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Development of *in situ* CO_2 and pH sensor for AUVs and ROVs

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been developing two-type autonomous underwater vehicles (AUVs): a cruising AUV and a working AUV, since October 2010. These vehicles will perform carbon dioxide (CO_2) and pH observations to explore hydrothermal plume on seabed mineral resources and to monitor a leak of CO_2 in carbon capture and storage (CCS) up to depth of 3,000 meters.

We here have been developing the compact *in situ* CO_2 and pH sensor (Hybrid CO_2-pH sensor: HCS) for the AUVs to obtain vertical and horizontal distributions of CO_2 and pH. The HCS consists of an aluminum pressure housing (diameter 84 mm, length 570 mm, weight 4 kg) and an acrylic silicon-oil filled, pressure-compensated vessel (diameter 90 mm, length 355 mm, weight 2 kg) containing valves and pump unit. The HCS is also useful for the observation by remotely operated vehicles (ROVs). The measured data were transmitted to the AUVs or ROVs by serial communications. We can monitor the data of *in situ* pCO_2, pH and so on in real time on board.

The measurement principle for the CO_2 sensor is based on spectrophotometry. The pCO_2 is calculated from the optical absorbance of the pH indicator solution equilibrated with CO_2 in seawater through a gas permeable membrane. On the other hand, we adopt potentiometric analysis using original glass and reference electrodes as a pH sensor because of the most commonly used technique for sea water pH measurements and high-speed response (within 20 seconds). From simultaneously measured data of *in situ* pCO_2 and pH, we can also calculate dissolved inorganic carbon (DIC) and total alkalinity (TA) as other carbonate species in the ocean. The resolutions of HCS are 1 μatm for pCO_2 and 0.001 pH. In the laboratory experiment, the HCS obtained precisions within 3 μatm and within 0.01 pH, respectively.

Our first *in situ* observational test of the HSC with cruising AUV was made in the coast of the Japan Sea last August. And also first *in situ* test of the HCS with ROV was performed at Okinawa Trough last September. The data obtained from each tests are consistent with predictions based on past studies.