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Marine Geology 202 (2003) 79–120
MARINE GEOLOGY
INTERNATIONAL JOURNAL OF MARINE GEOLOGY, GEOCHEMISTRY AND GEOPHYSICS
www.elsevier.com/locate/margeo

Geophysical constraints on the surface distribution of authigenic carbonates across the Hydrate Ridge region, Cascadia margin

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Received 28 June 2002; received in revised form 30 June 2003; accepted 18 August 2003

Abstract

On active tectonic margins methane-rich pore fluids are expelled during the sediment compaction and dewatering that accompany accretionary wedge development. Once these fluids reach the shallow subsurface they become oxidized and precipitate cold seep authigenic carbonates. Faults or high-porosity stratigraphic horizons can serve as conduits for fluid flow, which can be derived from deep within the wedge and/or, if at seafloor depths greater than ~300 m, from the shallow source of methane and water contained in subsurface and surface gas hydrates. The distribution of fluid expulsion sites can be mapped regionally using sidescan sonar systems, which record the locations of surface and slightly buried authigenic carbonates due to their impedence contrast with the surrounding hemipelagic sediment. Hydrate Ridge lies within the gas hydrate stability field offshore central Oregon and during the last 15 years several studies have documented gas hydrate and cold seep carbonate occurrence in the region. In 1999, we collected deep-towed SeaMARC 30 sidescan sonar imagery across the Hydrate Ridge region to determine the spatial distribution of cold seep carbonates and their relationship to subsurface structure and the underlying gas hydrate system. High backscatter on the imagery is divided into three categories, (I) circular to blotchy with apparent surface roughness, (II) circular to blotchy with no apparent surface roughness, and (III) streaky to continuous with variable surface roughness. We interpret the distribution of high backscatter, as well as the locations of mud volcanoes and pockmarks, to indicate variations in the intensity and activity of fluid flow across the Hydrate Ridge region. Seafloor observations and sampling verify the acoustic signals across the survey area and aid in this interpretation. Subsurface structural mapping and swath bathymetry suggest the fluid venting is focused at the crests of anticlinal structures like Hydrate Ridge and the uplifts along the Daisy Bank fault zone. Geochemical parameters link authigenic carbonates on Hydrate Ridge to the underlying gas hydrate system and suggest that some of the carbonates have formed in equilibrium with fluids derived directly from the destabilization of gas hydrate. This suggests carbonates are formed not only from the methane in ascending fluids from depth, but also from the shallow source of methane released during the dissociation of gas hydrate. The decreased occurrence of high-backscatter patches and the dramatic reduction in pockmark fields, imaged on the eastern part of the survey, suggest gas hydrate near its upper stability limit may be easily destabilized and thus, responsible for these seafloor features. High backscatter along the left-lateral Daisy Bank fault suggests a long history of deep-seated fluid venting, probably unrelated to destabilized gas hydrate in the subsurface.

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doi:10.1016/S0025-3227(03)00268-8