Detailed Geomorphology of Cold Seeps Associated with a Buried Salt Diapir, Offshore Nova Scotia, Canada

Calvin Campbell¹, Alexandre Normandeau¹, Paul Fraser¹, and Adam MacDonald²
¹Geological Survey of Canada-Atlantic, Dartmouth, Nova Scotia, Canada (calvin.campbell@canada.ca)
²Nova Scotia Department of Energy and Mines, Halifax, Nova Scotia, Canada

Cold seeps occur where fluids, such as hydrocarbons, migrate from depth and escape at the seabed. They are relatively common features in petroleum basins around the world. Cold seeps often host unique biological communities and are a potential geological hazard as they can indicate excess pore fluid pressures in shallow sediments. In addition, they can provide critical information about fluid migration pathways and fluid source. This study presents the detailed geomorphology and seismic stratigraphy of recently discovered cold seeps in 2700 metres water depth offshore Nova Scotia, Canada.

Petroleum industry 3D seismic reflection data, high-resolution single channel G.I. gun and sparker seismic reflection data, Autonomous Underwater Vehicle (AUV) sidescan, swath bathymetry, and sub-bottom profiler data were used to investigate the geomorphology of the cold seep and surrounding seabed. Piston core samples and seabed photography were also acquired in the study area.

The geomorphology in the study area is dominated by the seafloor expression of a salt diapir (L. Triassic to E. Jurassic). Despite being buried by ~1700 m of Cretaceous to Holocene sediment, the diapir forms an oblong mound, 10 km long by 5 km wide that rises 200 m above the surrounding seabed. Two major orthogonal faults are apparent on the seabed that cut the mound along its major and minor axes. Several crestal faults are imaged in the 3D seismic data but do not have a seabed expression. AUV data acquired over the crest of the diapir reveal a 500 m by 200 m fissure on the western flank of the diapir. The fissure is composed of a blocky central zone along its axis, and radiating “cracks” that show backscatter variation, possibly indicating recent fluid expulsion. Integration of the AUV data with the 3D seismic data show that the fissure is fed by a vertical chimney that intersects a bottom simulating reflection above the diapir. Remarkably, the chimney does not appear to be related to any of the sub-vertical crestal faults. Another seep occurs on the eastern flank of the diapir crest and, in contrast, coincides with a crestal fault. There is also evidence for mass wasting down-dip from the fault. Core samples recovered from the second seep contained gas hydrate. In both cases, the cold seeps present as very subtle features on the 3D seismic reflection data and are only positively identified in the AUV datasets. This study shows that conventional surface-acquired acoustic data are potentially insufficient for detecting cold seep morphologies in deep-water settings.