Integrating ROV MBES and photogrammetry data for comprehensive mapping of cold seep systems at Hakon Mosby Mud Volcano (HMMV) in the Barents Sea

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Cold seeps play a distinctive geo-ecological role in the deep-sea environment, influencing the dynamics of submarine sedimentary settings and shaping the landscape evolution. In this study, we introduce a comprehensive methodology that utilizes ROV-based multibeam mapping and underwater photogrammetry to enhance our comprehension of the physical interactions among geomorphic features within the Hakon Mosby Mud Volcano (HMMV) and the associated habitat distribution. Our approach integrates data acquired by a work-class ROV at multiple resolutions and from various sources. Microbathymetry data obtained by the ROV revealed different fine-scale submarine landforms in the central region of HMMV, identifying three distinct geomorphic units, with the central hummocky region being the most complex. Further analysis of ROV images, utilizing a defined Structure-from-Motion (SfM) workflow, generated millimetric resolution 2D and 3D models for in-depth exploration of this region. Applying Object-Based Image Analysis (OBIA) to orthomosaics enabled fine classification of main benthic communities, covering an area of 940 m^2, including the active seepage zone of the hummocky rim. Four major substrate types were identified: uncovered mud, high-density bacterial mats, low-density bacterial mats, and sediments with tubeworms. Investigating their relationship with terrain morphology and seepage activity at various spatial scales contributes to a comprehensive understanding of the ecological dynamics of cold seep ecosystems in mud volcanoes. The proposed workflow and innovative processing techniques presented in this study can serve as a model for future research on cold-seep systems. These investigations seek to resolve the interrelation of geomorphic, biogeochemical, and ecological processes in extreme environments marked by spatial patterns in associated habitats and sedimentary settings. This work comprises data collected during the CAGE21-1 cruise and within the framework of the INTPART-AKMA (287869).

Keywords: Cold Seeps, ROV, MBES, ROV Photogrammetry, Seafloor Mapping, High resolution