Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SCG66-P18 Room:Convention Hall Time:May 22 15:30-17:00

Development of an underwater gravimeter

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We have developed an underwater gravimeter for hydrothermal deposit surveys. A detectable resolution of 0.1 mgal was set as the development target, considering gravity anomalies due to a typical hydrothermal deposit with a dimension of 500 m x 500 m x 10 m and a density contrast of 1 g/cm^3 and a survey altitude of 50 m from the seafloor. The newly developed gravimeter system is stored in two pressure cases made of titanium alloy and is operable up to 4200 m in water depth. In order to keep its verticality, a gravity sensor (MicroG LaCoste S-174) is mounted on a gimbal control unit with an inertial navigation sensor (PHINS) and is stored in the first pressure case, while the data acquisition system is in the second case. Data are obtained at sampling rates of 88.1 Hz and 100 Hz from the gravity sensor and from the PHINS, respectively. High-frequency noise due to vehicle motions can be reduced by applying a low-pass filter to the collected data. We made gravity measurement experiments on a machine simulating pitch and roll motions with a period of 16 s and an amplitude of 7.5 degree, which is greater than expected in actual vehicle motions. Two-step low-pass filtering with 1-s and 150-s Gaussian filters was applied to the collected data. A vehicle speed of 2 knots and the filtering width of 150 s correspond to a spatial resolution of 75 m after this low-pass filtering, which is small enough to detect the gravity anomalies due to the deposits. The experiments revealed that the gravimeter has a gravity anomaly resolution better than the requirement: as the results of the low-pass filtering, tilt and earth tide corrections and assumption of linear temporal drift, RMS errors of 0.04 mgal and 0.02 mgal were obtained for the experiments of pitch and roll motions, respectively. A cruise is planned in September 2012 to test the hybrid system of this gravimeter and a gravity gradiometer, which is developed simultaneously, on an autonomous underwater vehicle (AUV).

Keywords: gravimeter, underwater, inertial navigation, jimbal, AUV