

# A Kinetic Modeling Approach to H<sub>2</sub>S Risk Assessment in the Pre-Salt Reservoirs in the Santos Basin

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## Abstract

The pre-salt play in the Santos Basin contains giant oil and gas accumulations and is considered the largest petroleum discovery in the last decade. However, the fields contain non-hydrocarbon gases (e.g., CO<sub>2</sub> and H<sub>2</sub>S) that bring technical challenges for exploration and production. Although H<sub>2</sub>S concentrations are quite low (15 to 180 ppmv), corrosion and environmental issues can arise, with higher costs required to mitigate these problems. Consequently, it is important to identify the generation processes of these gases to improve estimates of the required investments during the initial phases of the projects. Santos Neto et al. (2013) suggested that the main H<sub>2</sub>S generation process in the pre-salt reservoirs in the Santos Basin is thermochemical sulfate reduction (TSR), mainly based on the sulfur isotopic composition of H<sub>2</sub>S, oils, and anhydrites. Additional TSR proxy analyses were conducted (compound-specific sulfur isotope analyses - CSSIA and thiadiamondoid quantification) and these subsequent results suggested that TSR may not be involved. To constrain the possible origins of H<sub>2</sub>S, we have modelled in situ TSR in low temperature carbonate reservoirs (~100°C) using published kinetic parameters. TSR is a complex process that depends on many factors (e.g., time, temperature, water chemistry, reservoir mineralogy, and oil composition). We used the initial parameters provided by Zhang et al. (2012) to generate TSR models that we classify as catalytic and non-catalytic, following the proposed two-stage reaction scheme. In general, the catalytic models, which consider the presence of catalysts such as high H<sub>2</sub>S partial pressure, elemental sulfur, or acidic conditions, predict reaction rates that are too fast for the Santos Basin with unrealistically high H<sub>2</sub>S concentrations.

The non-catalyzed models predict sulfate reduction amounts varying from 0.003% up to 42%, which corresponds to H<sub>2</sub>S concentrations ranging from approximately 3 ppmv to 3.5%. These results highlight the sensitivity of H<sub>2</sub>S risk models to variations in TSR reaction kinetics. The modeling results show that it is possible to reach the same H<sub>2</sub>S content present in some oil fields in the Santos Basin with non-catalyzed TSR kinetics proposed by Ma et al. (2008). If the source of H<sub>2</sub>S in the basin is from TSR, it is possible that thiadiamondoids and CSSIA are not capable of recording small quantities of TSR when the reactants (oil and sulfate) have similar sulfur isotopic compositions. It is important to note that the current models assume that the TSR reaction only occurs within 10 m of the water/oil contact. The models could be improved by considering fluid mixing and diffusion beyond this reactive zone. Other possible H<sub>2</sub>S generation mechanisms should also be tested (e.g. oil or kerogen cracking). The source of H<sub>2</sub>S in the pre-salt reservoirs in Santos Basin is still unknown, and more studies are needed to address this question.