Mechanisms of Sulfur Transformation, Deposition, and Controls in HPHT Sour Gas Petroleum Systems

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Reserves of low sulfur crude oils are depleting worldwide, necessitating exploration and production of reservoirs of crude oils with high sulfur content [1]. Despite high overall activity in processing higher sulfur-bearing hydrocarbons across the globe, there is scant knowledge available on sulfur formation and transformation mechanisms in sour-gas reservoirs. Generally, these are believed to have formed from microbial sulfate reduction (MSR) or thermochemical sulfate reduction (TSR) processes present in anhydrite-capped carbonate reservoirs [2].

Redox reactions of reduced sulfide (H_2S/HS^-), elemental sulfur (S_8), and their intermediate sulfur compounds (e.g., polysulfide-S_n^2) are difficult to control in high pressure-high temperature (HPHT) sour gas environments, because of their variable non-linear behaviour/oxidation states, and exotic thermodynamic stability at reservoir conditions. The variations in reported reaction conditions in petroleum and gas reservoirs also raised significant concerns about crude quality, flow assurance, cost in facility planning, corrosion, and as well as health and safety [3].

Of these conditions, we highlight in our experiments the methodologies of quantifying sulfur species and mitigation approaches in HPHT reservoirs, source transformation chemistry via S-isotopic measurements, redox mechanisms, and desublimation pathways in sour gas systems. Results of these studies indicate differences in the operational pathway for diagenetic maturity and thermal alteration events of organic and inorganic sulfur species that are distinct to MSR and occur during any stage of petroleum history, from inception to production.

[1] Lewan MD. (1998): Sulfur-radical control on petroleum formation rates. *Nature* **391**, 164-166.
[2] Machel HG. (2001): Bacterial and thermochemical sulfate reduction in diagenetic settings - old and new insights. *Sedimentary Geology* **140**, 143-175.
[3] Yin C. et al., (2014): Study on the formation, determination, and removal of elemental sulfur in ultra-low sulfur gas oil. *Fuel Proc. Tech.* **120**, 16-21.