学位論文の要旨

Abstract of Thesis

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学位論文題目 Title of Thesis（学位論文題目が英語の場合は和訳を付記）

Reconstructions of temporal and spatial variations in surface conditions of the Indonesian Seas based on geochemical tracers in modern coral skeletons

（現生サンゴ骨格中の地球化学的トレーサーに基づくインドネシア多島海表層環境の時空間的変動の復元）

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The Indonesian Throughflow (ITF) connects the Pacific Ocean with the Indian Ocean and is a major pathway in global thermohaline circulation. The ITF plays an important role in the heat transport, water budget, and air–sea heat flux, and thus, it may modulate climate variability such as El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). During the northwest monsoon (January to March), eastward surface current carry low-salinity and buoyant seawater from the Java Sea to the southern Makassar Strait, and this water retards transportation of the ITF in the surface layer and is called “freshwater plug”. Conversely, during the southeast monsoon (July to September), westward surface current removes the freshwater plug from the southern Makassar Strait and carry high-salinity water from the Banda Sea. Thus, the behavior of the freshwater plug has been suggested to influence the Asian monsoon and climate variability in the Indian Ocean. Although understanding marine conditions and variability in the ITF is critical to elucidating regional and global climate variability, instrumental records around this area are inadequate because of the complexity of topography. In this study, geochemical tracers in reef coral skeletons were used to reconstruct surface conditions of the Indonesian Seas. For example, coral strontium-calcium ratio (Sr/Ca) and oxygen isotope ratio ($\delta^{18}O$) depend on sea surface temperature, coral $\delta^{18}O$ is also reflected by seawater $\delta^{18}O$, which is approximated to salinity. In addition, using massive coral skeleton such as *Porites* spp. are capable to obtain high time resolution (weekly to monthly) and long-term records because of faster growth rate and living for decades and more. Therefore, this study aims to investigate the temporal and spatial variations in surface conditions of the Indonesian Seas and its relationship with climate phenomena using *Porites* coral skeletal cores collected from two sites: the Seribu Islands which are located in the Java Sea and the southern Lombok Strait which is the ITF outlet closest to Makassar Strait.

・*Reconstruction of sea surface temperature (SST) and salinity (SSS) in the Seribu Islands*

Genda (2018, Master thesis) reported coral Sr/Ca and $\delta^{18}O$ for the period 1931–2002. Using these data, I estimated salinity data and investigated into relationship with climate phenomena such as ENSO and IOD. Reconstructed data of Seribu coral shows rapid warming in the mid-1950s and, almost simultaneously, a rapid salinity shift to saline condition. The relationship between SST and climate

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phenomena have changed after this rapid warming event: before the mid-1950s, SST variation was similar to those of the IOD with negative correlation; after the mid-1950s, ENSO also affected SST variation. Thus, the predominant factor controlling SST changed from the climate phenomenon of the Indian Ocean to that of the Pacific Ocean. On the other hand, SSS variation followed the IOD especially before mid-1950s whereas no clear relationship with either ENSO or IOD was found after mid-1950s. On the other hand, SSS variations seem to be govern more by local and/or regional condition such as local precipitation, the Asian monsoon and surface currents.

・*Reconstruction of SST and SSS in the southern Lombok Strait*

Reconstructed data of SST and SSS of Lombok coral covered from 1962 to 2012. SST record shows no clear trend of global warming, whereas the record includes a large colling event (~4°C) during 1996–1997. Although neither reconstructed SST nor SSS shows systematic and clear relations with ENSO and IOD, weak but significant correlations are found. Instead, sea surface conditions of the southern Lombok Strait seem to be linked more with monsoon affecting on the Maritime Continent. During the northwest monsoon, the anomalies of SST and SSS in the southern Lombok Strait are similar to those in the Seribu Islands for the 1962–1995, suggesting that the contribution of the freshwater plug reached at the Lombok Strait. For the decadal scale, coral record indicates decadal to sub-decadal variation in which warm (cold) and saline (fresh) conditions co-occur that could be explained by the behavior of the freshwater plug. For the longer-term record, although global warming trend has been widely identified in the Indonesian Seas (e.g., +0.74 °C/70 years at the Seribu Islands), the coral record show no clear warming trend in the Lombok Strait. Thus, it can be suggested that fluctuations of the ITF may be modulating the distribution of heat in the surface waters of the western Pacific and eastern Indian oceans.

・*Evaluate the effect of anthropogenic CO_2 on surface conditions of the Indonesian Seas*

To evaluate the effect of anthropogenic CO_2 on the Indonesian Seas, measurements of carbon isotope ratio ($\delta^{13}C$) and uranium-calcium ratio (U/Ca) were performed. Coral U/Ca depend on temperature and pH, and then I calculated the tentative pH by combining U/Ca and Sr/Ca. $\delta^{13}C$ record of the Seribu coral shows a trend toward lower value over 70 years, reflecting the ^{13}C Suess effect which is caused by burning of fossil fuels. In addition, tentative pH in the Seribu coral shifted to lower after 1975, corresponding with a steeper decline in $\delta^{13}C$. Consequently, the impact of anthropogenic CO_2 would be intensified around the Java Sea since around 1975. On the other hand, it was found no evidence of the impact of anthropogenic CO_2 on the southern Lombok Strait based on coral $\delta^{13}C$ and tentative pH. Although additional experiments would be required to confirm variations of seawater pH, it can be suggested that anthropogenic CO_2 may affect differently within the Indonesian Seas.