Box corer behavior monitored by inclinometer during exploration of deep-sea polymetallic nodules

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ABSTRACT

Box corer (BC) sampling is a well-known method in exploration of deep-sea polymetallic (manganese) nodules. This paper presents the results of monitoring the behavior of BC in a 2018 survey cruise in the Clarion–Clipperton Zone, Central Pacific Ocean. In particular, the sensor data on the depth and inclination of the BC body obtained by an offline inclinometer provided direct information on the BC's irregular behaviors in case of unsuccessful sampling. The data of inclinometer are consistent with those in other monitoring data, such as pinger or wire tension, and thus can be useful to improve equipment maintenance and operation during deployment.

KEY WORDS: manganese nodules; Clarion–Clipperton Zone; deep-sea sampling; box corer; inclinometer.

INTRODUCTION

Polymetallic nodules (also referred to as manganese nodules or nodules) on the seafloor are spherical to ellipsoidal manganese-oxide concretions ranging from a few to 10 cm in diameter. They contain metals such as copper, cobalt, and nickel, which are considered important mineral resources (e.g., Morgan, 2017; Hein et al., 2020; Cronan, 2022). The Clarion–Clipperton Zone (CCZ) in the Central Pacific is known to yield particularly large amounts of manganese nodules and has been the object of research cruises by countries and institutions around the world. Exploration activities for marine mineral resources in the open sea are managed by the International Seabed Authority (ISA) established under the United Nations Convention on the Law of the Sea (e.g., Lodge et al., 2014), recent activities in the open sea are aimed for not only resource estimation but also collection of environmental baseline data and testing mining machines (e.g., Amon et al., 2016; Jones et al., 2017; Sharma, 2020; Parianos et al., 2021; Kang and Liu, 2021; Muñoz-Royo et al., 2022). This paper reports the results of monitoring and sensor data on Box Corer (BC) sampling in a manganese nodules survey cruise conducted by Deep Ocean Resources Development, Co., Ltd. (DORD), which is under an exploration contract with the ISA.

The BC (Table 1) is one of the historically used survey instruments (Hessler and Jumars, 1974) and is still the primary one used in manganese nodule survey cruises (e.g., Rühlemann et al., 2009; Dreiseitl and Bednarek, 2011; Tsune and Murakami, 2019). BC is a type of sampler lowered to the seafloor by wire and consists of main frame body, a sampling box, a spade, and so on. After the stainless steel sampling box pierces the seafloor, the spade moves through a mechanical mechanism to close the bottom of the box and acquire the sample. Historically (i.e., before 1990s), free fall grab (FFG; Table 1) was mainly used for efficient data acquisition on the resource surveys. However, in recent years, BC has been used due to improve the data quality (e.g., Tsune and Okazaki, 2015; Parianos et al, 2021). Moreover, multiple corer and gravity corer have also been used to collect sediments (e.g., Sterk and Stein, 2015), but BC is particularly used for the collection of benthic organisms in CCZ. BC sampling box sizes of 0.25 m² (50 cm × 50 cm) have been widely used, although BCs with larger box sizes have also been used in recent years (e.g., Parianos et al., 2021; 0.75 m²).

For contractors who have exploration contracts with ISA and conduct exploration activities in the open sea, avoiding unsuccessful sampling is a very important topic for the time efficiency. Sensor data attached to the equipment and monitoring during deployment play an important role in considerations about improvement of operations and the other technical measures. In this paper, we present monitoring and sensor data on BC sampling during a 2018 survey cruise, particularly the irregular behaviors of the BC in case of unsuccessful BC sampling are examined based on log data of depth and inclination of an offline device (hereafter referred to as an inclinometer).

The organization of this paper is described below. The Methods section describes the BC used, the instruments attached to the BC and explanations on data of inclinometer and pinger as well as an overview of the 2018 survey cruise. The protocols for BC sampling, from BC deployment to recovery, are also outlined here as basic information for BC sampling. In addition, the criteria for the success or failure of the BC sampling are described. Meanwhile, the Results section organizes the information on the relationship among sampling results, monitoring, and sensor data. In the Discussion section, causes of unsuccessful BC sampling such as poor sea conditions and inadequate landing location are outlined, followed by interpretations of the obtained sensor and monitoring data and a discussion of the causes of failure. Finally, improvement measures about BC sampling are described.