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Critically Pressured Free Gas Reservoirs Below Gas Hydrate Provinces

Paleoceanographic evidence suggests that methane hydrates play a significant role in global climate change; however, mechanisms for sustained methane release into the biosphere during periods of global warming are poorly understood (Katz et al. 1999, Kennett et al., 2000). Here, we evaluate the possibility that gas flux into the hydrate stability zone, and perhaps into the oceans and atmosphere is mechanically regulated by hydrofracture or fault reactivation in overlying hydrate-bearing sediments. Our results reveal that a critical gas column thickness exists below most hydrate provinces in basin settings, implying that these hydrate provinces are poised for mechanical failure. Our results suggest that a free gas ''wedge'' of increasing thickness with BSR depth occurs in hydrate basins, and that a mechanically regulated maximum thickness of free gas exists. Furthermore, our results are consistent with observations of thicker free gas zones in deep hydrate basins and thin free gas zones on active, possibly water-phase overpressured, continental margins. Incorporating our result with Dickens' 2001 model for estimating BSR depths along ocean margins, and assuming 50% sediment porosity with gas filling 1% of the pore space, we calculate a value for the total free methane gas reservoir below all hydrate provinces to be 1/8 the total methane trapped in hydrate, or ~1300 Gt if 10,000 Gt of methane exists in hydrate (Kvenvolden, 1993). One key implication is that a significant reservoir of methane may exist as free gas beneath hydrate provinces that is highly sensitive to changes in pressure and temperature.