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Methane seepage along faults in the Santa Barbara coastal area, California: geologic and modern evidence

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ABSTRACT

Tertiary sediments of the Santa Barbara basin are a prolific hydrocarbon source and there is a good evidence that the basin has been leaking hydrocarbons, including methane, to the surface for least half a million years. Several carbonate cemented faults exposed onshore along the Santa Barbara coast show evidence of leakage of basin water, liquid hydrocarbons and methane. Some of these faults have calcite cements with textural evidence indicating multiple cement events that are contemporaneous with fault movement. Stable carbon isotopic value of the calcite is as light as ?13C = –40 indicating the carbon source is from methane. Inclusions in calcite indicate the presence of meteoric and saline aqueous fluids and hydrocarbons. Crystallization temperatures are about 80-110?C, based on fluid inclusions. Thus methane and hot fluids were leaking from 2-3 km depths in the basin and moving up faults on the basin flank. The leakage began at least 120,000 to greater than 500,000 years ago, based on U-Th dates from calcite.

Today, extensive seepage of methane occurs offshore in the coastal waters of the basin. Some of the most extensive methane seepage is along the crest of an underpressured anticline from a fault that is very similar in style to coastal onshore faults with high angle normal offset. Pressure build-up, and tidal frequency pressure variations occur at 1 km reservoir depth in a well penetrating the fault zone, which suggests sea water is going down the fault. Studies show that ocean tides cause 5-10% variation in methane seepage rate on the sea floor at water depths of 70m. These modern seeps are "cold" and do not appear to be carrying significant amounts of basin fluids up along the fault. Calcite cement has not been found at these modern seep localities. Thus over a 105 year time scale, the seepage has evolved from overpressured hot fluids and gas being carried up along basin flank faults to underpressured cold gas seepage up along faults within the basin.