with climate change and its paleoceanography.

A paleoclimate and paleoceanography study using microfossil proxies has been conducted in the Cendrawasih bay, Papua, Indonesia. The study shows that climate in the tropical west Pacific margin (Cendrawasih bay) during Late Pleistocene to Holocene shows high variability. There are nineteen climate changes occurred during Holocene. Early Holocene dated as *ca.* 11,800-year BP marked by rapid warming with SST differences to last glacial is about 4°C. Early to Middle Holocene (*ca.* 5960-year BP) marked by increasing temperature up to 2°C, interrupted by cooling at *ca.* 11230-, 8310- and 7120-years BP. At Middle Holocene temperature decreased rapidly and reached its peak at around *ca.* 3150-year BP. After cooling at *ca.* 3150-year BP, temperature increased and then decreased with its peak at *ca.* 1710-year BP. Since *ca.* 1710-year BP to Recent, temperature shows warming trend. SST from MAT shows warming environment to almost 1.5°C. The warming trend was interrupted by rapid cooling and warming at *ca.* 300-year BP. This last warming trend indicates that global warming had started before industrial era and rapid cooling, or warming can occur without anthropogenic gases influence. The typical Holocene climate of warm-wet, dry-cold reverse and become warm-dry, cold-wet during *ca.* 790-370-year BP and then reversed back to preceding state.

Semi-restricted basin occurred since last glacial with anaerobic condition and estuarine circulation system. Warming during interstadial 1e-1a, causing reverse water circulation and basin become sub-aerobic with anti-estuarine circulation. A lot of terrestrial organic matter flow to the bay and increase acidity and carbonate dissolution. High sedimentation found occurred during glacial period especially at the end of glacial period. Rapid warming during late glacial to middle Holocene, rising relative sea level and the bay become more open marine with well oxygenated bottom water and high marine productivity. Warm temperature and deeper thermocline depth (>~ 250 m) in west Pacific occurred up to *ca.* 5960-year BP. Decreasing Sea surface temperature at *ca.* 5960-year BP and drop of relative sea level causing sub-aerobic condition inside bay. The semi-restricted state with sub-aerobic condition occurred up to Recent.

Distribution of *Sphaeroidinella* group in the tropical west Pacific shows strong correlation with thermocline depth and reflect El Niño frequency event. Early middle Holocene dominated by La Niña-like condition and since Middle Holocene (*ca.* 5960-year BP) frequent El Niño event began to occur.

Keywords: microfossil, proxy, paleoclimate, paleoceanography, foraminifera, palynology, Cendrawasih Bay, Holocene climate.