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Source, sink and occurrence of hydrogen sulfide in the unconventional resources play

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Shale gas were believed to be “sweet gas” containing H_2S < 4 ppm, however, elevated H_2S concentration is encountered in various shale plays, including Haynesville, Bakken, Eagle Ford, Avalon, Bone Spring. Regional study is necessary to evaluate H_2S risk in order to reduce the cost for special treatment and meet health/safety/environmental requirement.

The sources of H_2S in the unconventional resources play are complicated. S-containing labile organosulfur compounds in both kerogen and oil decomposition during thermal maturation, thermochemical sulfate reduction (TSR) and bacteria sulfate reduction (BSR) are three potential sources. Sulfur isotope of H_2S, sulfate and pyrite framboid is an important geochemical parameter for potential source identification. In case of Haynesville Shale gas play, light H_2S sulfur with $\delta^{34}S$ = -9 to -20 ‰ is most likely derived from original kerogen sulfur, similar to that in framboidal and associated pyrite with $\delta^{34}S$ = -11.5 ± 2.6 ‰. Heavy H_2S sulfur (+16 to + 18 ‰) is most likely derived from TSR of the underlying Werner anhydrite i.e., Jurassic age sea water sulfate (+18 ±3 ‰; VCDT). H_2S in the Haynesville Shale appears to have been generated from multiple sources of sulfur.

Thermal decomposition of S-containing organic compounds in kerogen and crude during thermal maturation is the main source of H_2S in the Eagle Ford Shale. A trend of decreasing oil sulfur content with present burial depth provides a predictive way to determine the possible regions of high H_2S concentration. Elevated H_2S (>10 ppm) is associated with low API gravity oil that contains high sulfur content, and the generation of H_2S is associated with S-containing organic compounds thermal decomposition.

The H_2S dissolved in water, diagenetic reaction and pyrite formation and refractory organo-sulfur compounds are considered as various sinks. The dilution of CH_4-rich gas at higher thermal maturity also plays a role to reduce the H_2S concentration. A conceptual model of H_2S risk assessment is presented in terms of H_2S source, sink and occurrence in the unconventional resources play.