OCEAN ACIDIFICATION IN CORAL REEFS : THE ROLE OF MICROBIAL COMMUNITY TO THE DISSOLUTION OF CALCIUM CARBONATE UNDER ELEVATED pCO2

メタデータ	言語: en 出版者: Shizuoka University 公開日: 2014-10-20 キーワード (Ja): キーワード (En): 作成者: Md., Nazrul Islam メールアドレス: 所属:
URL	https://doi.org/10.14945/00007936

学 位 論 文 要 旨

Abstract of Doctoral Thesis

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論文題目：
Title of Thesis：

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論文要旨：
Abstract：

Ocean acidification has emerged as one of the biggest threats to coral reefs across the world. The effects of ocean acidification on calcifying organisms which are very abundant in coral reef are poorly understood. To determine the effects of ocean acidification on the dissolution of calcium carbonate, coral rubble with associated microbial community were incubated under natural and elevated pCO_2. The main objective of these incubations was to understand the role of associated microbial community for the dissolution of calcium carbonate in coral rubble under ocean acidification scenario. Incubations were conducted at Sesoko reef, Okinawa, Japan in May and September of 2011 and 2012. Short incubations (24 hours under natural illumination) and long incubations (4 days under natural illumination and dark condition) were carried out using white coral skeleton (control), natural rubble (with associated epilithic and endolithic communities), treated rubble (with removed epilithic community) and natural rubble with addition of organic matter (glucose or coral mucus) under different levels of pCO_2 (ambient, 520, 720 and 1120 ppm).

During short experiment under natural illumination, net primary production, net respiration and dissolution rates of treated coral rubble (only endolithic communities) were slightly lower than the natural rubble, indicating that the metabolism of endolithic community was much higher when compared to the epilithic community at all pCO_2 levels. In short incubation, treated rubble (with only endolithic communities) dissolution rates varied from 85-91%. In long experiment under natural illumination, carbonate dissolution rates varied from 23.7 ± 0.1 (ambient) to 50.5 ± 1.5 (1120 ppm) μmol $m^{-2}d^{-1}$ at night time and 3.2 ± 1.1 (ambient) to 5.8 ± 1.2 (1120 ppm) µmol $m^{-2}d^{-1}$ at day time. However, in long experiment under complete dark condition when photosynthesis was inhibited, carbonate dissolution increased to 81.6 ± 0.2 µmol $m^{-2}d^{-1}$ at high pCO_2. When compared natural rubble with white coral skeleton (control), around 80% of carbonate dissolution was due to the contribution of biological processes by the respiration of associated microbial communities. Conversely, very small amount of dissolution was observed from the control even under high pCO_2 condition. These suggest that biological processes and the time scale play a significant role in determining calcification and dissolution. Dissolution of calcium carbonate occurred even aragonite saturation state (Ω_{arg}) remained higher than 1 and this effect was more noticeable with increasing pCO_2 levels.

Addition of bioavailable organic matter significantly enhanced bacterial abundance (*t*-test; p=0.01) and net respiration (*t*-test; p=0.0001) and these increased with increasing pCO_2 levels ($p<0.05$). With the increase in respiration, dissolution rates also increased. Heterotrophic microbial communities produced more CO_2 and promoted further carbonate dissolution. This pattern was also reflected at high pCO_2 incubations. In the organic matter addition incubation bottles, bacterial abundance increased by 3 to 4 orders of magnitude and the dissolution rates increased by 2.5 times to 10 times more than in control (white skeleton). The results show that inputs of organic matter in the reefs will enhance metabolic activities of microbial communities associated with coral rubble which ultimately increase dissolution of calcium carbonate. These suggest that availability of organic matter accelerates carbonate dissolution with enhancing microbial abundance and their physiological activities. Therefore, bioavailable organic matter has a potentially important role for calcium carbonate dissolution.

Elevated CO_2 influenced carbonate ($CaCO_3$) dissolution in white coral skeleton (WCSk; control) but the magnitude of dissolution rates was very small. On the other hand natural rubble (NR) showed higher dissolution rates than the control both at natural illumination and dark condition. This suggests that CO_2 produced by the microbial community respiration intensified dissolution in these experiments. Therefore, in coral reefs ecosystem, calcium carbonate ($CaCO_3$) dissolution is not only governed by the physico-chemical processes but also biological processes in determining calcification and dissolution. These concepts were clearly demonstrated in the "Bio-Chemical Dissolution Processes (BCDP)" model.