New Bering Sea Basin Observations Imply that Ascending Thermogenic Methane Pools in Large Sub-BSR Accumulations and Contributes Regionally to Deposits of Near-Surface Methane Hydrate*

David W. Scholl[1,2], Warren T. Wood[3], Ginger A. Barth[2], and Jonathan J. Childs[2]

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[1]University of Alaska, Fairbanks (dscholl@usgs.gov)
[2]United States Geological Survey, Menlo Park, CA
[3]U.S. Naval Research Laboratory, Stennis Space Center, MS

Abstract

Beringian Continental Margin

In 2009, IODP Exp 323 drilled three deep-water sites along the Beringian continental margin of the Bering Sea (U1343 at 1951 m, U1344 at 3172 m, and U1345 at 1007 m) (Figure 1A and 1B). Warming and depressurized sediment cores vigorously released methane gas when brought on deck. Disassociation of pore-space methane hydrate is implied, but hydrate was not directly seen. P-T conditions at a regionally extensive BSR match those of the phase transition from methane gas below to methane hydrate above (Figure 1E). Beneath sectors of acoustically bright BSRs, seismic profiles record gas-blanking effects in wide columns (~1->3 km) extending downward to subsurface depths of 2-3 km (Figure 1C and 1D). A thermal gradient of ~53 deg C/km implies that at these depths methane generation is dominantly thermogenic. It is posited that vertical migration of thermogenic methane acoustically brightens near-surface BSRs and, within the overlying waters, venting may help sustain one of the world's most prolific ecosystems and fishing grounds.

Abyssal Floor of the Aleutian Basin

In the 1970s and 1980s, seismic reflection profiles of the 3-4-km-thick sedimentary sequence underlying the abyssal floor (3400-4000 m) of the Aleutian Basin revealed hundreds of vertical columns of near surface up-arched reflection horizons overlying down-bowed horizons extending to depths of several km (Figure 2). At a subsurface depth of ~360 m, the maximum up-arched reflector, which is also acoustically bright, is coincident with the regionally extensive gas-hydrate BSR. These **v**elocity-amplitude anomalies, or VAMP structures, were hypothesized to be

recordings of higher velocity sediment containing hydrate (velocity pull-up) overlying the top of a chimney of ascending low-velocity methane gas (velocity push-down). Cumulative downwarping increases down section through Miocene and younger diatomaceous sediment to depths of at least 1.5-2.5 km. A thermal gradient of ~60 deg/km implies methane generation at these depths is dominantly thermogenic.

In 2011, the R/V Langseth, using a long-offset (8 km) MCS cable, acquired reflection profiles that for the first time recorded subsurface velocity data. The new observations document that at VAMP structures a volumetrically large (0.5-1.0 TCF), downward tapering mass of methane gas underlies the BSR and is responsible for the posited velocity push down (dark purple colors, Figure 2C). The new data also established that large VAMPs rise above deeply buried (2-3.5 km) basement relief (i.e. knolls, seamounts, ridges) and that near-surface columns of up-arched reflectors chiefly reflect differential compaction over buried basement relief (Figure 2D).

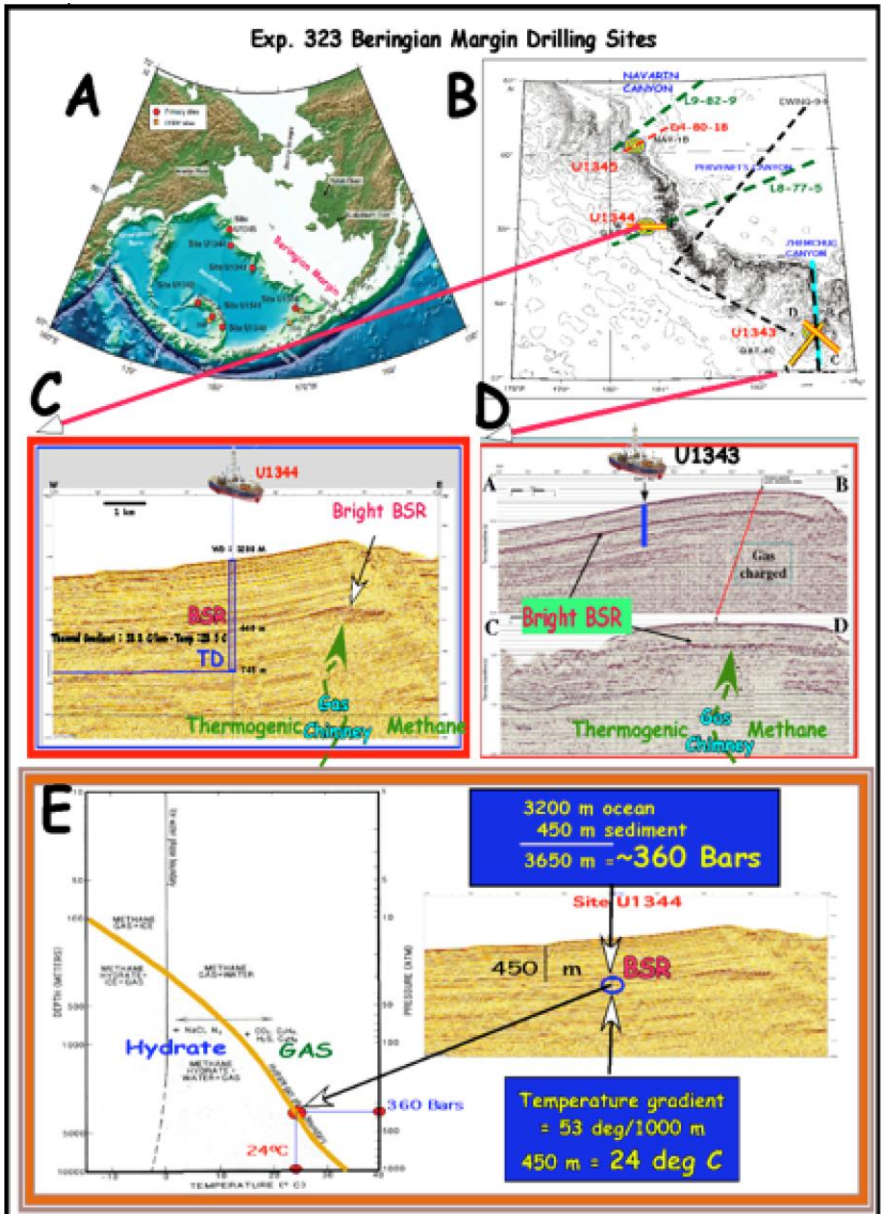

Figure 1. Beringian Margin BSR setting.

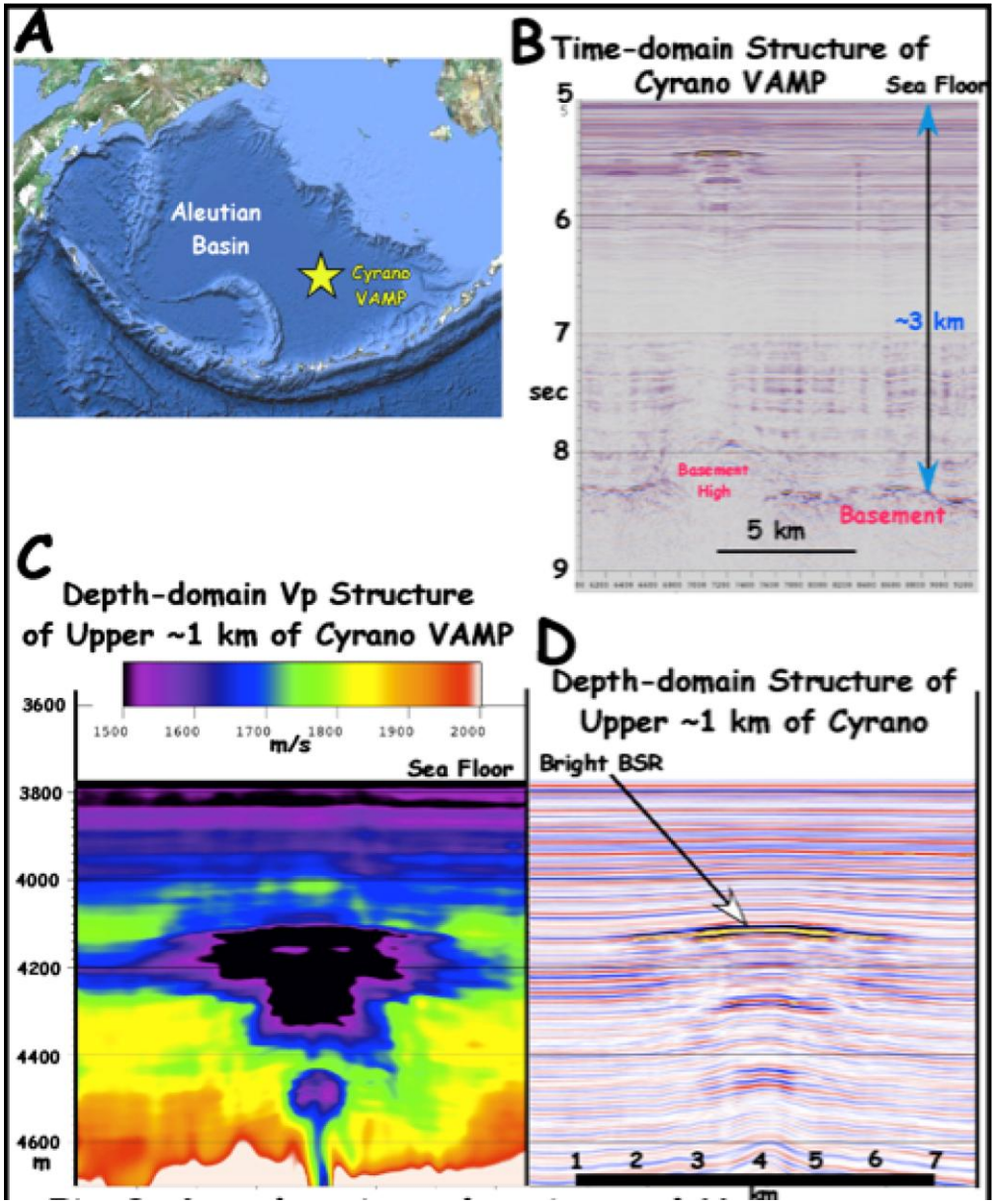

Figure 2. Depth-domain, time-domain, and Vp structure of Cyrano VAMP structure, Bering Sea.