Temporal variation in natural methane seep rate at the Venoco Seep Tent, Coal Oil Point area, California

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Abstract

Two large steel tents (each 30m by 30m), open at the bottom to the sea floor, capture about 16.4 x10^3 m^3 day^{-1} (580 MCF) of primarily methane from a large natural hydrocarbon seep, occurring a kilometer offshore in 67m of water. The gas is piped to shore where it is metered and processed. The seep flow rate has been monitored hourly for more than a year, to determine the effect of tides and longer term processes on the seep rate.

Results shows that 5-10% of the variation in gas flow rate is due to tidal variation (Boles et al., submitted). Time series analyses clearly show four principal tidal components with periods of 12.00 hr, 12.42 hr, 23.93 hr, and 25.82 hr. The correlation indicates that each 30 cm (foot) increase of sea height results in a decrease of 3.0 to 3.8 m^3 $hour^{-1}$ or 0.5% of the hourly flow rate. The observed changes can best be accounted for by 1) a pore activation model, whereby gas is released from small pores at low pressures but is inhibited at higher pressure and 2) pressure dependent gas solubility changes (see Boles et al., submitted).

New analysis of the tide-seepage data indicates there is a strong correlation (R^2=0.945) between rate of change in tide height and rate of change of seepage. The seepage rate changes by as much as 10 cubic meter/hour/hour depending on the rate of tide change. The slope of rate of tide change (dH) in cm/hour over rate of change in seepage rate (dQ) in cubic meter/hour/hour is dH/dQ = -6.4. The seepage response appears to be symmetrical to the changes in tide height.

In addition to tidal influences on seepage rate, the monitor period contains two large scale (5 month) sinusoidal variations in seepage, which are not related to periods of particularly high or low tide. The cause of these month scale variations is under investigation.

A long term (month to decadal time scale) comparison of variation in seep rate to hydrocarbon production from the nearby South Ellwood oil field indicates that during a 10 year period, reservoir pressure remain relatively constant in key wells, while the seep rate dropped by more than 40 %. A recent month long platform shutdown also did not affect the seep rate. Apparently on month to decadal time scales, removal of hydrocarbon from the reservoir or changes in reservoir pressure do not affect the seep rate at the tent. Changes in seepage are probably related to shifts in seep orifices at the sea surface with respect to the seep tents, and/or complex slug flow of buoyant natural gas along the steep dipping Ellwood anticline fault.